



UNIVERSITÀ DEGLI STUDI  
DI TRENTO

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# AGON: A GAMIFICATION-BASED FRAMEWORK FOR ACCEPTANCE REQUIREMENTS

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# Abstract

*We live in the days of social software where social interactions, from simple notifications to complex business processes, are supported by software platforms such as Facebook and Twitter. But for any social software to be successful, it must be used by a sizeable portion of its intended user community. This is fundamental for social software, but also a crucial point for most of the software systems in general, and the fulfillment of such (Usage) Acceptance Requirements critically depends on psychological, behavioral and social factors which may influence intrinsic and extrinsic motivations of the user. Operationalization techniques for Acceptance Requirements largely consist of making a game out of software usage where users are rewarded depending on the degree of their participation. The game, for instance, may be competitive or non-competitive, depending on the anticipated personality traits of intended users. Making a game out of usage is often referred to Gamification. It has attracted significant attention in the literature for the past few years because it offers a novel approach to software usage.*

*Gamification is a powerful paradigm and a set of best practices used to motivate people carrying out a variety of ICT-mediated tasks. Designing gamification solutions and applying them to a ICT system is a complex and expensive process (in time, competences and money) as software engineers have to cope with heterogeneous stakeholder requirements on one hand, and Acceptance Requirements on the other, that together ensure effective user participation and a high level of system utilization. As such, gamification solutions require significant analysis and design as well as suitable supporting tools and techniques.*

*In this thesis, we describe Agon, an Acceptance Requirements Framework based on Gamification, for supporting the requirements engineer in the analysis and design of engaging software systems. The framework adopts concepts and design techniques from Requirements Engineering, Human Behavior and Gamification. Agon encompasses both a method and a meta-model capturing acceptance and gamification knowledge. In particular, the framework consists of a generic acceptance goal meta-model that characterizes the problem space by capturing possible refinements for acceptance requirements, and a generic gamification meta-model that captures possible gamified operationalizations for acceptance requirements.*

*The framework is illustrated with the Meeting Scheduler Exemplar and different heterogeneous case studies. In particular, we describe Agon through a real case study concerning the gamification of a system for collaborative decision-making, within the Participatory Architectural Change Management in ATM Systems (PACAS) European Project. We describe also the Agon-Tool, a tool for enabling the requirements engineer in carrying out the systematic acceptance requirements analysis of the Agon framework in a semi-automatic supported way.*

## Keywords

[Acceptance Requirements, Gamification, Software Engineering, Requirements Engineering, Human Behavior]



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In a world where kindness and the valuable words “Thank you” are becoming more and more rare, I think that this acknowledgments Section is as important as the contributions of this PhD Thesis. Furthermore, *Acceptance* and *Gamification* are important topics of this Thesis, and can be used in combination for promoting behavior change, possibly for a positive change. Therefore, I hope that this Section could set also a good example towards fostering people to the positive behavior of saying “Thank you” more often.

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# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Acceptance Analysis and Gamification Engineering . . . . .	1
1.1.1	Acceptance Analysis . . . . .	2
1.1.2	Gamification Engineering . . . . .	3
1.1.3	A Successful Example of Acceptance and Gamification Engineering	5
1.2	Research Questions and Challenges . . . . .	6
1.3	Research Approach and Contributions . . . . .	12
1.4	Research Overview . . . . .	20
1.4.1	The Agon Framework . . . . .	21
1.4.2	Acceptance Requirements Analysis . . . . .	24
1.4.3	Acceptance Requirements Analysis with an Example . . . . .	24
1.5	Structure of the Thesis . . . . .	25
1.6	Published Work . . . . .	28
<b>2</b>	<b>State of the Art</b>	<b>31</b>
2.1	Acceptance and Acceptance Requirements . . . . .	32
2.1.1	Acceptance Requirements and Operationalization Techniques . . .	32
2.1.2	Acceptance Requirements and Agon . . . . .	33
2.1.3	Acceptance Models . . . . .	34
2.2	Gamification Engineering . . . . .	41
2.2.1	Importance of Gamification for Heterogeneous Fields . . . . .	42
2.2.2	Main Gamification Activities, Challenges and Concepts . . . . .	45
2.2.3	Gamification Frameworks . . . . .	51
2.3	Acceptance, Gamification and Requirements Engineering . . . . .	54
2.3.1	Acceptance and Requirements Engineering . . . . .	55
2.3.2	Gamification and Requirements Engineering . . . . .	55
2.4	Enhancements for Acceptance Requirements Engineering . . . . .	57

2.4.1	Human and Organizational Behavior Studies . . . . .	58
2.4.2	Agon and the Motivational Antecedents Framework . . . . .	59
2.5	Chapter Summary . . . . .	60
<b>3</b>	<b>Gamification of Software Systems</b>	<b>61</b>
3.1	Gamification for Sustainable Urban Mobility . . . . .	62
3.1.1	Using Gamification to Incentivize Sustainable Urban Mobility . . .	62
3.1.2	Research Context . . . . .	64
3.1.3	Technical solution . . . . .	65
3.1.4	The Experiment and The Gamified ViaggiaRovereto App . . . . .	68
3.1.5	Evaluation . . . . .	73
3.1.6	Summary and Future Work . . . . .	78
3.2	Gamification for Mobility Assistance for Children . . . . .	78
3.2.1	Virtual Coaches for Mission-Based Gamified Smart Communities .	79
3.2.2	Research Context . . . . .	80
3.2.3	Mobility Assistance for Children . . . . .	81
3.2.4	Characteristics of the Virtual Coaches . . . . .	82
3.2.5	Summary and Future Work . . . . .	84
3.3	Requirements of a Framework for the Design of Engaging Software . . . .	84
3.4	Chapter Summary . . . . .	90
<b>4</b>	<b>Agon: an Acceptance Requirements Framework Based on Gamification</b>	<b>91</b>
4.1	Acceptance Requirements and Agon . . . . .	91
4.1.1	Acceptance Requirements Definition . . . . .	92
4.1.2	Acceptance Requirements Examples . . . . .	93
4.2	An Acceptance Requirements Framework and Its Multi-Layer Meta-Model	94
4.2.1	The User Context Model . . . . .	97
4.2.2	The Acceptance Meta-Model . . . . .	99
4.2.3	The Tactical Meta-Model . . . . .	104
4.2.4	The Gamification Meta-Model . . . . .	106
4.2.5	The Instantiation Model . . . . .	110
4.3	Chapter Summary . . . . .	111
<b>5</b>	<b>The Agon Method and Tool</b>	<b>113</b>
5.1	The Agon Method . . . . .	114
5.1.1	The Doodle-Like Meeting Scheduler Exemplar (DLMSE) . . . . .	115
5.1.2	Phase 1: Base System Requirements . . . . .	117

5.1.3	Phase 2: Acceptance Requirements Elicitation and Analysis . . . .	117
5.1.4	Phase 3: Context Characterization . . . . .	119
5.1.5	Phase 4: Context-Based Analysis of Acceptance Requirements . . .	119
5.1.6	Phase 5: Acceptance Requirements Refinement . . . . .	121
5.1.7	Phase 6: Context-Based Operationalization via Gamification . . . .	124
5.1.8	Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms	125
5.1.9	The Gamified Doodle-Like Meeting Scheduler in a Nutshell . . . . .	126
5.1.10	Final Remarks . . . . .	129
5.2	The Agon-Tool . . . . .	129
5.2.1	The Agon-Tool Architecture and Technologies . . . . .	129
5.2.2	Using the Agon-Tool . . . . .	134
5.3	Chapter Summary . . . . .	147
<b>6</b>	<b>Applying Agon to a Real Case</b>	<b>149</b>
6.1	Participatory Architectural Change Management in ATM Systems (PACAS)	149
6.1.1	The PACAS European Project . . . . .	150
6.1.2	The PACAS Platform . . . . .	150
6.2	Gamification for Architectural Change Management in ATM Systems . . .	151
6.2.1	Case Study: Agon Applied to the PACAS Platform . . . . .	151
6.3	Gamification of the PACAS Platform . . . . .	162
6.3.1	Acceptance Analysis, Gamification Design and Implementation . .	165
6.3.2	The Challenger Path . . . . .	169
6.3.3	The Problem Solver Path . . . . .	178
6.3.4	The PACAS Platform Expertise Path . . . . .	180
6.3.5	Gamified Tutorials . . . . .	181
6.3.6	The Co-Pilot Avatar . . . . .	182
6.3.7	The Gamification Experience in the PACAS Platform . . . . .	182
6.4	Chapter Summary . . . . .	195
<b>7</b>	<b>Evaluation</b>	<b>197</b>
7.1	Evaluation Approach . . . . .	197
7.1.1	Evaluation Phases Overview . . . . .	198
7.2	Phase 1: Evaluation with Non-Experts in Realistic Cases . . . . .	202
7.2.1	Gamification for Meeting Scheduling . . . . .	203
7.2.2	Gamification for Food Services (the Smart Canteen) . . . . .	205
7.3	Phase 2: Evaluation with Non-Experts in Heterogeneous Cases . . . . .	208

7.3.1	Gamification for Sustainable Urban Mobility (SUM) . . . . .	211
7.3.2	Gamification for Mobility Assistance for Children (MA4C) . . . . .	211
7.3.3	Gamification for Project Management . . . . .	212
7.3.4	Gamification for Privacy Requirements (VisiOn EU Project) . . . .	213
7.3.5	Gamification for Collaborative Requirements Prioritization (SUPER- SEDE EU Project) . . . . .	214
7.4	Phase 3: Evaluation with Experts in a Real Case . . . . .	215
7.5	Phase 4: Evaluation with Users in a Real Case . . . . .	217
7.6	Discussion . . . . .	218
7.6.1	Results of the Case Studies and Experiments . . . . .	219
7.6.2	Ideas, Potential Improvements and Considerations . . . . .	234
7.6.3	Threats to Validity . . . . .	240
7.7	Chapter Summary . . . . .	245
<b>8</b>	<b>Conclusions and Future Work</b>	<b>247</b>
8.1	Summary . . . . .	248
8.2	Limitations, Ongoing and Future Work . . . . .	252
8.2.1	Agon Meta-Model Evolution . . . . .	252
8.2.2	Agon Method Evolution: Functional Improvements . . . . .	254
8.2.3	Agon Method Evolution: Usability Improvements . . . . .	256
8.2.4	Context Dependency . . . . .	256
8.2.5	Enhanced Automation: System Typologies . . . . .	257
8.2.6	User Case Studies and Experiments . . . . .	258
8.3	Importance of Extending and Integrating Agon . . . . .	258
8.4	Agon Extension Guidelines and Integration with the MAF Framework . .	259
8.4.1	Requirements Engineering and Organizational Behavior Techniques for Software Acceptance Analysis and Gamification Design . . . . .	261
8.4.2	The Motivational Antecedents Framework (MAF) . . . . .	264
8.4.3	Case Study Using Agon and MAF . . . . .	267
8.4.4	Comparison of Agon and MAF . . . . .	270
8.4.5	Guidelines for Extending and Integrating Agon . . . . .	274
8.4.6	Discussion and Conclusions . . . . .	276
8.5	Integrating Agon with Design Thinking . . . . .	277
8.5.1	Towards Identifying Key Requirements for a Collaborative Gamifi- cation Design Method . . . . .	279
8.5.2	An Example of Candidate Methods . . . . .	281

8.5.3	Concluding Remarks and Future Work . . . . .	283
8.6	Future Lines of Research . . . . .	284
8.6.1	A Full Stack Framework . . . . .	284
8.6.2	An Adaptive Gamification Framework for Long-Term Engagement	284
8.6.3	A Holistic Framework for The Design of Engaging Software . . . .	286
8.6.4	A Collaborative Method for the Design of Engaging Software . . . .	286
8.6.5	Future Operationalizations of Acceptance Requirements . . . . .	287

<b>Bibliography</b>		<b>289</b>
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# List of Tables

1.1	Evaluation activities and research methods [Wohlin et al., 2012] of this thesis	17
2.1	Acceptance models . . . . .	36
3.1	Sustainable mobility recommendation acceptance [Kazhamiakin et al., 2015]	75
3.2	Trips using bike sharing and car modes [Kazhamiakin et al., 2015] . . . . .	76
6.1	Gamification design of the Challenger Path within the PACAS platform [Piras et al., 2017b] . . . . .	169
6.2	Gamification design of the Problem Solver Path within the PACAS platform [Piras et al., 2017b] . . . . .	179
6.3	Gamification design of the PACAS Platform Expertise Path within the PACAS platform [Piras et al., 2017b] . . . . .	180
7.1	Experts and non-experts involved in the evaluations . . . . .	198
7.2	Case studies and experiments of this thesis . . . . .	200
7.3	Evaluation activities of <b>Eval1</b> (Table 1.1 and Table 7.2) with non-experts	204
7.4	Experiment activities of <b>Eval2</b> (Table 1.1 and Table 7.2) with non-experts	207
7.5	High-level pattern of evaluation activities for <b>Eval3</b> (Table 1.1 and Table 7.2) with non-experts . . . . .	210
7.6	Evaluation activities of <b>Eval4</b> (Table 1.1 and Table 7.2) with experts . . .	216
7.7	Evaluation activities of <b>Eval5</b> (Table 1.1 and Table 7.2) with real users .	218
7.8	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that participants, without using Agon, had difficulties in organizing game concepts together in a harmonious structure . . . . .	220

7.9	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that participants, without using Agon, realized that they were selecting concepts that, actually, were not the most suitable ones for the intended users . . . . .	221
7.10	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that participants, without using Agon, realized that they were selecting concepts that, actually, were not the most suitable ones for fulfilling psychological factors and strategies fitting the intended users . . . . .	222
7.11	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that Agon gamification suggestions inspire the analyst, by giving more elements to consider than the ones an analyst can have in mind . . . . .	222
7.12	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that Agon gamification suggestions provide the analyst with more details, and useful guidelines, concerning characteristics of gamification concepts to consider during the design of a gamification solution . . . . .	223
7.13	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that employing a systematic approach, e.g. the one of Agon, for gamifying a system is better, because allows the analyst to design more exhaustive, complete and effective solutions for motivating the intended users . . . . .	224
7.14	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that by using Agon, an analyst can execute a systematic acceptance requirements analysis for gamifying a system . . . . .	224
7.15	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that the systematic method of Agon supports the analyst in considering most of the psychological factors and strategies, which can affect positively intended users . . . . .	225
7.16	Answers to a question of the <b>Eval2</b> questionnaire, <i>Phase 1: Evaluation with Non-Experts in Realistic Cases</i> , confirming that the systematic method of Agon guides effectively the analyst in finding how to make concrete the abstract psychological strategies selected, by designing gamification solutions	226

7.17	Statistical Significance results obtained by performing non-parametric Chi-2 tests [Wohlin et al., 2012], over data observed within experimental activities of <b>Eval2</b> with non-experts . . . . .	228
7.18	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the requirement considering the importance of stimulating the user to collaborate with the others, in the PACAS platform, is relevant . . . . .	230
7.19	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the anti-requirement considering the importance of avoiding competition among users, in the PACAS platform, is relevant . . . . .	231
7.20	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the anti-requirement considering the importance of avoiding time pressure among users, in the PACAS platform, is relevant . . . . .	231
7.21	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the gamification design of the PACAS platform can stimulate the user in participating actively to the PACAS activities . . . . .	232
7.22	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the gamification design of the PACAS platform can favor collaboration among users . . . . .	232
7.23	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the gamification design of the PACAS platform can favor communication among users . . . . .	233
7.24	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the gamification design of the PACAS platform can stimulate the user in checking and improving, more frequently, the PACAS solutions . . . . .	233
7.25	Answers to a question of the <b>Eval5</b> questionnaire, <i>Phase 4: Evaluation with Users in a Real Case</i> , confirming that the gamification of PACAS can favor heterogeneous professionals to interact better for designing solutions with a wider “interdisciplinary coverage” (regarding safety, security, organizational and economic perspectives) . . . . .	234

8.1	Comparison of methodologies and support provided by the two frameworks to the analyst [Piras et al., 2017a] . . . . .	273
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# List of Figures

1.1	Abstraction layers of Agon with a simple example: an extract from the Doodle-Like Meeting Scheduler Exemplar [Piras et al., 2016, 2017a]	22
3.1	Architecture of the gamification framework [Kazhamiakin et al., 2015]	66
3.2	Software features of the <i>Not Gamified ViaggiaRovereto</i> mobile app [Kazhamiakin et al., 2015, Nurminen et al., 2014b]	70
3.3	Certificate of attendance with game results (left) [Kazhamiakin et al., 2015] and recommendations from Viaggia Rovereto App (right) [Kazhamiakin et al., 2015]	71
3.4	Gamified software features of the <i>Gamified ViaggiaRovereto</i> mobile app [Kazhamiakin et al., 2015, 2016, Nurminen et al., 2014b]	72
3.5	Distribution of saved trips per user during the experiment [Kazhamiakin et al., 2015]	74
3.6	Percentage of Km traveled for each mode of transport [Kazhamiakin et al., 2015]	76
4.1	Agon models at different abstraction layers, and the context model, composing the Agon Multi-Layer Meta-Model [Piras et al., a, 2016, 2017a,b]	95
4.2	Context dependent rules, gamification goals and tactics [Piras et al., 2017b]	98
4.3	The <i>User Context Model</i> of the Agon Multi-Layer Meta-Model, also available at [Piras et al., a]	100
4.4	An extract of the Agon acceptance meta-model [Piras et al., 2017b] based on UTAUT [Venkatesh et al., 2003]	101
4.5	Graphical notation followed by main elements of the Acceptance Meta-Model	102
4.6	The Agon multi-layer meta-model with a project management example [Piras et al., 2017b]	102
4.7	Graphical notation followed by main elements of the Tactical Meta-Model	105
4.8	Graphical notation followed by main elements of the Gamification Meta-Model	106

4.9	Left part of an extract of the Gamification Meta-Model (right part in Figure 4.10) related to the gamification concept of <i>Levels</i> [Piras et al., 2017b]	108
4.10	Right part of the extract of the Gamification Meta-Model (left part in Figure 4.9) related to the gamification concept of <i>Levels</i> [Piras et al., 2017b]	109
4.11	Graphical notation offered by Agon for instantiating the gamification solutions suggested by building the instantiation model . . . . .	110
5.1	The target group of users (professors), of the Doodle-Like Meeting Scheduler case study [Piras et al., 2017a], defined by instantiating the User Context Model of Agon [Piras et al., a, 2016, 2017a] . . . . .	116
5.2	Acceptance Need contributions annotated by CDRs [Piras et al., 2016] . .	119
5.3	Example of elements discarded by the analyst during “ <i>Phase 4: Context-Based Analysis of Acceptance Requirements</i> ” [Piras et al., a, 2016, 2017a]	120
5.4	Example of elements confirmed by the analyst during “ <i>Phase 4: Context-Based Analysis of Acceptance Requirements</i> ” [Piras et al., a, 2016, 2017a]	120
5.5	Elements proposed by Agon to the analyst during “ <i>Phase 5: Acceptance Requirements Refinement</i> ” [Piras et al., a, 2016, 2017a] . . . . .	121
5.6	Operationalizations proposed by Agon to the analyst during “ <i>Phase 5: Acceptance Requirements Refinement</i> (red Xs are the analyst’s decisions)” [Piras et al., a, 2016, 2017a] . . . . .	121
5.7	Additional elements proposed by Agon to the analyst during “ <i>Phase 5: Acceptance Requirements Refinement</i> ” (the elements circled in green are the additional ones selected now, and the elements circled in orange are the ones chosen previously) [Piras et al., a, 2016, 2017a] . . . . .	123
5.8	Solution proposed by Agon, after reasoning over the gamification model (“ <i>Phase 6: Context-Based Operationalization via Gamification</i> ”), in relation to the Badge gamification concept [Piras et al., a, 2016, 2017a] . . . . .	125
5.9	Example of customization and instantiation of gamification solutions proposed by Agon, performed in “ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”, regarding the Leader-boards gamification concept [Piras et al., a, 2016, 2017a] . . . . .	126
5.10	Example of instantiation and customization of gamification solutions proposed by Agon, performed in “ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”, regarding rewards achieved (badges) after completing a gamified tour [Piras et al., a, 2016, 2017a] . . . . .	127

5.11	Example of instantiation and customization of gamification solutions proposed by Agon, performed in “ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”, concerning Redeemable Points (RP) achievable through Leader-boards [Piras et al., a, 2016, 2017a] . . . . .	128
5.12	Acceptance solution obtained at the conclusion of “ <i>Phase 4: Context-Based Analysis of Acceptance Requirements</i> ”, i.e. the result of Context-Based reasoning over the Acceptance Model and analyst’s decisions [Piras et al., 2016, 2017a] (elements discarded by the reasoning or by the analyst have been removed to have a clear view of the result); Figure available at [Piras et al., a] . . . . .	130
5.13	Solution obtained at the conclusion of “ <i>Phase 5: Acceptance Requirements Refinement</i> ” (elements circled in orange and green are the selected tactics; green ones are the additional tactics chosen in the last part of this phase) [Piras et al., a, 2016, 2017a] . . . . .	131
5.14	Agon-Tool: the prototype that supports the usage of Agon and its method	132
5.15	Architecture of the Agon-Tool Java web application . . . . .	133
5.16	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 1: Base System Requirements</i> ” [Piras et al., a, 2016, 2017a] . . . . .	135
5.17	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 2: Acceptance Requirements Elicitation and Analysis (first part: guidelines)</i> ” [Piras et al., a, 2016, 2017a] . . . . .	137
5.18	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 2: Acceptance Requirements Elicitation and Analysis (second part: functions selection)</i> ” [Piras et al., a, 2016, 2017a] . . . . .	138
5.19	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 3: Context Characterization</i> ” [Piras et al., a, 2016, 2017a] . . . . .	139
5.20	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 4: Context-Based Analysis of Acceptance Requirements</i> ” [Piras et al., a, 2016, 2017a] . . . . .	140
5.21	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 5: Acceptance Requirements Refinement (part “a”: selection of tactics)</i> ” [Piras et al., a, 2016, 2017a] . . . . .	142
5.22	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 5: Acceptance Requirements Refinement (part “b”: selection of additional tactics)</i> ” [Piras et al., a, 2016, 2017a] . . . . .	143

5.23	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 6: Context-Based Operationalization via Gamification</i> ” [Piras et al., a, 2016, 2017a]	145
5.24	Support provided by the Agon-Tool to the requirements analyst in “ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ” [Piras et al., a, 2016, 2017a]	147
6.1	Example of elements suggested by Agon during “ <i>Phase 4: Context-Based Analysis of Acceptance Requirements</i> ” [Piras et al., a]	153
6.2	Example of analyst’s decisions on elements suggested by Agon during “ <i>Phase 4: Context-Based Analysis of Acceptance Requirements</i> ”, related to keeping the <b>Improve Perceived Ease of Use</b> need [Piras et al., a]	154
6.3	Example of analyst’s decisions (represented by red Xs) on elements suggested by Agon during “ <i>Phase 4: Context-Based Analysis of Acceptance Requirements</i> ”, related to discarding the <b>Improve Ease of Use</b> need [Piras et al., a]	154
6.4	Elements proposed by Agon to the analyst during “ <i>Phase 5: Acceptance Requirements Refinement</i> ” and analyst’s decisions as red Xs [Piras et al., a]	155
6.5	Operationalizations proposed by Agon to the analyst during “ <i>Phase 5: Acceptance Requirements Refinement</i> (red Xs are the analyst’s decisions)” [Piras et al., a]	156
6.6	Additional elements proposed by Agon to the analyst during “ <i>Phase 5: Acceptance Requirements Refinement</i> ” (the elements circled in green are the additional ones selected now, and the elements circled in orange are the ones chosen previously) [Piras et al., a]	157
6.7	Solution proposed by Agon, after reasoning over the gamification model (“ <i>Phase 6: Context-Based Operationalization via Gamification</i> ”), in relation to the kinds of user roles to use in the gamification design [Piras et al., a, 2017b]	158
6.8	Example of decision taken by the analyst, regarding the Leader-boards gamification concept, over solutions proposed by Agon after reasoning over the gamification model (“ <i>Phase 6: Context-Based Operationalization via Gamification</i> ”) [Piras et al., a]	159

6.9	Example of customization and instantiation of gamification solutions proposed by Agon, performed in “ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”, regarding the Path gamification concept [Piras et al., a, 2017b]	159
6.10	Example of customization and instantiation of gamification solutions proposed by Agon, performed in “ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”, regarding Levels of the PACAS Challenge Proposer Path (also called Challenger Path) [Piras et al., a, 2017b]	160
6.11	Some of the gamification elements implemented in the PACAS platform according to the Agon solution [Piras et al., 2017b]	163
6.12	Pillars of the PACAS platform and some of the gamification elements implemented in the PACAS platform according to the Agon solution [Paja et al., 2018, Piras et al., 2017b]	164
6.13	Customization and instantiation of gamification solutions proposed by Agon, performed in “ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”, regarding the Path gamification concept [Piras et al., a, 2017b]	167
6.14	Sequence diagram showing the gamification mechanism of challenges implemented in the PACAS platform [Piras et al., 2017b]	168
6.15	The high-level part of the instantiation of rules specifying conditions for progressing in the <b>Challenge Proposer Path</b> through the <i>Challenges</i> gamification concept (“ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”) [Piras et al., a, 2017b]	171
6.16	The high-level part of the instantiation of rules specifying conditions for progressing in the <b>Challenge Proposer Path</b> through the <i>Challenges</i> gamification concept (“ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”); specifically, this instantiate the rules for the <i>Novice Levels</i> [Piras et al., a, 2017b]	172
6.17	The high-level part of the instantiation of rules specifying conditions for progressing in the <b>Challenge Proposer Path</b> through the <i>Challenges</i> gamification concept (“ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”); specifically, this instantiate the rules for the <i>Intermediate Levels</i> [Piras et al., a, 2017b]	173

6.18	The high-level part of the instantiation of rules specifying conditions for progressing in the <b>Challenge Proposer Path</b> through the <i>Challenges</i> gamification concept (“ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”); specifically, this instantiate the rules for the <i>Expert Levels</i> [Piras et al., a, 2017b] . . . . .	174
6.19	The high-level part of the instantiation of rules specifying conditions for progressing in the <b>Challenge Proposer Path</b> through the <i>Challenges</i> gamification concept (“ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”); specifically, this instantiate the rules for the <i>Master Levels</i> [Piras et al., a, 2017b] . . . . .	175
6.20	The high-level part of the instantiation of rules specifying conditions for progressing in the <b>Challenge Proposer Path</b> through the <i>Challenges</i> gamification concept (“ <i>Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms</i> ”); specifically, this instantiate the rules for the <i>Guru Levels</i> [Piras et al., a, 2017b] . . . . .	176
6.21	The screen that is shown after the first time login in the gamified PACAS platform, and the PACAS <i>Co-Pilot</i> (the <b>Avatar</b> gamification concept) [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] . . . . .	184
6.22	The <i>Co-Pilot</i> (the <b>Avatar</b> gamification concept) of the gamified PACAS platform guiding the user in managing invitations [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] . . . . .	185
6.23	The <i>Co-Pilot</i> (the <b>Avatar</b> gamification concept) of the gamified PACAS platform and the STS-ML Editor (one of the modeling editors of PACAS) [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] . . . . .	187
6.24	The <i>Co-Pilot</i> (the <b>Avatar</b> gamification concept) of the gamified PACAS platform showing to the user her game results, and guiding her concerning how to progress in the game [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] . . . . .	188
6.25	The <i>Co-Pilot</i> (the <b>Avatar</b> gamification concept) of the gamified PACAS platform showing achieved results, and rewarding the user [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] . . . . .	189
6.26	<b>Gamified Tutorials</b> of the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] . . . . .	189
6.27	A <b>Gamified Tour</b> in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] . . . . .	190

6.28	Gamified Paths, Levels, Badges and Leader-boards of the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]	191
6.29	Button for throwing <b>Gamified Challenges</b> , in the top right corner of the screen, in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]	193
6.30	Form for throwing a <b>Gamified Challenge</b> in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]	193
6.31	Page of the <b>Gamified Challenges</b> in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]	194
6.32	Dialog for voting a <b>Gamified Challenges</b> in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]	195
7.1	Answers scale of the semi-structured questionnaires related to the experiments/case studies (Table 1.1 and Table 7.2) of this thesis	220
8.1	The big picture including graphical representations of ongoing, future work and future lines of research that could be started on the basis of this thesis	252
8.2	Screenshot of the big picture focusing on the Agon Meta-Model Evolution	253
8.3	Screenshot of the big picture focusing on the Agon Method Evolution	255
8.4	Context variables relevant for the acceptance and gamification requirements analysis and design [Piras et al., 2017a]	262
8.5	The Motivational Antecedents Framework and its context variables [Piras et al., 2017a]	265
8.6	Motivational Antecedents Framework and its elements highlighted (in bold) for this study [Piras et al., 2017a]	268
8.7	Comparison of the context variables of the two frameworks [Piras et al., 2017a]	271
8.8	Screenshot of the big picture focusing on future lines of research for making Agon a Full Stack Framework and an Adaptive Framework	285
8.9	Screenshot of the big picture focusing on future lines of research for integrating Agon with other Frameworks and Methodologies coming from other fields	287
8.10	Operationalizations of acceptance requirements related to future lines of research	288



# Chapter 1

## Introduction

The success of software systems highly depends on the user engagement. Thus, to deliver engaging systems, software has to be designed carefully taking into account *Acceptance Requirements* [Piras et al., 2017b] such as “70% of users will use the system” [Piras et al., 2016], and the psychological factors that could influence users to use the system [Piras et al., 2017a]. Analysis can then consider mechanisms that affect these factors, such as *Gamification* (making a game out of system use) [Piras et al., 2017a,b], advertising, incentives and more [Piras et al., 2016].

In this thesis, we propose a *Systematic Acceptance Requirements Analysis Framework* based on *Gamification* for supporting the requirements engineer in analyzing and designing engaging software systems [Piras et al., 2016, 2017a,b]. Our framework, named *Agon* [Piras et al., 2016], encompasses both a method [Piras et al., 2017a] and a meta-model [Piras et al., 2017b] capturing acceptance and gamification knowledge.

The rest of this chapter is structured as follows. Section 1.1 discusses Software Acceptance Analysis and Gamification Engineering. Section 1.2 states our research objective, presents related research questions and challenges. Section 1.3 outlines our research approach, adopted to address research questions, by highlighting our contributions and research methods used. Section 1.4 provides an overview of our research. Section 1.5 illustrates the structure of this thesis. Section 1.6 concludes listing the publications this research has produced.

### 1.1 Acceptance Analysis and Gamification Engineering

In this section, we start introducing *Acceptance Analysis* and, then, we outline *Gamification Engineering*. We highlight main challenges, best practices and correlations among

acceptance and gamification. Finally, we conclude with a real example of a successful app designed considering both acceptance and gamification concepts.

### 1.1.1 Acceptance Analysis

Usage is becoming the main factor that determines the success of a software system [Hamari et al., 2014, Pedreira et al., 2015, Zichermann and Cunningham, 2011], especially so for social software such as Twitter and Facebook. In fact, the human aspect has to be deeply taken into account and addressed by building into a system strategies for stimulating the user to carry out activities that the system supports. For instance, if we consider Facebook, its success resides mainly on people’s participation in platform activities. In fact, if people stop posting videos, comments, etc., the entire system would be deemed a failure. Thus, to guarantee the success of such a system, it is essential that users use functions of the system [Pedreira et al., 2015, Zichermann and Cunningham, 2011]. According to this, in order to maximize the usage and participation, favoring the success of a system, it is important to analyze and design a system considering also requirements for engaging the user [Zichermann and Cunningham, 2011]. Such requirements deal with acceptance aspects [Davis et al., 1989, Hamari et al., 2014, Venkatesh and Davis, 2000, Venkatesh et al., 2003], and, thus, we can call them *Acceptance Requirements*.

*Acceptance Requirements* and how to fulfill them have been receiving much attention in the literature [Deterding et al., 2011, Hamari, 2015, Koivisto and Hamari, 2014b, Sakamoto et al., 2014, Schell, 2014, Zichermann and Cunningham, 2011]. Fulfilling such requirements calls for expertise such as the one of psychologists, sociologists or marketing experts [Zichermann and Cunningham, 2011], and this makes the design process even more complex, error-prone and time-consuming than for vanilla software. Unfortunately, few requirements engineering studies and practices consider adequately such strategical concerns [Deterding et al., 2011, Hamari et al., 2014, Zichermann and Cunningham, 2011].

Therefore, to tackle these difficult acceptance requirements problems, we need tool supported methods for carrying out the related complex analysis, i.e. *Acceptance Analysis*. These methods should help the analyst to consider systematically as many as possible aspects belonging to the vast space of acceptance concepts, to individuate more easily and precisely the most appropriate techniques (operationalizations) for fulfilling the acceptance concepts selected. Specifically, we need tool supported methods able to:

1. guide the analyst in properly and accurately analyzing and eliciting *Acceptance Requirements*;
2. support in finding and designing operationalization (e.g., *Gamification*) solutions;

3. provide suggestions concerning which acceptance (e.g., psychological) strategies and operationalization (e.g., gamification) best practices to employ, on the basis of supporting knowledge bases (e.g., acceptance and gamification knowledge conceptualized and modeled as meta-models); an example is: suggestions obtained by taking into account the typologies of users the analyst has to engage;
4. reason on acceptance knowledge bases (e.g., represented as conceptual models, as mentioned in the previous point) to supply the analyst with proper suggestions.

### 1.1.2 Gamification Engineering

*Gamification* is a design technique that makes a game out of using a software system in order to enhance user experience thereby encouraging its user acceptance. Over the last decade, gamification has been drawing growing interest among scholars and practitioners in many fields Hamari et al. [2014]. Indeed, gamification has been considered as a useful tool to enhance participation, social interaction, motivation and performance when certain software-intensive activities and tasks are carried on. As such, gamification has been applied widely to many heterogeneous fields, among others collaborative activities Simperl et al. [2013], education Kapp [2012], urban mobility Kazhamiakin et al. [2015] and software engineering Pedreira et al. [2015].

Most of the successful gamification solutions [Hamari et al., 2014, Pedreira et al., 2015] offer users a gamified experience, typically by using mobile and web applications or, in some cases, also through other IT technologies Sakamoto et al. [2014]. Thus, building a gamification solution means to carry on a complete software engineering process delivering a gamified software solution. In general, such software engineering needs complex, difficult and error-prone activities requiring specialized expertise, beyond what is expected by the average software engineer.

Furthermore, the potential success, which could be achieved from the application of gamification to a software system, strictly depends on the accuracy of the gamification design and analysis performed [Hamari et al., 2014, Zichermann and Cunningham, 2011]. In fact, it is crucial to consider many aspects, some relevant examples are: **(i)** which are the users to be engaged, their characteristics, needs, interests and desires, **(ii)** which are the most suitable game concepts and strategies able to stimulate a specific kind of user, and **(iii)** how to amalgamate all these variegated elements together obtaining an effective gamification design. Today's practices for designing gamification software rely heavily on the expertise and creativity of designers [Schell, 2014, Zichermann and Cunningham, 2011].

As a result, many gamification attempts fail due to the lack of systematic approaches and supporting tools able to provide [Pedreira et al., 2015, Zichermann and Cunningham, 2011]: **(i)** the multidisciplinary knowledge required to consider and analyze most of the relevant aspects; **(ii)** an adequate support to reason over the vast space of available heterogeneous game elements and mechanics fulfilling the aspects; **(iii)** an adequate support for finding strategies able to put all these elements together in a homogeneous, engaging and operating gamification design.

Therefore, in order to overcome these problems, an increasing amount of studies regarding *Gamification Engineering* have been proposed Herzig et al. [2012, 2013], Kazhamiakin et al. [2015], Matallaoui et al. [2015], Monterrat et al. [2014], Piras et al. [2016, 2017a,b], Sripada et al. [2016], aiming to improve the gamification process, making it more systematic. For instance, *Gamification Frameworks* help in making it more systematic and reducing the workload required, thus, a huge effort has been undertaken to develop those frameworks Herzig et al. [2012, 2013], Kazhamiakin et al. [2015], Matallaoui et al. [2015], Monterrat et al. [2014], Piras et al. [2016, 2017a,b], Sripada et al. [2016] (we discuss Gamification Engineering and frameworks, more in detail, in Chapter 2).

**Definition 1.1 (Gamification Engineering).** *Gamification Engineering is the Software Engineering of Gamification [Piras et al., 2017a].*

**Definition 1.2 (Gamification Framework).** *A Gamification Framework is a software system that supports the analyst/designer/developer during software engineering activities (e.g., analysis, design, development) by applying gamification to a system and by offering well-established gamification procedures and ready-to-use tools [Piras et al., 2017a]. Gamification Frameworks in the literature are also called platforms, engines or systems [Piras et al., 2017a].*

An important criterion for the success of a software system consists of measuring the degree of acceptance of the system by its intended user community. Thus, *Requirements Engineering* (RE) and, above all, the elicitation and analysis of user requirements and acceptance requirements are key phases towards the creation of a gamified software Lombroser et al. [2016] aimed at involving and motivating users. In fact, right from the early phases of gamification engineering, it is fundamental to conduct an accurate and extensive analysis concerning the most important variables needed to design a successful gamification solution. According to the literature, this is not systematically done by practitioners, resulting in less accepted software than what its owners had hoped for [Deterding et al., 2011, Zichermann and Cunningham, 2011]. Gamification fails when people are not engaged and it is directly correlated to the fact that *human factors* are not adequately considered

in the gamification process and, above all, during the crucial phase of RE analysis. In fact, most of the important variables, to take into account during such analysis, concern *Human Behavior* and related context [Deterding et al., 2011, Zichermann and Cunningham, 2011]. Practitioners tend to use available gamification guidelines and resources, which are provided in commercial platforms or in publicly available wikis<sup>1</sup>. However, research literature on gamification design and on the evaluation of the effectiveness of the resulting solutions, points out the limits of current practices, identifies key concepts and discuss the need of specific methods to design engaging software, e.g. [Hamari, 2015, Koivisto and Hamari, 2014b]. In particular, systematic methodologies should guide designers in the exploration of a design space of alternatives. Such a design space is defined in terms of motivational, psychological, cognitive, behavioral factors that influence the fulfillment of *Acceptance Requirements*.

In summary, in order to produce an extensive high-quality gamification solution from acceptance requirements, the following activities need to be conducted:

1. analysis and characterization of context variables;
2. analysis, selection of psychological/cognitive strategies for stakeholder acceptance requirements;
3. analysis and design of gamification best practices for the problem-at-hand.

In the scientific literature and in the software development market, before producing the research results of this thesis, there were the important gaps, discussed before, regarding the existence of tool supported methods for helping and driving the analyst in systematically applying gamification during the RE process.

### 1.1.3 A Successful Example of Acceptance and Gamification Engineering

A noteworthy real example, from the industry, of a successful game, a mobile app, including intriguing game elements and mechanisms, designed considering both software acceptance and gamification techniques, is Pokémon GO<sup>2</sup>. In the last few years, Pokémon GO has become very popular counting millions of users per day. This huge success resides on the fact that its gamification design is based on accurate analysis of players and related psychological factors [Piras et al., b]. In a nutshell, Pokémon GO is an application based on the usage of the own smartphone, it envisages the capture of pokémons (by following

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<sup>1</sup>[https://en.wikipedia.org/wiki/Game\\_mechanics](https://en.wikipedia.org/wiki/Game_mechanics)

<sup>2</sup><https://www.pokemongo.com/>

them through geo-localized immersive virtual reality), their training, improvements of the game experience through in-app purchases of special elements, the competition against other players with challenges or the interaction with them in a collaborative way.

Concerning acceptance and gamification aspects, creators of Pokémon GO have put together different game elements and, above all, a set of varied psychological and cognitive techniques that adapt to different types of players, and in doing so they have defined a game experience that is appealing to a very wide audience [Piras et al., b]. For example, people who like socializing love the cooperation aspect of the game to catch or train Pokémons. Those who like challenges appreciate the fact that you can compete with others, and find out who catches more. Moreover, Pokémon GO is becoming a cultural phenomenon with different advantages and disadvantages [Piras et al., b]. Looking for Pokémon can reduce idleness and make people want to go out and socialize with other players, actually hunting for Pokémon requires long walks in the open. To increase the revenue of tourist locations, Pokémon are concentrated in interesting places in city centers, turning the hunt into a cultural tour. Among the side-effects of the phenomenon, some people were hit by cars while playing the game, and Pokémon GO players stormed restricted access areas in hospitals because very rare Pokémons were there. For this reason, some countries are considering regulations on Pokémon GO [Piras et al., b]. Some of these advantages and disadvantages can be considered also as by-products.

## 1.2 Research Questions and Challenges

On the basis of the gaps in the literature and the challenges concerning acceptance analysis and gamification engineering, expressed in the previous sections, in the following, we define our high-level research objective.

**Research Objective:** *to support the requirements analyst in a Systematic Requirements Analysis for designing Engaging Software Systems.*

We fulfilled our high-level research objective by answering to the next low-level research questions. In the following, we discuss them and also related challenges of this thesis.

**RQ1. Which are the factors and strategies that positively affect software users by stimulating them to use software?**

When we refer to factors and strategies for stimulating the user towards the “software usage”, we mean that we are interested in such mechanisms that could be considered in

order to make the software features more appealing and interesting for the user. Those mechanisms can come from very far fields, and are able to spur the user to accept to use a system through the employment of heterogeneous elements, for instance by: **(i)** inducing the user to feel some particular emotions such as fun, satisfaction, trust, altruism, self-esteem, etc., **(ii)** using tangible and/or virtual incentives of, for example, monetary, social nature, **(iii)** showing the user other achievements, correlated to the usage of the system, that can lead to, e.g., career progression, social status affirmation, etc.

Therefore, it is important to highlight that, for answering this research question, and in general relatively to this aspect of our research, we do not intend to define particular boundaries, but we are open to consider any kind of theory, coming from any field, able to address the considerations above. Thus, inline with this reflection and to the discussion provided in the previous sections, for stimulating users it is necessary to analyze many aspects related to acceptance (e.g., psychological, cognitive, behavioral aspects) and select strategies to employ for operationalizing a concrete solution (e.g., a solution based on serious games, game metaphors, tangible incentives, gamification, etc.).

Thus, to address this RQ, it is necessary to conduct a wide review of the literature, in a very interdisciplinary way, with the aim of identifying the most important candidate factors and strategies. Furthermore, such candidates, due to the fact that come from fields (e.g., psychology, sociology, cognitive and behavioral sciences, etc.) dealing with very abstract concepts, need to be operationalized through further more concrete techniques at a lower level of abstraction. Therefore, it is necessary also to carry out a further complex review aiming at finding concrete solutions and techniques, based on the more abstract concepts, able to operationalize high-level candidates.

**RQ2. How can we model the knowledge of RQ1, in a interoperable and homogeneous way, for designing a comprehensive - *interdisciplinary, interoperable, context-dependent, generic and extensible* - model for enabling a framework/tool to support the analyst?**

After identifying Acceptance and operationalizations (**RQ1**) as candidates for fulfilling the high-level research objective of this thesis, in order to leverage this complex knowledge for supporting the requirements analyst, it is needed to model such knowledge in a *interdisciplinary, interoperable, context-dependent, generic and extensible* model. Specifically, due to the characteristics of the knowledge and its different levels of abstractions, this will be a meta-model. After modeling such knowledge, the model can be leveraged, to support the analyst, by performing over it reasoning for providing the analyst with precise suggestions and solutions (objectives of the next RQs).

To model the *interdisciplinarity* of the meta-model, and, at the same time, to create homogeneity for guaranteeing *interoperability* in such model, it is a very complex challenge due to the different nature and abstraction of the acceptance solutions and operationalizations to deal with. In order to achieve this, it is required to tackle two complex intra-challenges and one even harder inter-challenge. The intra-challenges need respectively to:

1. model psychological, cognitive, behavioral factors and strategies in an Acceptance Model;
2. model operationalization concepts, strategies, guidelines and best practices in an Operationalization Model.

While, the even more complex inter-challenge requires to understand how to connect, create a bridge, among the two far worlds of acceptance and operationalization solutions. In fact, them stand at different abstraction layers, namely Acceptance is at a very high-level, and the other, being an operationalization of acceptance, is at a lower level being composed of more operative concepts and mechanisms. Thus, it is necessary to identify common concepts, at an intermediate abstraction level among the two, that, on the one hand, can refine acceptance concepts and, on the other hand, can be operationalized by low-level concepts.

Moreover, it is needed to design the meta-model as *context-dependent*. This is because, to select the most suitable acceptance and operationalization strategies to employ for improving a system, with the final aim of engaging users, it is required to consider the context (e.g., the typology of the user, factors concerning the software usage, social factors, external factors, etc.). In fact, it is important to design the meta-model enabling it to cover also those crucial aspects, for making it able to highlight the most appropriate solutions for a specific context, on which to perform reasoning for providing the analyst with proper suggestions and solutions (objectives of the next RQs).

In relation to the other characteristics of the meta-model, the *generality* aspect is important for guaranteeing the possibility to employ the model successfully in as many as possible heterogeneous cases. In fact, a framework, leveraging this model, should support successfully the requirements analyst in the analysis and design of engaging software systems within heterogeneous domains.

The *extensibility* is necessary to be able to make the meta-model evolve to be compliant with the newest physiological changes (typical of fields strictly dependent on Human Sciences as Acceptance and related operationalizations) coming from discoveries of new acceptance theories (e.g., psychological theories) and operationalization strategies, to keep

the model updated and, thus, effective. This is valid also for extending the model in the future, by including factors, concepts and strategies coming from other fields, new emerging fields, having alternative solutions, that can contribute to the user engagement.

**RQ3. How can we design a systematic method, and a tool, for analyzing fundamental factors and strategies, for enabling a framework to support the analyst in analyzing and specifying engaging software systems?**

The answer for **RQ2** could produce a comprehensive acceptance meta-model including acceptance operationalizations. It could be the core part of a valuable framework supporting the requirements analyst. In fact, such meta-model could represent knowledge concerning acceptance, operationalization solutions and related best practices and different alternatives, based on the specific context, necessary for analyzing and designing engaging software system. Referring to the analysis and specification of engaging software, we aim to include, in our modeled knowledge, as many as possible relevant theories and practices coming even from very far and heterogeneous fields. However, our final aim is not to be exhaustive, by including in the knowledge all the possible results from all the possible fields, but, rather, to provide an infrastructure and a framework able to put together the selected heterogeneous elements in a homogeneous way for supporting the analyst. As a result, starting from this stable, reusable and useful infrastructure, it will be possible, as a future research, to include new theories, coming from other fields, not originally included in the design. Accordingly, the method to be designed, objective of this RQ, has to support the analyst with mechanisms able to consider systematically the broad, even limited, knowledge, made of heterogeneous elements, for suggesting the most suitable solutions, given a certain context, to the analyst. Furthermore, suggestions and solutions produced will be composed of engaging elements, coming from theories and practices included in the knowledge modeled (i.e. the knowledge modeled by answering to **RQ2**).

Therefore, in order to take advantage of the meta-model and of all its peculiarities, for performing a systematic analysis, by considering and navigating the different complex interdisciplinary abstraction layers of the meta-model, it is necessary to design a *supporting, guiding* method. In particular, a method able to provide *guidance*, and *suggestions*, to the analyst in *analyzing systematically*, through well-defined steps, the wide space of acceptance and operationalization alternatives. Moreover, a method that performs this in a *semi-automatic, interactive way*, where, at each step the analyst:

- receives automatically - through reasoning over the meta-model - the most suitable solutions as suggestions, for the current abstraction level and the context specified

by the analyst;

- can interactively consider those suggestions and take further decisions;
- can continue with the next step, or come back to the previous ones for revising some decisions.

Thus, the main challenges, tied to this RQ, are: **(i)** to design a systematic method for acceptance analysis able to guide the requirements analyst in considering systematically the most relevant aspects, and to suggest the most suitable strategies at different level of abstraction, starting from acceptance towards more concrete operationalization solutions; **(ii)** to integrate and develop such method in a tool-supported framework, able to guide the analyst in all the phases, supporting the analyst, by reasoning over the meta-model, for providing her with the most appropriate solutions for the specific user and context.

**RQ4. Can a framework and its method, derived by answering previous RQs, support the requirements analyst in analyzing and specifying engaging software systems in real and realistic settings?**

The act of addressing the previous RQs could produce the design of **(i)** a meta-model enclosing knowledge related to acceptance and acceptance operationalizations (**RQ1**, **RQ2**), **(ii)** a method for taking advantage of this model (**RQ3**), and **(iii)** a tool for semi-automatizing and simplifying the usage of a framework supporting the method (**RQ3**). Afterwards, within this RQ, such elements have to be employed in real and realistic settings for analyzing and specifying engaging software systems, with the aim of demonstrating their support and usefulness offered to the requirements analyst.

As deeply explained in **RQ3**, with the specification of engaging software, we mean a specification composed of a vast, but limited, set of solutions, suggested by a framework through reasoning over a knowledge model. Solutions are limited because bounded to the elements included in a broad, but not exhaustive, knowledge model made of concepts coming from heterogeneous fields. Such fields are numerous, in fact, there are many promising candidates. However, the aim of our research is, not to design a completely exhaustive model, but to model and employ a feasible set of concepts, coming from a selection of fields, allowing us to demonstrate that a model and a framework, designed on the basis of them, are the proof of concept that such framework, by using such model, is able to support the requirements analyst in these particular kinds of software engineering activities. With this, we do not exclude that, on top of such valuable framework and its model, interesting future works could aim at enlarging the model by including new

concepts, coming from other fields, for enabling the analyst to take into account even more alternatives. Therefore, the main contributions of this thesis will be the meta-model, the framework and the method taking advantage of the model, for supporting the analyst. Accordingly, this RQ requires exactly to collect, from the requirements analyst's perspective, evidences regarding the support and usefulness supplied by such elements. Thus, to address this RQ, it is needed to perform different research activities for evaluating if the requirements analyst, in the employment of such a framework for analyzing and specifying engaging software systems, recognizes to:

- be effectively guided in a systematic analysis;
- be supported in analyzing the system and understanding which are the most critical functions that require to be improved for stimulating the user to use the software;
- be supported in characterizing the user regarding most important aspects that help to understand which acceptance and operationalization strategies to employ;
- receive well-structured solutions and useful suggestions;
- find the most suitable solutions among the wide space of acceptance and operationalization alternatives;
- be further inspired by those suggestions (much more than not using the framework);
- receive suggestions fitting the kind of user to be motivated.

The previous ones are some of the important points to be evaluated, all the points are discussed in the next chapters of this thesis. In summary, to address this RQ, it is necessary to perform evaluation activities, in real and realistic settings, for making software systems more engaging, and to evaluate the usefulness of the framework for the requirements analyst. For instance, valuable settings to consider regard case studies, for making software systems more appealing, in the context of European projects and master courses, involving requirements analysts at different levels of expertise (e.g., experts and master students).

Moreover, thanks to those settings, and in case of receiving positive evaluation from the analysts involved and by observing them, **RQ4** can be addressed, and it is also possible to further confirm to have collected (**RQ1**) and modeled correctly, in a homogeneous, interoperable way, the interdisciplinarity of the concepts involved in a useful model (**RQ2**). Analogously, it is also possible to collect evidences on the generality (**RQ2**) and usefulness

of the meta-model, and of the approach (**RQ3**), if it is employed successfully, effectively, and in a flexible way, in heterogeneous cases and domains (**RQ2**, **RQ3**). Furthermore, evaluating such a framework in heterogeneous cases, implies also the possibility to test it with different contexts, for confirming the possibility that, using the method, the meta-model and its context-dependent elements, the framework can perform reasoning and provide valuable and precise suggestions for the specific context (**RQ3**), by selecting appropriate solutions from the wide space of alternatives (**RQ2**).

### 1.3 Research Approach and Contributions

We fulfilled our high-level research objective (**Research Objective:** *to support the requirements analyst in a Systematic Requirements Analysis for designing Engaging Software Systems.*) by answering to the RQs expressed before. In the following, we discuss our research approach, and how we addressed the RQs by highlighting also the contributions of this thesis.

Concerning **RQ1 (Which are the factors and strategies that positively affect software users by stimulating them to use software?)**, according to the discussion in the previous sections, for stimulating users it is necessary to analyze many aspects related to acceptance (e.g., psychological, cognitive, behavioral aspects) and select strategies to employ for operationalizing a concrete solution (e.g., a solution based on serious games, game metaphors, tangible incentives, gamification, etc.). Thus, to address **RQ1**, we conducted a wide review of the literature confirming that most of the relevant candidate factors and strategies come from the acceptance field [Piras et al., 2016, 2017b] (Chapter 2, 4, 8). Furthermore, there exist different acceptance operationalizations, i.e. the ones listed above, and we decided to focus on gamification within this thesis [Piras et al., 2016, 2017a].

Moreover, in order to model acceptance and gamification concepts for addressing **RQ2 (How can we model the knowledge of RQ1, in a interoperable and homogeneous way, for designing a comprehensive - *interdisciplinary, interoperable, context-dependent, generic* and *extensible* - model for enabling a framework/tool to support the analyst?)**, we analyzed case studies from the literature and success cases from the industry (Chapter 2), and personally carried out experiences [Kazhamiakin et al., 2015, Piras et al., 2015, Wohlin et al., 2012] on gamifying software systems such as a gamification experiment [Kazhamiakin et al., 2015, Wohlin et al., 2012] (Chapter 3), conducted with explanatory quantitative research methods [Kazhami-

akin et al., 2015, Wohlin et al., 2012], and a preliminary theoretical study [Piras et al., 2015, Wohlin et al., 2012], conducted with preliminary exploratory qualitative research methods [Piras et al., 2015, Wohlin et al., 2012] (Chapter 3). On the one hand, these experiences helped us to understand in practice what really means to gamify a software system, which are the related challenges, difficulties of the process, the knowledge and skills required [Kazhamiakin et al., 2015, Piras et al., 2015], and factors, concepts and strategies to consider, to select and to employ [Piras et al., 2016, 2017a,b]. On the other hand, the literature review helped us to collect and formalize the broad knowledge regarding acceptance and gamification [Piras et al., 2016, 2017b]. On the basis of those elements, we have been able to define the requirements of a framework for the analysis and the design of engaging software (Chapter 3), and to design, accordingly, our framework by modeling the knowledge and developing a systematic method that leverages on such knowledge model [Piras et al., 2016, 2017a,b].

Thus, answering **RQ1**, we identified Acceptance and Gamification as candidates for fulfilling the high-level research objective of this thesis, and, for addressing **RQ2**, we designed a meta-model based on the concepts behind those candidates [Piras et al., 2017b]. Specifically, it has been needed to model the related knowledge in a *interdisciplinary*, *interoperable*, *context-dependent*, *generic* and *extensible* meta-model [Piras et al., 2017b] (Chapter 4, 8), in order to obtain a model on which to perform reasoning for providing the analyst with a support made of suggestions and ready-to-use solutions [Piras et al., 2016, 2017a,b] (objectives of the other RQs).

Given the different nature of the solutions selected, i.e. Acceptance and Gamification, we had to tackle and found solutions for the complex intra-challenges and inter-challenges, described in the preceding Section, related to modeling the *interdisciplinarity* of the meta-model, and, at the same time, creating homogeneity for guaranteeing *interoperability* in such model [Piras et al., 2017a,b]. To overcome the intra-challenges we designed two models, i.e. the Acceptance Model and the Gamification Model. Specifically, we modeled psychological, cognitive, behavioral factors and strategies into an Acceptance Model (Chapter 4), and gamification concepts, strategies, guidelines and best practices in a Gamification Model (Chapter 4). In parallel, we had to find ways for connecting, creating a bridge among, the two far worlds of acceptance and gamification for overcoming the related inter-challenge [Piras et al., 2017a,b]. The problem is due to the fact that them stand at different abstraction layers [Piras et al., 2017b]. In fact, Acceptance is at a very high-level, and gamification, being an operationalization of acceptance (aspect discovered by us answering **RQ1**), is at a lower level being composed of game concepts and mechanisms. We were able to solve this dilemma by identifying common concepts, at

an intermediate abstraction level among Acceptance and Gamification [Piras et al., 2016, 2017a,b], that, on the one hand, can refine acceptance concepts and, on the other hand, can be operationalized by gamification concepts. We modeled those intermediate concepts in the Tactical Model [Piras et al., 2016, 2017b] (Chapter 4).

Furthermore, we designed our meta-model also to be *context-dependent* [Piras et al., 2016, 2017b]. This is a crucial point, because in order to select which acceptance and gamification strategies to employ for gamifying a system, with the final aim of engaging users, it is required to consider the context [Piras et al., 2017a] (e.g., the typology of the user, factors concerning the software usage, social factors, external factors, etc.). For this purpose, answering **RQ1**, we collected the most important variables to take into account for motivating the user, and modeled them in the User Context Model of Agon (Chapter 4, 8). This model is composed of characterization variables such as user personal data (e.g., age, gender, etc.), her kind of player (e.g., socializer, achiever, explorer, etc.), the goal to achieve and the task to carry out by using the software, the social context where she will use the software [Piras et al., 2017a], etc. On the basis of different instantiations of these variables, different acceptance and gamification solutions have to be considered, because different users (with different life contexts, digital contexts and personal characteristics) are stimulated by different strategies. Therefore, we modeled this knowledge with the User Context Model, and, above all, with annotations, regarding variables of this model, specified over the elements of the other models of Agon, i.e. acceptance, tactical and gamification meta-models [Piras et al., 2017b] (Chapter 4, 8). This contributed to design a complete meta-model [Piras et al., 2017b], able to consider also those crucial aspects for selecting most appropriate solutions for the specific context, on which to perform reasoning for providing the analyst with proper suggestions and solutions [Piras et al., 2016, 2017a] (objectives of the other RQs).

Moreover, it is important to guarantee the possibility to employ the Agon Meta-Model successfully in as many as possible heterogeneous cases, domains, for analyzing and gamifying related software systems [Piras et al., 2017b]. Therefore, we modeled it also to fulfill the *generality* concept required by **RQ2**. Accordingly, as discussed more in detail later in this Section, to evaluate the usefulness of Agon in gamifying systems for different problems, we tested Agon in different heterogeneous case studies obtaining positive results [Piras et al., 2016, 2017a,b] (Chapter 5, 6, 7, 8).

The last concept indicated by **RQ2** is the *extensibility* [Piras et al., 2017a]. In the context of Human Sciences such as Acceptance and Gamification, new acceptance theories (e.g., psychological theories) and gamification strategies are continuously proposed [Piras et al., 2017a]. Therefore, we modeled the Agon meta-model to be extensible, to be able to

make it to evolve to be compliant with the newest discoveries, to be updated and, thus, effective [Piras et al., 2017a,b] (Chapter 8). This is valid also for extending the model by including factors, concepts and strategies coming from other fields [Piras et al., 2017a], having alternative solutions, that can contribute to the engagement of the user [Piras et al., 2016] (Chapter 8). We provided general guidelines for extending Agon [Piras et al., 2017a], and individuated also additional concepts from other fields that could further enhance Agon [Piras et al., 2017a] (Chapter 8).

In summary, by addressing **RQ2** we have designed the core part of the Agon framework, i.e. a comprehensive acceptance and gamification meta-model [Piras et al., 2017b], representing acceptance and gamification knowledge, best practices and different alternatives [Piras et al., 2016], based on the specific context, necessary for analyzing and designing engaging software system [Piras et al., 2017a,b].

This meta-model is valuable for supporting the requirements analyst [Piras et al., 2016, 2017a,b], but due to its complexity and vastness, including the numerous concepts and solutions coming from acceptance and gamification [Piras et al., 2017b], in order to support concretely the analyst, it was needed to design a *systematic, supporting, guiding, semi-automatic, interactive* method [Piras et al., 2016, 2017a], addressing **RQ3 (How can we design a systematic method, and a tool, for analyzing fundamental factors and strategies, for enabling a framework to support the analyst in analyzing and specifying engaging software systems?)**. In fact, on top of the Agon meta-model, we designed such method and defined it as: a *Systematic Acceptance Analysis Based on Gamification* [Piras et al., 2016, 2017a,b] (Chapter 4). Furthermore, we implemented it, and the Agon framework, in a software system named *Agon-Tool* (Chapter 5). We performed case studies and experiments (as discussed later in this Section) on Agon and its method, by gamifying systems related to heterogeneous domains, obtaining positive results [Piras et al., 2016, 2017a,b] (Chapter 5, 6, 7, 8).

Specifically, our method can guide and support the analyst in performing a systematic analysis, by considering and navigating the different complex interdisciplinary abstraction layers of the meta-model [Piras et al., 2017b], providing *guidance*, and *suggestions*, to the analyst in *analyzing systematically*, through well-defined activities, the wide space of acceptance and gamification alternatives [Piras et al., 2016, 2017a]. Furthermore, our method is *semi-automatic, interactive* and composed of different phases. During each phase, the analyst receives the most suitable solutions as suggestions [Piras et al., 2017b] (automatically elaborated by Agon through reasoning over the meta-model [Piras et al., 2017a]), for the current abstraction level and the context specified by the analyst [Piras et al., 2016, 2017b]. Moreover, on the basis of those suggestions, the analyst can interac-

tively take further decisions, and either to continue with the next phase, or to come back to the previous ones for revising some decisions [Piras et al., 2016, 2017a]. Furthermore, this highlights that our method is also *flexible* and *iterative* [Piras et al., 2016, 2017a,b].

After concluding most of the activities related to the previous research questions, we had designed [Piras et al., 2016, 2017a,b]:

1. the Agon framework and its meta-model enclosing acceptance and gamification knowledge (**RQ1**, **RQ2**);
2. a method for taking advantage of the Agon framework and its meta-model (**RQ3**);
3. the Agon-Tool for semi-automatizing and simplifying the usage of the Agon framework (**RQ3**).

At this point, all these elements reached an adequate maturity for being employed in real and realistic settings, and, thus, for trying to address **RQ4 (Can a framework and its method, derived by answering previous RQs, support the requirements analyst in analyzing and specifying engaging software systems in real and realistic settings?)**. Thus, we performed different studies for evaluating if the requirements analyst, from her perspective, perceived to receive adequate support and guidance for conducting a systematic acceptance requirements analysis, based on gamification, for designing engaging software systems [Piras et al., 2016, 2017a,b]. With engaging software systems, we mainly refer to systems that depend on the user contribution (i.e. usage of software functions) for fulfilling stakeholders' objectives, and - with the aim of motivating the user to contribute - functions to be used are proposed with a more engaging design, enriched for instance by introducing incentivizing strategies. A powerful example of incentivizing strategy, supported by Agon, is gamification, which offers solutions made of game design mechanisms and concepts. Specifically, for achieving our research objective (**Research Objective:** *to support the requirements analyst in a Systematic Requirements Analysis for designing Engaging Software Systems.*), and for answering to **RQ4**, we performed the evaluation studies in Table 1.1. Furthermore, we formulated also the next 2 hypotheses, related to different kinds of requirements engineers, and investigated both of them in our evaluations:

**H1.** Agon and its method can support *non-experts*;

**H2.** Agon and its method can support *experts*.

Table 1.1: Evaluation activities and research methods [Wohlin et al., 2012] of this thesis

Study	Phase	Eval	Participants / Hypothesis	Scenario	Research Method	Research Activity Kind
1	1	1	Non-Experts / H1	Realistic	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews
2	1	2	Non-Experts / H1	Realistic	Explanatory Qualitative and Quantitative Research	Human-Oriented Experiment + Semi-Structured Questionnaires
3	2	3	Non-Experts / H1	Real	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews + Evaluation Report
4	2	3	Non-Experts / H1	Realistic	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews + Evaluation Report
5	2	3	Non-Experts / H1	Realistic	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews + Evaluation Report
6	2	3	Non-Experts / H1	Real	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews + Evaluation Report
7	2	3	Non-Experts / H1	Real	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews + Evaluation Report
8	3	4	Experts / H2	Real	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews
9	4	5	Users / N.A.	Real	Exploratory Qualitative Research	Case Study + Semi-Structured Interviews + Evaluation Report

In the following, we provide an overview of the evaluation activities [Piras et al., 2016, 2017a,b] and research methods [Wohlin et al., 2012] of this thesis (Table 1.1). While, the related full details can be found in Chapter 7.

Therefore, our main aim has been to understand if (non-experts and experts) requirements engineers, during the analysis and design of engaging software systems, experienced to **(i)** be effectively guided in a systematic analysis; **(ii)** be supported in analyzing the system and understanding which are the most critical functions that require to be gamified for stimulating the user to use the software; **(iii)** be supported in characterizing the user

regarding most important aspects that help to understand which acceptance and gamification strategies to employ; **(iv)** receive well-structured solutions and useful suggestions; **(v)** find the most suitable solutions among the wide space of acceptance and gamification alternatives; **(vi)** be further inspired by those suggestions (much more than not using Agon); **(vii)** receive suggestions fitting the kind of user to be motivated.

Referring to Table 1.1, we conducted 9 evaluation studies [Piras et al., 2016, 2017a,b] distributed in the next phases:

- *Phase 1: Evaluation with Non-Experts in Realistic Cases;*
- *Phase 2: Evaluation with Non-Experts in Heterogeneous Cases;*
- *Phase 3: Evaluation with Experts in a Real Case;*
- *Phase 4: Evaluation with Users in a Real Case.*

In *Phase 1: Evaluation with Non-Experts in Realistic Cases* (Table 1.1), we started investigating on **H1** by involving, as non-experts, 5 computer science Master students from the University of Trento (Italy). We conducted exploratory qualitative research with a preliminary evaluation activity, **Eval1** (Table 1.1), i.e. a case study with a small amount of participants aiming at evaluating the feasibility of the approach [Piras et al., 2016]. We proposed, individually, to design the gamification of a software system, regarding a realistic scenario, and each participant had to gamify it, before without using Agon, and then by using Agon. Afterwards, we interviewed each participant, in a semi-structured way, for understanding their perception concerning their 2 different experiences.

The outcome of this first activity was positive (Chapter 7), we established the potential feasibility and usefulness of Agon [Piras et al., 2016], but, due to the small number of participants, it has been just a preliminary confirmation. Therefore, in this phase, we conducted also explanatory qualitative and quantitative research [Wohlin et al., 2012], performing an experiment, **Eval2** (Table 1.1), with a more representative number of participants. In fact, we involved 21 volunteers (computer science Master students from the University of Trento, Italy) to participate to a human-oriented experiment [Wohlin et al., 2012]. We proposed, individually, to design the gamification of a software system, regarding a realistic scenario, and each participant had to gamify it, before without using Agon, and then by using Agon. Afterwards, we asked them to compile semi-structured questionnaires, for understanding their perception concerning their 2 different experiences. The results of **Eval2** confirmed the preliminary results obtained in **Eval1**, thus, we established **H1** and addressed all the RQs within **H1**.

However, so far, we were able to partially address **RQ2**. Specifically, we do not completely confirmed the *generic* aspect of the Agon meta-model. Thus, we moved to the *Phase 2: Evaluation with Non-Experts in Heterogeneous Cases* (Table 1.1). Before this phase, we had tested Agon over 2 different realistic domains [Piras et al., 2016, 2017a] achieving positive results, so we continued to test Agon in other 5 heterogeneous realistic and real cases (Table 1.1). Especially, we performed 5 case studies, each one related to a different domain, and we refer to all of them with the evaluation activity **Eval3** (Table 1.1). Furthermore, some of the case studies have been conducted within European Projects. We executed exploratory qualitative research [Wohlin et al., 2012] also by using semi-structured interviews and evaluation reports [Wohlin et al., 2012]. We concluded establishing **RQ2** also regarding the *generic* property of the Agon meta-model (further details in Chapter 7).

In *Phase 3: Evaluation with Experts in a Real Case* (Table 1.1), we investigated on **H2**, by employing Agon with experts, in the context of the *Participatory Architectural Change Management in ATM Systems* (PACAS) European project<sup>3</sup> (Chapter 6). We performed the evaluation activity **Eval4** (Table 1.1), by conducting exploratory qualitative research [Wohlin et al., 2012], with a case study in a real scenario [Piras et al., 2017b]. We involved 10 experts in the process of gamifying the PACAS platform, and solutions obtained in the different Agon phases [Piras et al., 2017b] (Chapter 6) have been shared, discussed and implemented with them [Piras et al., 2017b]. During the entire process we interviewed them in a semi-structured way [Wohlin et al., 2012]. Within **Eval4**, we established also **H2** and addressed all the RQs (details in Chapters 6, 7).

In the last phase, *Phase 4: Evaluation with Users in a Real Case* (Table 1.1), we evaluated if the gamification solution [Piras et al., 2017b], designed by using Agon in the preceding phase, and implemented in the PACAS platform, could be appreciated by real users through real usage of the gamified platform [Piras et al., 2017b]. We conducted exploratory qualitative research [Wohlin et al., 2012], in a case study (**Eval5**), within the PACAS<sup>4</sup> EU project, where we involved, in the usage of the PACAS platform, 4 participants, i.e. Advisory Board (AB) members and Air Traffic Management (ATM) experts (ATM is the application domain of PACAS) external to the project, which use in their job similar platforms. Within this case study, we interviewed them, in a semi-structured way, and asked them to write an evaluation report. We collected positive results and feedback from them, mainly concerning the engagement produced by the PACAS platform gamified by Agon [Piras et al., 2017b].

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<sup>3</sup><http://www.pacasproject.eu/>

<sup>4</sup><http://www.pacasproject.eu/>

However, it is important to note that the core evaluation phases of this thesis are *Phase 1: Evaluation with Non-Experts in Realistic Cases*, *Phase 2: Evaluation with Non-Experts in Heterogeneous Cases* and *Phase 3: Evaluation with Experts in a Real Case*. In fact, those have been enough to establish the hypotheses and to address RQs of this thesis, having the aim to evaluate Agon from the perspective of the requirements engineer. Specifically, we investigated principally on analysis and design activities conducted by requirements analysts, and, accordingly, we evaluated if the support received was adequate from the perspective of non-expert and expert analysts. Thus, **Eval5** and *Phase 4: Evaluation with Users in a Real Case* are to be considered as preliminary parts of a broader future work, we already started. This future work will investigate on the next level of evaluation, centered on the user perspective, with the objective of understanding if the gamification implementation, of the design produced by using Agon, is appreciated by the users. Accordingly, in Table 1.1, the row of **Eval5** reports “Users” as participants, and “Not Applicable (N.A.)” for the hypothesis. “N.A.” is due, as explained above, to the the fact that we have not defined a specific hypothesis for this, being a preliminary part of a future work, interesting to be mentioned in this Thesis, but not being a core part of this Thesis.

In summary, we executed evaluation studies (Table 1.1) in real and realistic settings for gamifying software systems and evaluating the usefulness of Agon from the requirements analyst’s perspective [Piras et al., 2016, 2017a,b], obtaining positive results. Such settings concerned also studies for the gamification of software systems in the context of European projects and master courses (Chapter 5, 6, 7, 8), involving experts and students [Piras et al., 2016, 2017a,b]. Moreover, thanks to these activities, we have been able to test also to have modeled correctly, and in a homogeneous, interoperable way, the interdisciplinarity of the concepts involved in a useful model, the Agon meta-model [Piras et al., 2017a,b]. Furthermore, we collected evidences on the generality and usefulness of the meta-model, and of our approach, due to the fact that it has been employed effectively, and in a flexible way, in heterogeneous cases and domains [Piras et al., 2017a,b]. Evaluating Agon in heterogeneous cases, implied also the possibility to test it with different contexts, in fact, we confirmed also the fact that the Agon meta-model, and our approach, on the basis of its context-dependent annotations, can perform reasoning and provide valuable and precise suggestions for the specific context by selecting appropriate solutions from the wide space of alternatives [Piras et al., 2016, 2017a,b].

## 1.4 Research Overview

We have been interested in developing a generic framework for modelling, analyzing and fulfilling acceptance requirements for software systems through gamification. Our objective is to support the systematic design of engaging software that meets acceptance requirements. To meet our objective we conducted a wide review of the literature to select the most important, effective and representative user acceptance models [Ajzen, 1991, Compeau et al., 1999, Davis, 1986, Davis et al., 1992, Moore and Benbasat, 1991, Sheppard et al., 1988, Taylor and Todd, 1995, Thompson et al., 1991, Venkatesh and Davis, 2000, Venkatesh et al., 2003]. We have integrated elements of existing models to create an *Acceptance Model* based on goal modeling techniques [Chung et al., 2012, Horkoff et al., 2017, Li et al., 2013, Mylopoulos et al., 1992]. This model gives a generic characterization of the problem space for acceptance requirements.

We have also developed a *Gamification Model* that defines a design space for gamified solutions to acceptance requirements, also through a literature review. This model includes gamification concepts such as point systems (i.e., experience, redeemable, skill, karma, reputation and training points), badges, leader-boards, levels, paths, gamified training (i.e., suggestions, tricks, tours, tutorials, training paths), gamified market (i.e., rewards and market policies of redeeming, making gifts, purchasing), game roles, powers, unlockable powers, gamified community [Deterding et al., 2011, Hamari, 2015, Schell, 2014, Zichermann and Cunningham, 2011], etc., and the alternative choices a designer has when designing a gamified solution [Deterding et al., 2011, Hamari, 2015, Schell, 2014, Zichermann and Cunningham, 2011]. Our framework, named Agon<sup>5</sup>, recognizes the importance of understanding game mechanics and dynamics by applying well-known gamification patterns and guidelines Schell [2014], Zichermann and Cunningham [2011] in producing an effective gamified design.

The rest of this Section is organized as follows. In 1.4.1, we provide an overview of the Agon Framework. In Section 1.4.2, we give an overview of the Agon method, and, in Section 1.4.3 an example for showing this method in action.

### 1.4.1 The Agon Framework

Agon [Piras et al., 2016, 2017a,b] offers concepts, tools and techniques for systematically designing gamified solutions for acceptance requirements. These solutions take into account cognitive aspects able to affect positively particular kinds of users. For instance, this can be especially useful in the context of social software systems, where it is essential to motivate user participation in system activities. Accordingly, Agon guides and supports

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<sup>5</sup>Agon (in Greek *Άγων*) means “game” or “competition”, as in Olympic Games (*Ολυμπιακοί Αγώνες*)

the requirements analyst to analyze *Acceptance Requirements* Piras et al. [2016], and select for them a gamification solution.

Figure 1.1 shows the abstraction layers of the framework with sample elements (described in Section 1.4.3) for each layer. In the sequel, we introduce the models that reside in each layer. In Chapter 4 we describe more in detail these models that compose the *Agon Multi-Layer Meta-Model*.

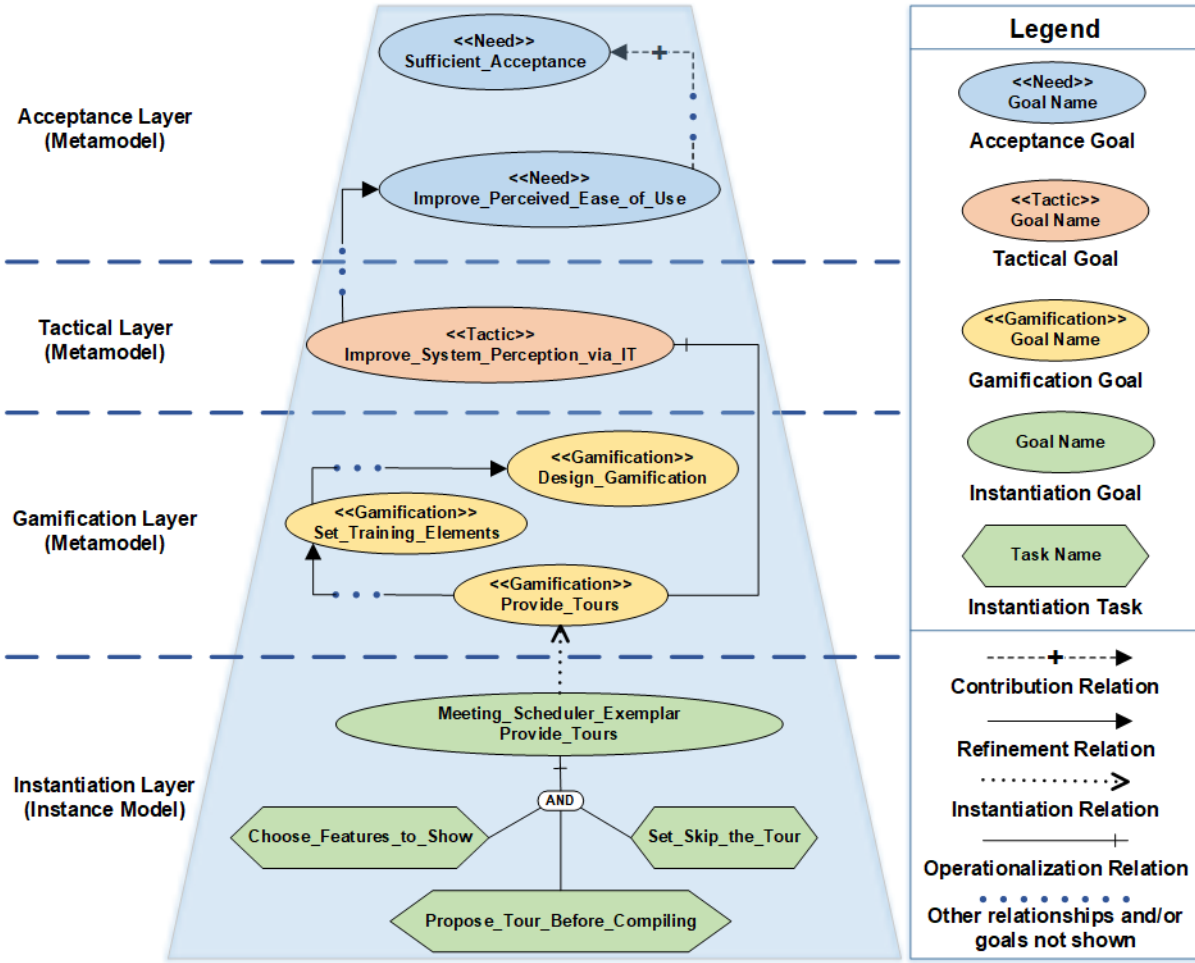


Figure 1.1: Abstraction layers of Agon with a simple example: an extract from the Doodle-Like Meeting Scheduler Exemplar [Piras et al., 2016, 2017a]

Principal elements of the framework [Piras et al., 2016, 2017b] are two goal models: a generic *Acceptance Meta-Model*, at the *Acceptance Layer* (Figure 1.1), and a generic *Gamification Meta-Model*, at the *Gamification Layer* (Figure 1.1). The first one represents the problem space offering refinements for acceptance requirements that include psychological factors that contribute to system acceptance. The second one captures

gamified operationalizations for acceptance requirements as gamification elements and design patterns.

Agon also includes a *Tactical Meta-Model* [Piras et al., 2016, 2017b] (Figure 1.1) that acts as a bridge between the two worlds of acceptance and gamification. In fact, the tactical model covers the gap between acceptance and gamification models and, at the same time, makes it possible to decouple them. Moreover, the tactical model offers further refinements (named tactics) for acceptance requirements and links them with gamification goals.

The three models are located at different abstraction layers [Piras et al., 2016, 2017b] (Figure 1.1). At the acceptance layer there are psychological needs that can be refined by tactics located at the tactical layer, and these can be operationalized by the more concrete goals that constitute the gamification layer.

Moreover, different kinds of people are motivated effectively by different kinds of gamification strategies Bartle [1996], Koivisto and Hamari [2014b], Venkatesh et al. [2003], Zichermann and Cunningham [2011]. This concept is captured by a *User Context Model* and *Context Dependent Rules* (CDRs) [Piras et al., 2016, 2017b]. Dimensions of the user context model are user characteristics related to common aspects (e.g., gender and age) [Piras et al., 2016, 2017b], gamification aspects (e.g., player types such as socializer, achiever, explorer, killer) [Piras et al., 2016, 2017b], acceptance aspects (e.g., expertise and familiarity regarding the proposed system) [Piras et al., 2016, 2017b] and organizational behavior aspects (e.g., goal, task, social structure, etc.) [Piras et al., 2017a]. CDRs associate those dimensions with the most pertinent acceptance and gamification concepts for representing best strategies able to improve user involvement depending on the user characteristics [Piras et al., 2016, 2017b]. Moreover, the acceptance and gamification models are annotated by these rules in order to support reasoning over them for selecting most suitable strategies to engage the intended group of users [Piras et al., 2016, 2017b].

Agon models are generic reference meta-models [Piras et al., 2016, 2017b], because they do not refer to a particular domain and can be applied to a variety of domains [Piras et al., 2016, 2017b]. They are composed of 352 goals and 487 relations [Piras et al., 2017b] of different kinds and have been continuously growing and evolving in dimension and quality by adding new psychological factors, gamification concepts and best practices Piras et al. [2016] [Piras et al., 2016, 2017b]. The models were designed by extending the *NFR Framework* Chung et al. [2012] and the user context model by extending *Context Dimension Trees* Orsi and Tanca [2011]. Complete models and a glossary (concerning elements of the Agon Framework) are available online at Piras et al. [a].

### 1.4.2 Acceptance Requirements Analysis

The *Acceptance Requirements Analysis* process supported by Agon, i.e. the Agon method we call as *Systematic Acceptance Requirements Analysis Based on Gamification*, can be summarized as follows [Piras et al., 2016, 2017a].

In the first phases, the requirements analyst uses Agon for the **(i)** design of a goal model representing the software to be gamified, **(ii)** identification of the functions that need to be gamified and the definition of acceptance requirements, **(iii)** characterization of the intended group of people to motivate by referring to the user context model [Piras et al., 2016, 2017a].

Then, Agon, on the basis of the user characterization chooses psychological factors that best fit by using the acceptance model. These factors are refined by tactics of the tactical model that in turn are used by the framework for selecting most suitable gamification concepts and best practices. On the basis of selected elements, Agon provides the analyst with a gamified solution [Piras et al., 2016, 2017a].

Moreover, the process can be interactive because the analyst can make decisions, during all the phases, concerning intermediate and final solutions proposed by Agon [Piras et al., 2016, 2017a].

In the next Subsection, we describe this process in action with the example in Figure 1.1. Then, the Agon method is described in detail in Chapter 5 with the gamification of the Doodle-Like Meeting Scheduler [Piras et al., 2016, 2017a] as an example [Piras et al., 2016], and in a real case study for the gamification of a platform in the context of a European project. It is the Participatory Architectural Change MAnagement in ATM Systems (PACAS<sup>6</sup>) European project, and we describe the related case study in Chapter 6.

### 1.4.3 Acceptance Requirements Analysis with an Example

Here, to explain the Agon method with sample elements, we provide an example (Figure 1.1). The example represents a very simplified version concerning the gamification of the Doodle-Like Meeting Scheduler Exemplar [Piras et al., 2016, 2017a] (part of a case study [Piras et al., 2017a]) we describe in Chapter 5. The example regards how to stimulate users of a Doodle-like meeting scheduler to indicate their preferred dates for scheduling a meeting [Piras et al., 2016, 2017a].

First of all, the requirements analyst uses Agon for representing the software to be gamified as a goal model. Then, she identifies, by analyzing the model, the functions that need to be gamified and defines the acceptance requirements. For concluding the definition

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<sup>6</sup><http://www.pacasproject.eu/>

of acceptance requirements, she needs also to characterize the participants. Therefore, the analyst characterizes the intended group of people to convince: senior employed males that are achievers as kinds of players, they are not experts regarding using Doodle or similar software, it is not mandatory for them to fill the Doodle and they have not scheduled meetings by using IT systems previously.

Agon, on the basis of the characterization, proposes to take into account the **Reduce Effort Expectancy** acceptance need, because there is a rule annotating it saying that elders are influenced positively if that need is satisfied Venkatesh et al. [2003]. Agon chooses **Improve Perceived Ease of Use** (Figure 1.1) as need that can contribute positively to the previous one, and as refinement of it the **Improve System Perception via IT** tactic (Figure 1.1).

Finally, it individuates as operationalization of this tactic a gamified training element that is **Provide Tours** (Figure 1.1). Thus, the gamified solution is to motivate elders making them aware using Doodle requires low efforts, by improving their perception of it through a gamified IT solution: a gamified tour showing how to use Doodle.

Concluding the example, because Agon models are generic reference meta-models and do not refer to a particular domain, the analyst has to instantiate the tour with elements specific of her domain, the meeting scheduler. Thus, she adds final tasks Chung et al. [2012] (activities that can be executed by a person or the system-to-be fulfilling the upper goals) for indicating the features to show in the tour concerning the usage of Doodle (**Choose Features to Show** in Figure 1.1), for proposing the tour before compiling (**Propose Tour Before Compiling** in Figure 1.1) and the possibility to skip the tour making it an optional feature (**Set Skip the Tour** in Figure 1.1).

## 1.5 Structure of the Thesis

The next chapters of this thesis are organized as follows.

- Chapter 2 reviews Acceptance and Gamification studies from the literature and real cases from the industry. We consider both studies coming from other fields and, above all, the ones closer to Acceptance and Gamification within the Software Engineering and Requirements Engineering fields. Regarding Acceptance, we introduce it, we discuss Acceptance Requirements, their operationalization techniques and the support for them provided by Agon. Then, we review Acceptance Models that are the baseline on which we designed the Agon Acceptance Model. Concerning Gamification, we review main concepts, success cases from heterogeneous domains to show

the powerful and flexibility of gamification. Regarding *Gamification Engineering* (see Definition 1.1), we analyze gamification frameworks (see Definition 1.2) from the industry and from the literature, and compare them with Agon. We conclude by illustrating approaches coming also from other fields such as Human and Organizational Behavior studies, that could be used for enhancing the Acceptance Requirements Engineering and the Agon Framework (as deeply discussed in Chapter 8).

- Chapter 3 describes respectively: **(i)** a gamification experiment in a real scenario, we conducted it in the context of the STREETLIFE European project<sup>7</sup>, where we applied gamification for incentivizing citizens to choose *Sustainable Urban Mobility* (SUM) solutions; **(ii)** a preliminary theoretical study, in a realistic scenario, using gamification for favoring *Mobility Assistance for Children* (MA4C). We used the scenarios of these experiences also for some case studies illustrated in Chapter 7, where some master students carried out their master theses, under our supervision, by using the Agon framework for gamifying the related software systems. Both the experiences, above all the first one, helped us to understand better, by employing gamification theories and strategies to real and realistic cases, the complexity behind the analysis, design, development and delivering of engaging software systems. Furthermore, these experiences helped us also in the design of the Agon Framework. Moreover, we discuss the lessons learned we derived from our studies and, above all, from our wide literature review (Chapter 2). On the basis of this, we illustrate the key requirements, we identified, for the design of a framework for supporting the requirements analyst in the analysis and design of engaging software. Such requirements led us to the design of the Agon Framework we describe in Chapter 4.
- Chapter 4 describes *Agon*, our *Acceptance Requirements Framework Based on Gamification*, objective of this thesis, and *Acceptance Requirements*. Specifically, we start defining acceptance requirements, exposing also some realistic examples coming from well-known domains such as meeting scheduling and project management. Then, we illustrate Agon, the framework we designed, able to deal with acceptance requirements and to provide gamification operationalizations for them. Concerning the framework, we describe in detail also its *Agon Multi-Layer Meta-Model*, illustrating each model composing the multi-layer meta-model by providing details, regarding how we designed them, and examples. Such models are the *Acceptance Meta-Model*, *Tactical Meta-Model*, *Gamification Meta-Model* and *User Context Model*.

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<sup>7</sup><http://www.streetlife-project.eu/>

- Chapter 5 describes the *Agon Method*, i.e. the *Systematic Acceptance Requirements Analysis Based on Gamification*. This method is provided by Agon to the requirements analyst for the analysis and design of engaging software systems. The Chapter illustrates such method in action for gamifying the famous Meeting Scheduler exemplar, which comes from the Requirements Engineering Community. For this occasion, we propose a more collaborative, social version of the meeting scheduler, inspired to Doodle<sup>8</sup>, and we name it as: the *Doodle-Like Meeting Scheduler Exemplar*. Therefore, we show both the Agon method, and the gamification of the Doodle-Like Meeting Scheduler Exemplar, which is part of a case study we carried out [Piras et al., 2017a] and illustrate in Chapter 8. Finally, this Chapter outlines also the *Agon-Tool* that is the software supporting the requirements analyst in using Agon and its meta-model for performing a systematic acceptance requirements analysis based on gamification. The Agon-Tool architecture, its main components and other technical details are illustrated. Moreover, we show also the Agon-Tool in action, by describing how it can be used for performing an *Acceptance Requirements Analysis Based on Gamification*.
- Chapter 6 describes the main case study of this thesis, a real case study in the context of a European project, where we applied Agon for the gamification of a software platform. The *Participatory Architectural Change Management in ATM Systems* (PACAS) European project<sup>9</sup> is such project. In particular, we analyzed the complex context of PACAS and delivered an engaging platform for motivating decision makers to collaborate in a participatory way by using such platform. We explain how we employed Agon for the analysis and design of this engaging platform. Specifically, we introduce the PACAS European project, its context and the PACAS platform. Then, we describe the case study where we gamified the PACAS platform by using Agon, and the gamification solution we designed and implemented.
- Chapter 7 presents the activities we carried out for the evaluation of the Agon framework, and discusses the results obtained. Specifically, we performed case studies and experiments in real and realistic settings for gamifying software systems and evaluating the usefulness of Agon for the requirements analyst, obtaining positive results. Such settings concerned the gamification of software systems in the context of European projects and master courses (Chapter 5, 6, 7, 8), involving experts and students.

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<sup>8</sup><https://doodle.com>

<sup>9</sup><http://www.pacasproject.eu/>

- Chapter 8 concludes with a summary on the Agon framework, its meta-model, its method and related contributions. Furthermore, this Chapter provides guidelines for extending the Agon framework, and discusses advantages obtainable by integrating it with other frameworks and methodologies. Moreover, current limitations are discussed, and future works and potential new research directions starting from this thesis are presented.

## 1.6 Published Work

In the following, we list the publications this research has produced. We organize them in different categories: Journals, Conferences and Workshops. All of them are refereed.

### International Journals

- J. Horkoff, F. B. Aydemir, E. Cardoso, T. Li, A. Maté, E. Paja, M. Salnitri, L. Piras, J. Mylopoulos, and P. Giorgini. Goal-Oriented Requirements Engineering: an Extended Systematic Mapping Study. *Requirements Engineering Journal*, 2017

### International Conferences

- L. Piras, E. Paja, P. Giorgini, and J. Mylopoulos. Goal Models for Acceptance Requirements Analysis and Gamification Design. In *36th International Conference on Conceptual Modeling (ER)*. Springer, 2017b
- L. Piras, E. Paja, R. Cuel, D. Ponte, P. Giorgini, and J. Mylopoulos. Gamification Solutions for Software Acceptance: A Comparative Study of Requirements Engineering and Organizational Behavior Techniques. In *11th IEEE International Conference on Research Challenges in Information Science (RCIS)*. IEEE, 2017a
- L. Piras, P. Giorgini, and J. Mylopoulos. Acceptance Requirements and their Gamification Solutions. In *24th Int. Requirements Engineering Conf. (RE)*. IEEE, 2016
- R. Kazhamiakin, A. Marconi, M. Perillo, M. Pistore, G. Valetto, L. Piras, F. Avesani, and N. Perri. Using Gamification to Incentivize Sustainable Urban Mobility. In *1st Intern. Smart Cities Conf. (ISC2)*. IEEE, 2015

### International Workshops

- L. Piras, G. Valetto, A. Marconi, and M. Pistore. Virtual Coaches for Mission-Based Gamified Smart Communities. In *CHI-PLAY 2015 Workshop, Personalization in Serious and Persuasive Games and Gamified Interactions*. ACM, 2015

### International Journals Under Preparation

- L. Piras, E. Paja, P. Giorgini, and J. Mylopoulos. Agon: an Acceptance Requirements Framework Based on Gamification. *Under preparation for the Requirements Engineering Journal*, 2018c
- L. Piras, E. Paja, R. Cuel, D. Ponte, P. Giorgini, and J. Mylopoulos. MAgon: an Integrated Framework for Acceptance Requirements and Motivational Antecedents. *Under preparation for the Requirements Engineering Journal*, 2018b

### Papers Under Review

- E. Paja, L. Piras, M. Salnitri, M. Ragosta, and P. Giorgini. Stakeholder end-to-end Inclusion in Requirements Engineering: the European Air Traffic Management Case. In *12th IEEE International Conference on Research Challenges in Information Science (RCIS)*, 2018. Submitted



# Chapter 2

## State of the Art

This Chapter reviews Acceptance and Gamification studies from the literature and real cases from the industry. We consider both studies coming from other fields and, above all, the ones closer to Acceptance and Gamification within the Software Engineering and Requirements Engineering fields.

Regarding Acceptance, in Section 2.1, we introduce it, we discuss Acceptance Requirements, their operationalization techniques and the support for them provided by Agon. Then, we review Acceptance Models that are the baseline on which we designed the Agon Acceptance Model (Chapter 4).

Concerning Gamification and, above all Gamification Engineering (see Definition 1.1), in Section 2.2, we **(i)** introduce gamification and main concepts, **(ii)** illustrate success cases from heterogeneous domains to show the powerful and flexibility of gamification, **(iii)** describe main activities and challenges related to the software engineering gamification process, and main gamification concepts employed, **(iv)** revise gamification frameworks (see Definition 1.2), which can help IT technicians in applying gamification to software systems, and compare them with Agon,

Then, in Section 2.3, we highlights the importance of considering acceptance aspects in the Software Engineering of Gamification, and revise Acceptance and Gamification studies close to the Requirements Engineering field.

Finally, in Section 2.4, illustrate approaches coming also from other fields, e.g., Human and Organizational Behavior studies, for enhancing the *Acceptance Requirements Engineering* field and *Acceptance Requirements Engineering Frameworks* such as Agon. In Chapter 8 we discuss extensively this possibility.

## 2.1 Acceptance and Acceptance Requirements

The design of any software system requires that a high percentage of its intended users actually accept to use the system. Fulfillment of such requirements critically depends on psychological, behavioral and social factors which may influence intrinsic and extrinsic motivations. Such requirements for software in general, and for social software as a relevant specific case, have come to prominence in the past decade [Piras et al., 2016, 2017a,b]. To address them, researchers have studied the human and social factors that affect acceptance [Simperl et al., 2013, Tokarchuk et al., 2012], and developed incentive mechanisms for addressing them, including gamification [Deterding et al., 2011] and other incentive-based mechanisms [Sakamoto et al., 2014, Schell, 2014, Zichermann and Cunningham, 2011].

In general, the software engineering process for designing high quality software systems is very expensive and complex. Even after investing conspicuous efforts and until the end of the system delivery, it is not completely possible to verify and guarantee that users will appreciate and use the system. It is even more true for social software systems, where the humans' participation and contribution are crucial factors to the software success and even to assure the accomplishment of key tasks. For instance, as it is shown in Chapter 4, in the case of the social version of the meeting scheduler example, if potential participants do not actively contribute by using the system and declaring preferred dates, it becomes impossible to schedule a meeting, and, thus, to satisfy the main objective of the system.

The case of social software is a relevant example, in fact, nowadays, digital social interactions are central elements in people's lives. Social software, e.g., Facebook and Twitter, are based on this concept and support it massively by offering a wide range of social mechanisms, starting from simple notifications to complex business processes. The key of success, for each software, is to maximize the *usage* of system functions by the majority of its intended users. Therefore, *Usage Requirements* are an important aspect to take into account and to define accurately. Usage requirements are usually referred to as *User Acceptance Requirements* (or simply *Acceptance Requirements* [Piras et al., 2016, 2017a,b]) and they constitute a class of often forgotten requirements.

### 2.1.1 Acceptance Requirements and Operationalization Techniques

*Acceptance Requirements* [Piras et al., 2016, 2017a,b] (further discussed in the next Chapters, starting from the Chapter 4 where we provide also the definition) have been treated in a more general context as *Technology Acceptance*, with many applications reported in the literature. For example, convincing elders to use Mobile Remote Presence Systems Beer

and Takayama [2011], customizing systems for the masses Arning et al. [2013], supporting project management in order to minimize risks Davis and Venkatesh [2004], dealing with Software Quality Management Poston and Calvert [2015], using recommendation systems for enhancing the user engagement [Giboney et al., 2015], favoring behaviours towards dietary modifications by convincing people to introduce, e.g., wholegrain foods Kuznesof et al. [2012].

Furthermore, in the literature there are acceptance models, from sociology, psychology and IT fields, that have been designed and proved to satisfy acceptance needs in different contexts. We have conducted a wide review of the literature and selected the most important, effective and representative models Ajzen [1991], Compeau et al. [1999], Davis [1986], Davis et al. [1992], Moore and Benbasat [1991], Sheppard et al. [1988], Taylor and Todd [1995], Thompson et al. [1991], Venkatesh and Davis [2000], Venkatesh et al. [2003]. We have merged their most valuable elements to create the Agon Acceptance Model (Chapter 4), based on Goal Modeling techniques Chung et al. [2012], Li et al. [2013], Mylopoulos et al. [1992]. In Section 2.1.3 we review Acceptance Models introduced above.

Operationalization techniques for acceptance requirements can reside on designing a game, composed of challenges, rewards, penalizations and other different kinds of game mechanics, where the objective is to increase the quantity and improve the quality of user's activities, by engaging the user, as a player, in using the system and participating more actively to it. Moreover, on the basis of typologies of users/players, different game mechanisms and game characteristics (e.g., competitive or non-competitive) can be selected [Kaptein et al., 2015, Piras et al., 2015, Schell, 2014, Zichermann and Cunningham, 2011]. This kind of operationalization is referred to as *Gamification*, and, in the last few years, it has attracted huge attention in the literature, because it offers a novel approach to enhance and increase software usage. Our framework, Agon, supports Acceptance Requirements [Piras et al., 2017b] and operationalize them with a particular class of solution, i.e. gamification. We think that there are also other solutions for operationalizing acceptance requirements (e.g., serious games, game metaphors, game-inspired design, tangible incentives, marketing strategies, advertisement, persuasive messages, etc.) [Piras et al., 2016], however, in this thesis we focus on gamified solutions. We discuss, more in detail, Gamification Engineering in Section 2.2.

### 2.1.2 Acceptance Requirements and Agon

Acceptance requirements for software systems are nearly as well understood as other well-studied requirements, such as performance, security and usability. Our review of

the literature suggests that so far, acceptance requirements have been treated either in a more general context as technology acceptance, with many applications reported in the literature Arning et al. [2013], Beer and Takayama [2011], Davis and Venkatesh [2004], Poston and Calvert [2015], or for very specific cases concerning software systems, as in Sutcliffe et al. [2014] where it is considered a very precise kind of user, system and domain.

Thus, we found a gap in the literature, i.e. there is a lot of work either on technology acceptance in general or for very specific cases, not for software in general (that is a subset of technology acceptance, but more general than specific ad-hoc cases). The novelty of our proposed framework rests also on its focus to software in general (not to domain-specific software, neither to technology acceptance in general). Furthermore, most of the technology acceptance studies are related to empirical evaluation research by employing and evaluating psychological models. While, our research has a software design perspective. In fact, the aim of our research has been to define a complete framework for supporting and improving the requirements analysis, by enriching it with acceptance requirements, for finding software design solutions able to favor the usage of IT systems.

Moreover, we are focusing on software engineering that is a very precise aspect of the more general technology acceptance, but at the same time we are doing it in a generic way, in a manner that it can apply to any kind of software. In fact, our models are generic reference models related to different layers of abstraction: the acceptance model concerning psychological factors favoring acceptance, and the gamification model regarding gamified best practices for involving users. Furthermore, the entire approach is enriched by context dependent rules used as a powerful tool for guiding reasoning and reducing automatically the wide space of design. In the summary, we have proposed a general framework, for the analysis and design of engaging software systems, having generic models that offer solutions in the problem space of acceptance requirements and include, as operationalization, the space of gamification solutions, thus, it is a general framework for dealing with acceptance requirements by using gamification.

### **2.1.3 Acceptance Models**

In the following, we review Acceptance Models coming from technology acceptance, human and cognitive behavior sciences, psychology, sociology, and IT fields [Ajzen, 1991, Compeau et al., 1999, Davis et al., 1992, Moore and Benbasat, 1991, Sheppard et al., 1988, Taylor and Todd, 1995, Thompson et al., 1991, Venkatesh and Davis, 2000, Venkatesh et al., 2003]. Those models are the baseline on which we designed the Agon Acceptance

Model, based on Goal Modeling techniques Chung et al. [2012], Li et al. [2013], Mylopoulos et al. [1992]. We have selected and merged the most valuable elements of those acceptance models to create the Agon Acceptance Model [Piras et al., 2017b] (Chapter 4). Our model is based on a number of acceptance models from the literature that have been proven useful in determining acceptance needs in different circumstances. We selected (Table 2.1): the *Unified Theory of Acceptance and Use of Technology* (UTAUT) model [Venkatesh et al., 2003], the *Theory of Reasoned Action* (TRA) model [Sheppard et al., 1988], the *Theory of Planned Behavior* (TPB) model [Ajzen, 1991, Taylor and Todd, 1995], the *Technology Acceptance Model 2* (TAM2) [Venkatesh and Davis, 2000], the *Combined TAM and TPB* (C-TAM-TPB) model [Taylor and Todd, 1995], the *Innovation Diffusion Theory* (IDT) model [Moore and Benbasat, 1991], the *Social Cognitive Theory* (SCT) model [Compeau et al., 1999], the *Motivational Model* (MM) model [Davis et al., 1992], and the *Model of PC Utilization* (MPCU) [Thompson et al., 1991].

### The Theory of Reasoned Action (TRA) Model

The *Theory of Reasoned Action* (TRA) model [Sheppard et al., 1988] (Table 2.1) has been designed including the concepts: **Subjective Norm** and **Attitude Toward Behavior**.

**Subjective Norm** is related to social influence aspects, for example the major probability that a user is available to use the system, if she receives such suggestion from a person important for her (e.g., her boss, colleague, friend, parent, etc.).

**Attitude Toward Behavior** regards the positive/negative feelings related to adopting a certain behavior in performing a certain activity (e.g., by using a system). A person can like or not like a task, can feel satisfied, not satisfied by acting in a particular manner for executing a task, etc.

TRA comes from the Psychology field and has been employed also for technology acceptance cases.

### The Theory of Planned Behavior (TPB) Model

The *Theory of Planned Behavior* (TPB) model [Ajzen, 1991, Taylor and Todd, 1995] (Table 2.1) is composed of the following concepts: **Perceived Behavioral Control**, **Attitude Toward Behavior** and **Subjective Norm**.

**Perceived Behavioral Control** regards the perception that, by using a new software/technology, she has the adequate knowledge and resources to use it. Additionally, other factors can be related to the fact to perceive that the usage of the new system will not negatively affect and will be compatible with current user behaviors (behaviors related

## 2.1. ACCEPTANCE AND ACCEPTANCE REQUIREMENTS

Table 2.1: Acceptance models

Acceptance Model	Main Field/s and Context/s	Main Concepts	Main Overlaps/ Similarities Identified
Theory of Reasoned Action (TRA) [Sheppard et al., 1988]	Psychology; Technology Acceptance	Subjective Norm; Attitude Toward Behavior	TPB
Theory of Planned Behavior (TPB) [Ajzen, 1991, Taylor and Todd, 1995]	Technology Acceptance	Perceived Behavioral Control; Attitude Toward Behavior; Subjective Norm	TRA
Technology Acceptance Model 2 (TAM2) [Venkatesh and Davis, 2000]	Technology Acceptance (Company Contexts)	Perceived Ease of Use; Perceived Usefulness; Subjective Norm	TRA
Combined TAM and TPB (C-TAM-TPB) [Taylor and Todd, 1995]	Technology Acceptance (Company Contexts)	Perceived Behavioral Control; Attitude Toward Behavior; Perceived Usefulness; Subjective Norm	TAM2; TPB
Innovation Diffusion Theory (IDT) [Moore and Benbasat, 1991]	Sociology; Technology Acceptance; Information Technology Acceptance; Innovations Acceptance (Agriculture and Company Contexts)	Ease of Use; Results Demonstrability; Compatibility; Image; Voluntariness of Use; Visibility; Relative Advantage	TAM2
Social Cognitive Theory (SCT) [Compeau et al., 1999]	Human Behavior; Performance Measuring; Technology acceptance; Information Technology Acceptance; Computer Usage;	Self-Efficacy; Outcome Expectations; Anxiety; Affect	TPB
Motivational Model (MM) [Davis et al., 1992]	Psychology; Individual Motivation Evaluation; Technology Acceptance	Extrinsic Motivation; Intrinsic Motivation	SCT
Model of PC Utilization (MPCU) [Thompson et al., 1991]	Human Behavior; Information Technology Acceptance; Computer Usage	Affect Towards Use; Complexity; Job-Fit; Social Factors; Facilitating Conditions; Long-term Consequences	TAM2; SCT; MM
Unified Theory of Acceptance and Use of Technology (UTAUT) [Venkatesh et al., 2003]	Information Technology Acceptance; Technology Innovations Acceptance (Company Contexts)	Use Behavior; Behavioral Intention; Facilitating Conditions; Social Influence; Performance Expectancy; Effort Expectancy	TAM2; IDT; SCT; MM; MPCU

to job organization, activities, responsibilities, etc.), personal commitments or style, other systems used.

Moreover, TBP takes **Attitude Toward Behavior** and **Subjective Norm** from TRA.

TPB has been employed with success in different contexts also related to technology acceptance.

### **The Technology Acceptance Model 2 (TAM2)**

Venkatesh and Davis designed the *Technology Acceptance Model 2* (TAM2) [Venkatesh and Davis, 2000] (Table 2.1) including the concepts: **Perceived Ease of Use**, **Perceived Usefulness** and **Subjective Norm**.

The first two elements are related to just the perception of the user regarding the system, it is different from the real feeling that the user has actually using the system. For example, the user just having a look to a software system can have the perception that it is easy to use (**Perceived Ease of Use**), but then by really using the system she could have a different real feeling.

In detail, **Perceived Ease of Use** indicates the desire of the user to perceive the use of the system as easy as possible, for instance concerning the fact that it is perceived as understandable, clear and that it seems to be effortless to use system functions.

**Perceived Usefulness** regards the need to perceive that by using the software allows the user to be effective, productive, be able to carry out a high-quality work in a short period of time (i.e. to be fast), etc.

The **Subjective Norm** concept is similar to the one described in TRA.

TAM2 has been used successfully in heterogeneous sectors mainly related to technology acceptance within job contexts.

### **The Combined TAM and TPB (C-TAM-TPB) Model**

Taylor and Todd merged TAM and TBP for obtaining the *Combined TAM and TPB* (C-TAM-TPB) model [Taylor and Todd, 1995] (Table 2.1). It is composed of the following elements keeping the same meaning of the original models: **Perceived Behavioral Control**, **Attitude Toward Behavior**, **Perceived Usefulness** and **Subjective Norm**.

C-TAM-TPB has been employed with success in heterogeneous contexts also related to technology acceptance.

### **The Innovation Diffusion Theory (IDT) Model**

The *Innovation Diffusion Theory* (IDT) model [Moore and Benbasat, 1991] (Table 2.1) is composed of the following elements: **Ease of Use**, **Results Demonstrability**, **Compatibility**, **Image**, **Voluntariness of Use**, **Visibility** and **Relative Advantage**.

**Ease of Use** is a stronger concept than **Perceived Ease of Use** examined in TAM2. In fact, the latter is referred to just the perception of the user regarding the system, while **Ease of Use** concerns the real feeling that the user has actually using the system. For example, the user just having a look to a software system can have the perception that it

is easy to use (**Perceived Ease of Use**), but then by really using the system she could have a different real feeling (**Ease of Use**).

**Results Demonstrability** regards the need of the user to see that an innovation lead to concrete positive results and this can be disseminated.

**Compatibility** is analogue to the **Perceived Behavioral Control** concept in relation to its compatibility facet, but in a perspective more tied to the adoption of an innovation from the user.

**Image** can be translated as the perceived possibility of improvement of the user social status as a consequence of embracing an innovation.

The **Voluntariness of Use** is tied to the possibility to be free to decide if to embrace an innovation.

The **Visibility** concept refers to the possibility to see the usage of an innovation by other colleagues (e.g., in the workplace).

**Relative Advantage** is the perception of the user concerning obtaining advantages in using an innovation compared to using the previous technology (e.g., the usage of a new software leads to having more advantages than using the previous software).

IDT has been designed in the Sociology field and used for the acceptance of innovations related to many fields, some of them are the agriculture, technology, information technology and organization of companies.

### The Social Cognitive Theory (SCT) Model

The *Social Cognitive Theory* (SCT) model [Compeau et al., 1999] (Table 2.1) has been designed including the concepts: **Self-Efficacy**, **Outcome Expectations**, **Anxiety**, and **Affect**.

**Self-Efficacy** is similar to **Perceived Behavioral Control** of TPB, considering the aspect related to the adequate knowledge, but **Self-Efficacy** is stronger because it is not related to just the perception.

**Outcome Expectations** has been designed with two different elements: **Performance** and **Personal**. Therefore, in the first case, it refers to what the user expects from using a technology (e.g., a software system) in relation to possible outcomes such as job results, career progressions, and improvements in the workplace. In the second case, it is related to personal outcomes, for instance to expect to be satisfied after have used a technology and concluded the related task.

**Anxiety** is related to negative feelings regarding an approaching event where a technology will be used.

**Affect** concerns positive emotions of the user respect to the activity of using a technology.

SCT has been proposed in the the Human Behavior studies field. SCT has been originally employed for measuring performance, then adopted also in the context of technology acceptance, information technology acceptance, computer usage.

### **The Motivational Model (MM) Model**

The *Motivational Model* (MM) model [Davis et al., 1992] (Table 2.1) has been designed including the concepts: **Extrinsic Motivation** and **Intrinsic Motivation**.

**Extrinsic Motivation** is analogous to **Outcome Expectations** of SCT considering its **Performance** aspect. Therefore, **Extrinsic Motivation** refers to the availability of the user to carry out a task because she perceives that, after concluding the task, she can receive something beyond the task (e.g., to obtain an additional income, advancement in her carrier, etc.)

**Intrinsic Motivation** is similar to **Outcome Expectations** of SCT considering the **Personal** aspect. Thus, **Intrinsic Motivation** refers to the desire of the user to carry out a task because she perceives that, just executing the task, she will be satisfied by the task itself.

MM comes from the Psychology field and has been originally used for evaluating the individual motivation, then, in different domains including that of technology acceptance.

### **The Model of PC Utilization (MPCU)**

The *Model of PC Utilization* (MPCU) [Thompson et al., 1991] (Table 2.1) has been designed including the concepts: **Affect Towards Use**, **Complexity**, **Job-Fit**, **Social Factors**, **Facilitating Conditions**, and **Long-term Consequences**.

**Affect Towards Use** is analogous to **Affect** of SCT.

**Complexity** is analogous to **Perceived Ease of Use** of TAM2.

**Job-Fit** is similar to **Extrinsic Motivation** of MM and **Outcome Expectations** of SCT referring to its **Performance** aspect. However, **Job-Fit** considers the outcome as strictly connected to the job itself (not beyond of it), thus, it concerns the possibility that a user considers the use of a technology as a factor to improve her performance in her job.

**Social Factors** is composed of three aspects related to the social context where the individual should use a technology and which social factors could push him to embrace a certain behavior (e.g., using a system). The first is related to the fact that the usage of a technology is *socially pushed*. For instance, if the company, where the user works,

advertises the usage of a technology, suggests strongly the usage and major promoters (e.g., managers) contribute in spreading it. The second one is very close to the previous one, it regards if the usage of the technology is *socially supported*. It means that, if the employee realizes that the company is strongly supporting, by investing resources (e.g., money), spreading and advertising activities, and maybe organizing also training courses for that technology, she can be influenced to embrace such technology. The third one concerns the *embrace of the technology*. For example, if an employee sees that most of her colleagues are embracing a new technology, she can be influenced to adopt such technology.

**Facilitating Conditions** is close to the *socially supported* of **Social Factors**. However, it specifically refers to the assistance activities offered to the employees and the resources directly supplied to the employee. Examples for the first case, are related to the possibility that the company organizes assistance activities for learning the new technology through, for instance, **(i)** software systems for individually training the user, **(ii)** forums where to share problems with other colleagues concerning the technology, **(iii)** courses with teachers for learning the new technology in class with a group of colleagues. Examples for the second case, regards the company that facilitates the employee by directly supplying to her a new computer able to support the new technology, other resources that could help her in this way, or simplifying company procedures (e.g., bureaucratic or administrative procedures) for adopting a new technology.

**Long-term Consequences** is similar to **Job-Fit**, but referring to outcomes that could become concrete in the future and for long-term. Furthermore, outcomes considered by **Long-term Consequences** are the ones of **Job-Fit**, but it is broader including also the ones of **Outcome Expectations** of SCT referring to its **Performance** aspect. In any case, **Long-term Consequences** refers always to these items as future and long-term outcomes.

MPCU comes from the Human Behavior studies field. It has been used within the PC utilization context and in information technology acceptance contexts.

### The Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh et al. [Venkatesh et al., 2003] have proposed the *Unified Theory of Acceptance and Use of Technology* (UTAUT) model (Table 2.1). They considered the other available acceptance models and designed UTAUT by choosing the following factors: **Use Behavior**, **Behavioral Intention**, **Facilitating Conditions**, **Social Influence**, **Performance Expectancy**, and **Effort Expectancy**.

They individuated correlations among those elements. In particular, **Use Behavior** represents the possibility that the user accepts and uses a technology. This depends di-

rectly on **Facilitating Conditions** and **Behavioral Intention**. In turn, **Behavioral Intention** represents the intention of the user in embracing a new technology and depends on **Social Influence**, **Performance Expectancy**, and **Effort Expectancy**. In turn, **Facilitating Conditions**, **Social Influence**, **Performance Expectancy**, and **Effort Expectancy** depend on factors similar to the ones of the models described above.

**Facilitating Conditions** comprehends concepts similar mainly to the ones of **Facilitating Conditions** of the MCPU model.

**Social Influence** refers mainly to concepts analogous to **Social Factors** of MCPU.

**Performance Expectancy** is composed of elements coming mainly from **Job-Fit** (MCPU), **Extrinsic Motivation** (MM) and **Outcome Expectations** of SCT referring to both **Performance** and **Personal** aspects.

**Effort Expectancy** refers mainly to concepts analogous to **Perceived Ease of Use** of TAM2 and **Ease of Use** of IDT.

UTAUT comes from the Information Technology Acceptance field. UTAUT has been used successfully in many contexts, and mainly employed to investigate the user intention to use, and real usage of, new technologies within company contexts.

## 2.2 Gamification Engineering

Gamification is the application of typical elements of game design in non-game contexts [Deterding et al., 2011]. The objective of non-game contexts is not to entertain the user, but to make the user to act for achieving goals of the specific context [Deterding et al., 2011, Zichermann and Cunningham, 2011]. Thus, the purpose of gamification is to engage users in non-game activities, which commonly have not as primary characteristic to make the user to have fun [Kazhamiakin et al., 2015, Piras et al., 2016, 2017a,b]. For example, many work procedures are repetitive and boring, but with gamification we can make them interesting and appealing, and motivate employees to complete their tasks as if they were playing a game, triggering behavioral change. The core idea is that of a virtuous circle in which users are motivated to perform a certain task, are rewarded, have fun, and continue to perform the same task. Users at first carry out the task because they are having a good time and are stimulated by the reward, but then do so because the task has become part of their usual behavior [Deterding, 2012, Deterding et al., 2011, Piras et al., 2016, 2017a,b, Zichermann and Cunningham, 2011].

Gamification can be applied to different sectors [Bartley et al., 2013, Bielik et al., 2012, Cowley et al., 2011, Hoh et al., 2012, McCALLUM, 2012, Merugu et al., 2009, Shiraishi et al., 2009, Walsh and Golbeck, 2014], and many case studies confirm this, with successful

outcomes for gamification both in large companies and in experimental studies [Hamari et al., 2014, Pedreira et al., 2015]. According to many studies, gamified software applications can lead citizens to use sustainable means of transportation [Kazhamiakin et al., 2015], thus limiting traffic and reducing carbon emissions Merugu et al. [2009], promote regular physical exercise [Bartley et al., 2013, Bielik et al., 2012, Walsh and Golbeck, 2014], or raise awareness on energy consumption, for instance, through positive competitions among neighbors in which families challenge each other to use less energy Cowley et al. [2011], Shiraishi et al. [2009].

In the next Section, we analyze more deeply the effectiveness of gamification, and its flexibility concerning the possibility to employ it successfully in heterogeneous domains.

### **2.2.1 Importance of Gamification for Heterogeneous Fields**

In recent years, gamification has been applied to many systems and apps from many sectors obtaining many positive results [Bartley et al., 2013, Bielik et al., 2012, Cowley et al., 2011, Hoh et al., 2012, McCALLUM, 2012, Merugu et al., 2009, Shiraishi et al., 2009, Walsh and Golbeck, 2014]. In fact, both practical experiences from the market and studies from the literature, confirm that gamification can be very useful in heterogeneous sectors Hamari et al. [2014], McCALLUM [2012], Pedreira et al. [2015]. For instance, thanks to gamification it is possible either to drastically reduce the traffic congestion Merugu et al. [2009] or, by coupling gamification and crowdsourcing, to involve citizens in sharing information about city parking and to distribute the usage of them in an optimized way Hoh et al. [2012]. Gamification is also useful for motivating people to have a regular physical activity Bartley et al. [2013], Bielik et al. [2012], Walsh and Golbeck [2014]. In the energy field, gamification has been successfully employed to achieve a decrease in energy consumption and to avoid waste of energy, for instance, through positive competitions among neighbors in which families challenge each other to use less energy Cowley et al. [2011], Shiraishi et al. [2009].

Furthermore, over the last decade, gamification has been drawing growing interest among scholars and practitioners in many fields Hamari et al. [2014]. Indeed, gamification has been considered as a useful tool to enhance participation, social interaction, motivation and performance when certain software-intensive activities and tasks are carried on. As such, gamification has been applied widely to many heterogeneous fields, among others collaborative activities Simperl et al. [2013], education Kapp [2012], air traffic management and decision making [Piras et al., 2017b], urban mobility Kazhamiakin et al. [2015], and software engineering Pedreira et al. [2015].

One of the most promising fields of application is *Software Engineering* Pedreira et al. [2015]. In this field, the engagement and motivation of the users is of special interest considering the human-intensive nature of software-mediated processes. As a matter of fact, gamification has been applied to many aspects in this area such as for instance user requirements elicitation, software requirement analysis implementation and versioning Pedreira et al. [2015].

### A Noteworthy Real Example: Pokémon GO

A relevant success case, described more in detail in Section 1.1.3, is Pokémon GO<sup>1</sup>. It is a noteworthy real example, from the industry, of a successful game, a mobile app, including intriguing game elements and mechanisms, designed considering both software acceptance and gamification techniques. In the last few years, Pokémon GO has become very popular counting millions of users per day. This huge success resides on the fact that its gamification design is based on accurate analysis of players and related psychological factors [Piras et al., b]. In a nutshell, Pokémon GO is an application based on the usage of the own smartphone, it envisages the capture of pokémons (by following them through geo-localized immersive virtual reality), their training, improvements of the game experience through in-app purchases of special elements, the competition against other players with challenges or the interaction with them in a collaborative way [Piras et al., b].

### Smart Cities

Gamification is relevant also for *Smart Cities* (this is described even more in detail in Chapter 3 and in [Kazhamiakin et al., 2015]).

**Definition 2.1 (Smart City).** *A Smart City is a conglomerate of services, sensors, smart devices/objects, apps, IT systems and new technologies [Piras et al., 2015]. A smart city is a dynamic open environment where sub-elements can appear, disappear or change behavior [Piras et al., 2015].*

In this context, gamification can be leveraged to affect citizens' behavior in relation to many major smart city concerns, such as participatory governance Oliveira et al. [2014], tourism and culture Gordillo et al. [2013], mobility Charitos et al. [2014], etc.

One of the work described in Chapter 3 is on promoting city-defined sustainable mobility policies and smart cities citizens' VTBC is in the area of gamification for smart

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<sup>1</sup><https://www.pokemongo.com/>

and sustainable urban mobility [Kazhamiakin et al., 2015]. VTBC is the promotion of *Voluntary Travel Behavior Change* (VTBC) has been indicated as a key issue for sustainable urban mobility in the scientific literature Banister [2008], Brög et al. [2009], as well as in official national and international policy documents European Commission [2011]; it is also tightly coupled with the definition and execution of city-wide mobility policies. On the one hand, policies that target sustainability - and the corresponding smart mobility services - can be successful only if they are embraced by citizens in a convinced and continued way; on the other hand, city policies that create and manage effective incentives, as *Gamification* can help to break citizens' habits and affect their mobility choices, boost acceptance, and, ultimately, make a difference in the urban environment.

Some other recent works have reported promising results in the Smart Cities area. Merugu et al. Merugu et al. [2009] illustrated an application to reduce traffic congestion, while Hoh et al. Hoh et al. [2012] coupled gamification and crowdsourcing, in order to involve citizens in sharing information about parking spaces in the city. Gabrielli et al. describe design methodologies and lessons learned, based upon gamification case studies carried out in the cities of Trento (Italy), Milan (Italy), Helsinki (Finland) and Barcelona (Spain) Gabrielli et al. [2013, 2014]. Buningh et al. Buningh et al. [2014b] successfully implemented in Eindhoven (The Netherlands), a gamified system for stimulating company employees to choose sustainable means of commuting to work. Abou-Zeid and Fujii Abou-Zeid and Fujii [2015] demonstrated that gamification applied to the public transport is useful to convince commuters to use sustainable transports and to increase their travel satisfaction. Wells et al. Wells et al. [2014] proposed a gamification model for motivating people to embrace sustainable mobility. Their approach is based on tracking people's mobility behaviour, proposing challenges and goals, and modulating these variables on the basis of the current progress. Forbes et al. Forbes et al. [2014] studied a method able to compute persuasive notifications on the basis of the mobility people's behaviour in order to increase the usage of sustainable transports.

### Studies Based on Missions and Virtual Coaches in Heterogeneous Domains

In the last few years, many systems have been gamified, some of them use the gamification concept of *Missions* in combination with *Virtual Coaches* (one of the work described in Chapter 3, and in [Piras et al., 2015], provides even more details related to these particular gamification solutions).

**Definition 2.2 (Gamification Concept: Mission).** *The Mission gamification concept is composed of a set of activities the player carries out, in order to satisfy some system's*

goals, and receives gamification rewards (e.g., typically other gamification concepts) [Piras et al., 2015]. In the literature, missions are named also as challenges, quests and goals [Piras et al., 2015].

**Definition 2.3 (Gamification Concept: Virtual Coach).** *A Virtual Coach is a visible or invisible assistant that supplies the player with direct or indirect suggestions on how to fulfill gamification goals of the player and, indirectly, of the system [Piras et al., 2015].*

Virtual coach suggestions may at times be tuned to the individual player with some form of personalization [Piras et al., 2015]. A virtual coach can make dynamic decisions on the most appropriate missions for a player at a given juncture; its recommendations can be based upon multiple dimensions, including players' profiles and preferences, in-game incentives, or application state, including the collective goals and requirements of a group of users, community, supported by a participatory application [Piras et al., 2015]. Furthermore, a virtual coach is able to guide the player in a system by offering tips and tricks, guiding the choice of tasks that lead the player to satisfy her objectives, by motivating her and offering a fun experience. This is even more valuable if the player has no knowledge of the specific domain.

In the literature, missions and coaches have been used either coupled or separated. Concerning mission-based gamification of group of people, communities, without the employment of virtual coaches, there are successful studies. Fitz-Walter et al. [Fitz-Walter et al., 2014] demonstrated that, in the process of the university orientation, supplying students with a missionbased gamified mobile app improves that experience. Dodero et al. [Dodero et al., 2014] proved that the mission-based approach can be effective also for groups of primary school children. These studies do not carry on the phase of selecting and proposing missions in an automated way, for instance by employing a virtual coach.

Virtual coaches are used in many gamification domains [Piras et al., 2015]. For example, in the automotive sector, virtual coaches are employed to support the exploration of a vehicle Diewald et al. [2015], or to guide drivers to eco-driving styles Diewald et al. [2015], Magaña and Organero [2014] and to save fuel Magana and Munoz-Organero [2015]. Richards Richards [2014] proposed to apply invisible coaches to exergames. Kulyk et al. Kulyk et al. [2014] described guidelines for designing coaches for the gamification of physical and personal health activities. Buningh et al. Buningh et al. [2014a] implemented a gamified system, with a coach, for stimulating company employees to choose sustainable means of commuting to work.

### 2.2.2 Main Gamification Activities, Challenges and Concepts

Nowadays companies are facing increasing problems: how to convince people to choose their app, service, website, system, or software in general, and after that preliminary step, how to maintain the related usage and fidelity at a very high level. These problems are due to the extreme competition that is occurring among companies in the last few years. In fact, this is producing a widespread availability of applications very similar to each other in relation to the same specific field, forcing enterprises to improve the quality of services offered but also to seek new ways to attain peoples engagement, participation and motivation [Piras et al., 2017a, Zichermann and Cunningham, 2011].

Gamification is an effective approach that can help to overcome these problems. Although it has only recently been employed, in the majority of cases it has been used successfully. In fact, many companies by gamifying their systems have increased both the number of people that choose them and the usage of related services, registering levels of success even greater than expected [Kazhamiakin et al., 2015, Piras et al., 2017a, Zichermann and Cunningham, 2011].

Although Gamification is a powerful method, the current main gap concerning its practical application is that this process is still difficult, entails long processes and requires high costs in terms of analysis, design and development efforts [Piras et al., 2016, 2017a, Zichermann and Cunningham, 2011]. In fact, the practical application of gamification requires solving interdisciplinary problems by involving heterogeneous specialists such as IT professionals, gamification experts and domain experts [Piras et al., 2017a, Zichermann and Cunningham, 2011]. Furthermore, in order to gamify a system they have to collaborate with each other performing a multitude of activities that affect many aspects of the system [Piras et al., 2017a, Zichermann and Cunningham, 2011].

### **Main Activities and Challenges in the Gamification Process**

A typical gamification process consists of inserting typical game concepts to apps or systems by including game domain elements in the business domain [Schell, 2014, Zichermann and Cunningham, 2011]. This can happen either contextually to the software engineering phases for designing a new system, or working on a pre-existing system that has not been originally designed by including gamification, and that needs to be improved for making it more appealing and engaging for the user through gamification [Piras et al., 2016, 2017a, Schell, 2014, Zichermann and Cunningham, 2011].

An example of gamification behaviour expected from a gamified app/system can be summarized with the following points [Deterding et al., 2011, Schell, 2014, Zichermann and Cunningham, 2011]:

1. to provide challenges to the player with very clear win conditions;
2. after the player has satisfied them, to reward the player with incentives like virtual/real goods;
3. to compute leaderboards of players that have carried out activities related to similar paths;
4. to reward the best players with badges or additional powers;
5. to publish in the community the player's achievements and any new status acquired to motivate other players and to involve new possible participants.

To construct these kind of game mechanisms it is necessary to employ gamification elements (e.g. points, badges, paths, levels and leaderboards), and, above all, design a coherent gamification solution able to make work, homogeneously, harmoniously and effectively, all those gamification concepts, for engaging particular kinds of users, the target users of the system to be gamified, to be motivated in using a specific software [Piras et al., 2017a]. Therefore, if the (as-is or to-be) features of a system are not enough attractive for the users, it is necessary to gamify them by performing some gamification activities.

Those activities are related to a complete gamification software engineering process, named *Gamification Engineering* (see Definition 1.1). This means that IT technicians have to conduct complex analysis and design tasks, being supported by heterogeneous professionals such as psychologists, sociologists, economists, for understanding the needs of the user to be motivated on the basis of the user characterization, the particular kind of target users [Piras et al., 2016, 2017a]. This is a crucial point that for deciding which gamification concepts and strategies to employ and how to design them for decorating the system making it more attractive and engaging [Piras et al., 2016, 2017a,b, Schell, 2014, Zichermann and Cunningham, 2011].

Other important phases are the implementation, delivery, runtime, and tuning phases. Therefore, it is needed to implement in the system the gamification design, comprehensive of the development of gamification elements and the integration of them in a workflow made of the system functions enhanced with gamification concepts [Kazhamiakin et al., 2015, Piras et al., 2017b].

The game delivery phase sets up the game in the environment, and the game runtime phase allows users to really use system functions in a gamified experience [Kazhamiakin et al., 2015].

In relation to the tuning phase, it is important to evaluate if the gamification solution is really engaging the user, or if there are some mechanisms that need to be revised or replaced with other ones [Deterding, 2015, Piras et al., 2016]. If gamification monitoring/validation components have been designed and implemented during the previous phases, they can be very helpful for analyzing the results and executing the tuning. The tuning can be done either at design time, for improving the current gamification solution, or, better, at runtime if it is employed an adaptive gamification framework (see Definition 1.2). The latter solution needs a framework that is able, on the basis of the monitored events, to take dynamic (at runtime) decisions regarding how to improve the gamification design. The tuning is important, above all, when the system is not able to guarantee the long-term engagement of the user. This is a typical problem of gamification, in fact, it has been proven in many cases that gamification is effective for short-term engagement, while to confirm the long-term engagement of gamification is an open research problem. Therefore, it is strongly suggest to evaluate the gamification solution time to time (e.g., as described above), and if there are problems, to improve/update the related gamification design for guaranteeing long-term engagement [Cuel et al., 2011, Deterding, 2015, Piras et al., 2017a, Schell, 2014, Simperl et al., 2013, Tokarchuk et al., 2012, Zichermann and Cunningham, 2011].

As described, this process can be very complex and expensive [Kazhamiakin et al., 2015]. Thus, it is very important to drastically reduce the efforts concerning the entire gamification process, and gamification frameworks [Piras et al., 2017a] (see Definition 1.2) can be an helpful solution. Those frameworks are tools that allow gamification designers to gamify user actions of a specific domain by designing game design elements, not from scratch, but with the use of ready-to-use gamification components [Kazhamiakin et al., 2015, Piras et al., 2017a]. Unfortunately, current frameworks have still important limitations [Kazhamiakin et al., 2015, Piras et al., 2017a]. This is discussed deeply in Section 2.2.

## **Main Gamification Concepts**

Concerning the gamification concepts used during the gamification engineering (see Definition 1.1) of a system, there is a considerable amount of literature describing them [Deterding, 2012, Deterding et al., 2011, Montola et al., 2009, Salen and Zimmerman, 2004, Schell, 2014, Zichermann and Cunningham, 2011], related taxonomies Alvarez et al. [2007], McCALLUM [2012], and literature reviews Hamari et al. [2014], Pedreira et al. [2015]. In the following we briefly explain some of those canonical gamification concepts.

*Points* are the metric of most of the games, they can be used for associating values to game actions. The point system is the central strategic mechanism of games and often the other game mechanics depend on it. Zichermann et al. in Zichermann and Cunningham [2011] outlined 5 types of point systems: experience points, redeemable points, skill points, karma points, reputation points.

*Badges* are another type of reward. For instance, they can be achieved either by cumulating an amount of points, after reaching a certain level in a game, or after performing a specific action. They show an achieved status or a skill owned. The powerful and further characteristics of Badges are described in Anderson et al. [2013], Goligoski [2012], Hamari [2015], Santos et al. [2013].

*Leaderboards* are rankings of players or teams that can be built on the basis of various needs. The most common are global, geolocalized, social or dynamic in relation to time Zichermann and Cunningham [2011].

Anyway, there are many other gamification concepts available, such as *levels*, *paths*, *challenges*, *stories*, *feedback*, *progress*, *powers*, etc. On the one hand, the availability of concepts is directly proportional to the gamification design expressiveness. On the other hand, there is a continuous proposition of new concepts. Therefore, it is necessary for systems that offer tools for the design and the application of the gamification to be extensible [Piras et al., 2016, 2017a,b].

Designing Agon, by reviewing the vast amount of gamification concepts, we have also developed a *Gamification Model* (Chapter 4) that defines a design space for gamified solutions to acceptance requirements [Piras et al., 2016, 2017a,b]. This model includes gamification concepts such as point systems (i.e., experience, redeemable, skill, karma, reputation and training points), badges, leader-boards, levels, paths, gamified training (i.e., suggestions, tricks, tours, tutorials, training paths), gamified market (i.e., rewards and market policies of redeeming, making gifts, purchasing), game roles, powers, unlockable powers, gamified community [Deterding et al., 2011, Hamari, 2015, Schell, 2014, Zichermann and Cunningham, 2011], etc., and the alternative choices a designer has when designing a gamified solution [Deterding et al., 2011, Hamari, 2015, Schell, 2014, Zichermann and Cunningham, 2011].

Moreover, such gamification elements are the building blocks for constructing a gamified experience [Deterding et al., 2011, Schell, 2014, Zichermann and Cunningham, 2011]. This means to design a gamification solution as an experience able to engage the user, making her to immerse in a pleasant usage of the software features that is stimulating and motivating [Deterding et al., 2011, Zichermann and Cunningham, 2011], by fitting concerns and motivations of the particular kind of user [Bartle, 1996, Zichermann and

Cunningham, 2011], and that is able to maintain her interest and attention at a very high level [Zichermann and Cunningham, 2011], by deciding the right times and pace for involving her in the use of software features [Zichermann and Cunningham, 2011], and/or by rewarding her for this, in unexpected ways at unexpected times [Douglas and Hargadon, 2000]. Therefore, the final objective is to keep the user in a continuous effective engagement flow [Zichermann and Cunningham, 2011], by designing the gamification experience to be **(i)** not too easy, otherwise the user can get bored, and **(ii)** not too difficult, otherwise the user can get frustrated. In fact, in both of these cases, the result is that the user leaves the system and, instead, we aim at the case where the design is balanced and, thus, able to engage continuously the user [Schell, 2014, Zichermann and Cunningham, 2011]. These are fundamental design concepts often referred to *User Engagement*, *Immersion* and *Flow* [Douglas and Hargadon, 2000].

Furthermore, to build an effective gamification solution, *User Engagement*, *Immersion* and *Flow*, are designed on the basis of the different kinds of the users to be engaged [Bartle, 1996], by pushing on different user emotions and feelings [Douglas and Hargadon, 2000]. In fact, different users are motivated by different strategies and game mechanisms [Deterding et al., 2011, Schell, 2014, Zichermann and Cunningham, 2011]. According to one of the most important taxonomies [Bartle, 1996], users can be socializers, achievers, explorers or killers [Bartle, 1996] (they are not mutually exclusive characterizations, in fact a user can be a mix of them with different associated percentages). There exist many strategies for designing software features to be more appealing from the user perspective, which envisage to enrich software features making them challenging, rewarding, amusing, depending on the user kind [Bartle, 1996, Zichermann and Cunningham, 2011]. For example, some strategies leverages on the *Surprise Effect* concept [Tokarchuk et al., 2012]: some users, in particular *explorers* [Bartle, 1996], are incentivized by receiving rewards at unexpected times [Zichermann and Cunningham, 2011]. Another strategy, useful for explorers that are also achievers [Bartle, 1996], suggests to show unexplored parts of the system (e.g., new available features or virtual objects) that can be unlocked after completing challenges proposed by the system [Simperl et al., 2013] (often, by fulfilling challenges, the user is also satisfying stakeholders' objectives). With *achievers* [Bartle, 1996] can be beneficial to allow them to publish their achievements (e.g., badges) into a community, leveraging on the *Social Status* concept [Tokarchuk et al., 2012, Zichermann and Cunningham, 2011]. While, with *socializers* [Bartle, 1996], to engage them, it is important to envisage a social dimension in the system, with social concepts and mechanisms [Cuel et al., 2011], enabling the users to improve their social relationships (e.g., through a gamified community tied to the software). For instance, a gamification solution can make use of *Karma Points*, where

such points are collected by socializers and can be used in a gamified market for making gifts to other users [Zichermann and Cunningham, 2011]. This particular typology of user is very important, because most of the users are socializers [Bartle, 1996, Zichermann and Cunningham, 2011].

In summary, the effectiveness of a gamification solution strongly depends also on considering the kinds of users to engage. Thus, it is crucial to characterize the user and to analyze and design strategies fitting the user needs [Piras et al., 2016, 2017a,b]. Our Agon framework includes the design concepts expressed in this Section [Piras et al., 2016, 2017a,b], and related rules implemented as context annotations [Piras et al., 2016, 2017b] (further details in Chapter 4), and it is able to support the requirements analyst in designing a gamified experience by providing her with well-structured gamification solutions [Piras et al., 2016, 2017a], in the form of goal modeling suggestions, which are the most suitable ones for the kind of user to engage [Piras et al., 2017b]. In order to systematically act in this way, the Agon method [Piras et al., 2016, 2017a] (further details in Chapter 5) includes also phases and support for characterizing the user to engage and reasoning techniques, applied over the Agon meta-model, for producing gamification solutions and suggestions [Piras et al., 2016, 2017a,b].

### **2.2.3 Gamification Frameworks**

Gamification applies design concepts of games in non-game contexts Deterding et al. [2011]. In recent years, gamification has been exploited for software systems and apps in different domains with positive results Cowley et al. [2011], Hamari et al. [2014], Kazhamiakin et al. [2015]. In fact, both practical experiences from the market and studies from the literature, confirm that gamification can be very useful in very heterogeneous sectors and for various aims Hamari et al. [2014].

Although Gamification is a powerful method, the current main gap concerning its practical application is that this process is still difficult, entails long processes and requires high costs in terms of analysis, design and development efforts [Piras et al., 2016, 2017a, Zichermann and Cunningham, 2011]. In fact, the practical application of gamification requires solving interdisciplinary problems by involving heterogeneous specialists such as IT professionals, gamification experts and domain experts [Piras et al., 2017a, Zichermann and Cunningham, 2011]. Furthermore, in order to gamify a system they have to collaborate with each other performing a multitude of activities that affect many aspects of the system [Piras et al., 2017a, Zichermann and Cunningham, 2011].

As described in Section 2.2.2, the gamification process can be very complex and

expensive [Kazhamiakin et al., 2015]. Thus, it is very important to drastically reduce the efforts concerning the entire gamification process, and gamification frameworks [Piras et al., 2017a] can be an helpful solution. Those frameworks are tools that allow gamification designers to gamify user actions of a specific domain by designing game design elements, not from scratch, but with the use of ready-to-use gamification components [Kazhamiakin et al., 2015, Piras et al., 2017a] (see Definition 1.2).

Therefore, the process of applying gamification to an IT system can be referred to gamification engineering activities. Many gamification tools such as gamification frameworks and related studies [Herzig et al., 2012, 2013, Kazhamiakin et al., 2015, Matallaoui et al., 2015, Monterrat et al., 2014, Piras et al., 2016, Sripada et al., 2016] recently appeared to reduce the complexity and resources needed by those difficult activities.

### **Gamification Frameworks from the Market**

The gamification frameworks available on the market, besides their advantages, have still important limitations Kazhamiakin et al. [2015], Piras et al. [2017a], Sripada et al. [2016]. Most of them are not flexible and generic enough to be successfully applied to a variety of cases, mainly because they are domain-specific design (e.g., Youtopia <sup>2</sup> focuses only on education), support only a reduced set of gamification concepts (e.g., UserInfuser <sup>3</sup> and Mozilla OpenBadges <sup>4</sup>) Herzig et al. [2012], and are quite limited in their expressiveness to design a significant variety of gamification scenarios. Another limitation is due to the dependence on third-party environments in relation to configuration, implementation, maintenance or run time aspects, such as most of the platform illustrated in Herzig et al. [2012]. This means that the provider does not sell an engine that is self-contained but one that needs to continuously interact with the provider's servers or to be managed by the specialized personnel of the provider.

There are many commercial solutions and few free or open source solutions. Both have some of the deficiencies underlined above. For instance, two relevant open source platforms are Mozilla OpenBadges and UserInfuser. The authors of Goligoski [2012], Santos et al. [2013] described Mozilla OpenBadges <sup>5</sup> and evaluated the positive impact offered by the employment of this framework. This platform allows users to collect their badges, which are achieved in various sites in the web, in only one place. Moreover, Mozilla has proposed

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<sup>2</sup><http://www.youtopia.com>

<sup>3</sup><https://code.google.com/archive/p/userinfuser/>

<sup>4</sup><https://openbadges.org/>

<sup>5</sup><https://openbadges.org/>

a standard, which is used by other sites, to reward users with badges that are compliant with the Mozilla's system; in that way, the badges achieved in other sites can be added directly to the virtual backpack provided by Mozilla. Some fellow sites of Mozilla, which are oriented towards assigning badges for the education field, are Youtopia<sup>6</sup>, Badg.us<sup>7</sup>, Makewaves<sup>8</sup>, and Classbadges<sup>9</sup>. Mozilla has designed an interesting infrastructure that is reliable and well supported by a large community; unfortunately, it is focused only on badges.

UserInfuser<sup>10</sup> is an open source gamification platform that can be integrated in another system and customized in relation to the gamification concepts available. If a developer wants to employ it in his or her environment can do that with no third party dependence. Unfortunately, UserInfuser does not support a web service layer that could be useful to decouple the gamification platform from the application that is to be gamified; moreover, it is focused only on a reduced set of gamification concepts.

### Gamification Frameworks from the Literature

In the literature there are still a few (but increasing in numbers) studies that try to overcome the limitations of existing frameworks, thus that topic appears to open new research directions. Some researchers propose generic gamification engineering approaches and generic frameworks that are more flexible and employable in a wider range of cases Herzig et al. [2012], Kazhamiakin et al. [2015], Monterrat et al. [2014], Sripada et al. [2016].

Herzig et al. Herzig et al. [2012] present a prototype gamification platform for enterprise information systems and business-to-business integrated systems based on an event-driven architecture.

Monterrat et al. Monterrat et al. [2014] proposed a generic gamification system for gamifying learning environments acting at the presentation level. It selects, on the basis of the users behavior, gamified elements for engaging more the player and adds them to the user interface dynamically.

Kazhamiakin et al. Kazhamiakin et al. [2015] developed an extensible service-oriented gamification engine and tested it successfully in a field case study concerning motivating citizens to use sustainable urban transports.

Sripada et al. Sripada et al. [2016] describes a generic, extensible framework for modeling

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<sup>6</sup><http://www.youtopia.com>

<sup>7</sup><http://badg.us/>

<sup>8</sup><https://www.makewav.es/>

<sup>9</sup><http://classbadges.com/>

<sup>10</sup><https://code.google.com/archive/p/userinfuser/>

gamification concepts as modules able to expose RESTful web services. They defined a service-oriented architecture able to integrate and extend already existing gamification services. Their study aims at gamifying software engineering tasks.

#### Agon Compared to the other Gamification Frameworks

Gamification frameworks mentioned earlier provide support regarding gamification design and development activities. At the time of writing, the only framework able to support the analyst in the requirements elicitation and analysis phases for applying gamification to a system is Agon [Piras et al., 2016, 2017a,b]. Agon is an *Acceptance Requirements Framework* where the designer takes into account the kind of user/player to engage and select the most suitable psychological/cognitive strategies and gamification concepts to employ to produce an effective gamified solution. Agon is founded on the premise that gamifications are solutions to *Acceptance Requirements* Piras et al. [2017b] that stakeholders have about a system-to-be. We describe in detail Agon, through different chapters, starting from the Chapter 4.

## 2.3 Acceptance, Gamification and Requirements Engineering

The acceptance of a software system, i.e. motivating people in accepting and using a software system is a crucial factor for the success of a system [Piras et al., 2016, 2017a,b]. *Gamification* meets such *Acceptance Requirements* [Piras et al., 2016, 2017a,b] through insertion of game elements and game strategies in systems that operate in non-game contexts [Deterding et al., 2011] (e.g., sustainable mobility [Kazhamiakin et al., 2015], air traffic management and decision making [Piras et al., 2017b], software engineering tasks [Pedreira et al., 2015]).

However, just following available gamification guidelines is not enough to design engaging software [Hamari, 2015, Koivisto and Hamari, 2014b, Piras et al., 2017a]. Practitioners tend to use available gamification guidelines and resources, which are provided in commercial platforms or in publicly available wikis<sup>11</sup>. Accordingly, research literature on gamification design and on the evaluation of the effectiveness of the resulting solutions, points out the limits of current practices, identifies key concepts and discuss the need of specific methods to design engaging software [Hamari, 2015, Koivisto and Hamari, 2014b, Piras et al., 2017a]. In particular, systematic methodologies should guide designers in the exploration of a design space of alternatives [Piras et al., 2016, 2017a,b]. Such a design

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<sup>11</sup>e.g., [https://en.wikipedia.org/wiki/Game\\_mechanics](https://en.wikipedia.org/wiki/Game_mechanics)

space is defined in terms of motivational, psychological, cognitive, behavioral factors [Piras et al., 2017a] that influence the fulfillment of *Acceptance Requirements* [Piras et al., 2016, 2017b]. For instance, the fact that the approach of applying available gamification guidelines directly to a software system is not enough to create engaging software, has been confirmed in the case of the *DMGame* tool [Busetta et al., 2017]. DMGame is a gamified collaborative requirements prioritization tool, which has been developed within the European project SUPERSEDE<sup>12</sup> [Busetta et al., 2017]. The tool has been validated in the context of three industrial use cases. Moreover, the effectiveness of specific game elements was further investigated through an experiment [Kifetew et al., 2017] that confirmed a lack of acceptance by intended users.

In general, to increase the engagement of a system through the design of high-quality gamification, it is required an approach supporting systematic and wide acceptance requirements analysis [Piras et al., 2016, 2017a,b]. Furthermore, such an approach has to take into account the variables that affect positively the user needs and goals, on the basis of the analysis of the user characteristics, for selecting the most suitable gamification strategies to apply into the software functionalities [Piras et al., 2016, 2017a,b].

### 2.3.1 Acceptance and Requirements Engineering

Acceptance Requirements [Piras et al., 2017b] constitute a class of quality requirements as important as those concerning performance, security, etc. At the moment of writing, acceptance requirements have been considered for ad-hoc domains [Sutcliffe et al., 2014] or for the specific case of technology acceptance [Arning et al., 2013, Beer and Takayama, 2011, Davis and Venkatesh, 2004, Poston and Calvert, 2015]. While, we designed Agon with generic reference meta-models concerning software acceptance and gamification strategies, and in both of the cases models are not tied to a particular domain, they can be applied to a variety of domains by instantiating the generic solutions provided.

Sutcliffe and Sawyer [Sutcliffe and Sawyer, 2014] emphasize the importance of user attitude-related requirements in RE and present case studies where such requirements have been addressed through a combination of mechanisms. Our research has a different aim, which is to help the requirements engineer to deal with a specific class of attitude-related requirements, i.e. acceptance requirements, through a specific class of operationalization mechanisms, i.e. gamification.

### 2.3.2 Gamification and Requirements Engineering

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<sup>12</sup><https://www.supersede.eu/>

In the literature there are many gamification studies, from other fields, that do not employ software and requirements engineering knowledge. However, they could be relevant for enhancing requirements engineering practices, and current gamification frameworks, by including new gamification theories, as we did in the case of Agon. For example, MDA [Hunicke et al., 2004] is a formal and iterative approach to design games. It was developed in game design workshops and consists of the three components: mechanics, dynamics, aesthetics. The aim of the MDA framework is to “bridge the gap between game design and development, game criticism, and technical game research”. Although the authors present reasonable examples, it is unclear how the framework was developed and how it overlaps and can be integrated in existing software development approaches.

Another approach presented in literature is based on the analysis of gamified systems. The resulting Gamification patterns [Ašeriškis and Damaševičius, 2014] include constrain, extensions, property and chance, and solver patterns. The authors conducted a case study, but did not describe how the design patterns were integrated and applied in the development process.

Deterding [Deterding, 2015] introduces a gameful design method based on four steps in which the designer uses skill atoms and design lenses. The method was applied in two case studies, but, as stated by Deterding, “it lacks a formal empirical evaluation of its utility and usability”. Moreover, from our perspective, Deterding does not consider existing software and requirements engineering knowledge.

Concerning the application of gamification in requirements engineering tasks, the following research work are worth mentioning. iThink [Fernandes et al., 2012] and GREM [Lombriser et al., 2016] apply gamification to requirements elicitation within multi-user online games, where stakeholders collaborate and discuss with the mediation of an interactive system that mixes typical game elements (avatars, points in chats among players, etc.) with the traditional expression of requirements in form of textual statements. The gamified processes have been evaluated through the analysis of case studies. Findings indicate a greater engagement by stakeholders and greater productivity in terms of number of elicited requirements with respect to traditional face-to-face discussions.

Snijders et al. [Snijders et al., 2015] also propose a gamified approach for supporting requirement engineering activities in crowdsourcing settings, which they evaluated through a case study.

In the Requirement Engineering literature some studies that make use of gamification strategies with specific solutions for specific domains are emerging. Beckers and Pape [Beckers and Pape, 2016] analyze and create a desk game representing the real environment of a company and involve employees to play a game where the objective is

to elicit as many as possible social engineering security requirements.

Busetta et al. [Busetta et al., 2017], within the European project SUPERSEDE<sup>13</sup>, analyzed and created a gamified software for stimulating decision makers in prioritizing requirements. For this aim, they developed a gamified collaborative requirements prioritization tool [Busetta et al., 2017], and evaluated their approach in the context of three industrial use cases. Furthermore, the effectiveness of specific game elements was further investigated through an experiment [Kifetew et al., 2017] that confirmed a lack of acceptance by intended users.

Moreover, in the literature there are gamification frameworks (Section 2.2.3) for supporting gamification design and development tasks, but the unique framework for supporting requirements elicitation and analysis for gamifying a software system is Agon [Piras et al., 2016, 2017a,b]. This is explained in Section 2.2.3 and [Piras et al., 2017a]. We describe in detail Agon, through different chapters, starting from the Chapter 4.

## 2.4 Enhancements for Acceptance Requirements Engineering

*Acceptance Requirements Engineering*, and *Acceptance Requirements Engineering Frameworks* for analyzing and designing engaging software systems such as *Agon*, can be enhanced by taking advantage of concepts and techniques coming also from other fields [Piras et al., 2017a]. In Chapter 8 we consider approaches and frameworks coming from other fields, discuss which are the advantages obtainable by integrating them with *Agon*, and provide guidelines for executing such integration activities. In particular, in Chapter 8, we compare concepts and techniques, coming from *Organizational Behavior* and *Acceptance Requirements Engineering* fields, for achieving the same objective of developing engaging systems. Furthermore, we find that it could be possible, as a future work, to integrate the different strategies for obtaining an even more complete and effective approach, enabling the requirements analyst in having a wider space of alternatives and solutions [Piras et al., 2017a].

Specifically, the aim of this Section, is to highlight that it is beneficial to consider continuously other social sciences fields, and related concepts and rules, to be included in the design of a framework able to fulfill the objectives of this Thesis. In fact, in *Agon*, we have included relevant elements from social sciences, supporting the analyst with a wide range of alternatives, but not all the possible ones. We are aware that, as future work, could be very interesting to evaluate to include other valuable concepts, coming from those fields, to increase the space of alternatives offered by *Agon*. Accordingly, the

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<sup>13</sup><https://www.supersede.eu/>

main contribution of this Thesis has been to devise and propose a framework, its method, and a meta-model, with a well-defined infrastructure for analysing and designing engaging software, which is suitable to be extended, in the future, by including other concepts from other fields, for enriching its potential effectiveness.

In order to start illustrating this fundamental concept, in this Section we consider concepts coming from a potential candidate field, *Human and Organizational Behavior Studies*, and one framework of such field, the *Motivational Antecedents Framework* (MAF), as an example of a candidate framework to be integrated with Agon. It is important to note that this is just an example, indeed we do not want to claim that this is the only possible interesting field, actually there are many others and, with this, we want just to highlight the importance of the concept behind: to enrich/extend the alternatives space of a framework with the characteristics illustrated in this Thesis. With this aim, in the next, we briefly introduce MAF and its field, which is a very vast field, not being exhaustive, but giving an overview of the main concepts. We already started this future work, and illustrate related preliminary results, in a detailed way, in Chapter 8.

In the following sections, we briefly describe, as an example of field that could provide further improvements to Acceptance Requirements Engineering, main elements of the *Organizational Behavior* field. In Chapter 8, we discuss extensively this possibility.

### 2.4.1 Human and Organizational Behavior Studies

*Human and Organizational Behavior Studies* have proposed theories and best practices for the analysis of human-technology interactions that can serve as foundations for the design of systems that promote user participation. Moreover, motivational factors have been studied in *Organizational Studies*, *Experimental Economics*, *Sociology*, and *Political Science* since the 1930s Camerer [2003], Mayo [1949], Premack [1965], Vroom [1982].

In the last decades, various studies have focused on user motivational factors, human willingness to participate in a process, and best practices (*Mechanism Design*) for encouraging participation. The terms, the epistemologies and the languages used in organizational studies are very different than those in Requirements Engineering studies, but the subject of analysis is almost the same. These studies reveal that the inner motivations that drive people to participate are heterogeneous and strongly influenced by the uniqueness of each action. Some regularities can be identified and motivation can be categorized as: needs of reciprocity, reputation, competition, conformity to a group, altruism, self esteem, fun and personal enjoyment, implicit promise of future rewards, and money Cuel et al. [2011], Tokarchuk et al. [2012]. Nowadays some of these factors can be profitably

used as antecedents to identify incentives, best practices and game mechanisms that spur individuals to act in accordance with a specific goal [Unkelos-Shpigel and Hadar, 2015].

In Simperl et al. [2013], Tokarchuk et al. [2012] an extensive analysis of various studies on motivation have been conducted from an *Organizational Study* perspective, and some variables have been identified as ones that influence contributor/worker performance. These variables are described in the *Motivational Antecedents Framework* Simperl et al. [2013], Tokarchuk et al. [2012].

### 2.4.2 Agon and the Motivational Antecedents Framework

The *Motivational Antecedents Framework* (MAF) Simperl et al. [2013], Tokarchuk et al. [2012] has been developed in the field of *Organizational Studies*, intended to support the analysis of human behaviors in physical and organizational contexts. There is a huge field of studies on human behaviors, motivations and incentives in organization referred to as *Organizational Behavior* since the pioneering work of Mayo and his famous “Hawthorne and the Western Electric Company” case study Mayo [1949] in 1930. Even though MAF has not been designed with an engineering perspective, and its method is largely organizational studies-based, it can support the Requirements Engineering analysis phase analogously to Agon [Piras et al., 2017a]. Even though MAF was conceived in a field far away from Requirements Engineering, it has been used as a theoretical gamification framework to develop a set of incentives embedded and implemented in IT solutions Simperl et al. [2013], Tokarchuk et al. [2012].

In Chapter 8, we present a comprehensive comparison of two frameworks for software gamification, Agon and MAF [Piras et al., 2017a]. The two frameworks have their origins in strikingly different disciplines, even though they are tackling basically the same problem. Our comparison consisted of applying each framework to a meeting scheduling system, noting concepts used, forms of analysis employed, and the final outcomes consisting of gamification solutions for the meeting scheduler. Given the outcomes of the meeting scheduling case study, we have conducted a careful comparison of the two frameworks, noting relative strengths and weaknesses as well as gaps in the concepts, tools and techniques they offer [Piras et al., 2017a]. In addition, we have conducted an investigation on how to combine elements of the two frameworks into a single framework for designing gamified solutions for acceptance requirements. We provided guidelines for it, and as a future work, we will integrate the two frameworks [Piras et al., 2017a]. In Chapter 8, we provide more details concerning all these aspects.

## 2.5 Chapter Summary

In this chapter, we review Acceptance and Gamification studies from the literature and real cases from the industry. We consider both studies coming from other fields and, above all, the ones closer to acceptance and gamification within the Software Engineering and Requirements Engineering fields.

In Section 2.1, we introduce it, we discuss Acceptance Requirements, their operationalization techniques and the support for them provided by Agon. Then, we review Acceptance Models that are the baseline on which we designed the Agon Acceptance Model (Chapter 4).

In Section 2.2 we discuss Gamification and Gamification Engineering (see Definition 1.1), introducing them and the main related aspects. Furthermore, to show the powerful and flexibility of gamification we illustrate success cases from heterogeneous domains. Then, we describe main activities and challenges related to the software engineering gamification process, and the main gamification concepts that can be employed. We finish this section, revising gamification frameworks (see Definition 1.2) and comparing them with Agon.

In Section 2.3, we highlights the importance of considering Acceptance aspects in the Software Engineering of Gamification, and revise Acceptance and Gamification studies close to the Requirements Engineering field.

Finally, in Section 2.4, illustrate approaches coming also from other fields, e.g., Human and Organizational Behavior studies, for enhancing the *Acceptance Requirements Engineering* field and *Acceptance Requirements Engineering Frameworks* such as Agon. In Chapter 8, we discuss extensively this possibility.

## Chapter 3

# Gamification of Software Systems

In this Chapter we describe two gamification experiences, we carried out personally, for gamifying software systems. Specifically, the first one (Section 3.1) is a gamification experiment [Kazhamiakin et al., 2015, Wohlin et al., 2012], conducted with explanatory quantitative research methods [Kazhamiakin et al., 2015, Wohlin et al., 2012], and the second one (Section 3.2) is a preliminary theoretical study [Piras et al., 2015, Wohlin et al., 2012], conducted with preliminary exploratory qualitative research methods [Piras et al., 2015, Wohlin et al., 2012]. Both the experiences, above all the first one, helped us to understand better, by employing gamification techniques to real and realistic cases, the complexity behind the analysis, design, development and delivering of engaging software systems. Moreover, these experiences helped us also in the design of the Agon Framework (Chapter 4).

In Section 3.1 we describe a gamification experiment on a real scenario, we conducted it in the context of the STREETLIFE European project<sup>1</sup>, where we applied gamification for incentivizing citizens to choose *Sustainable Urban Mobility* (SUM) solutions [Kazhamiakin et al., 2015].

In Section 3.2 we illustrate a preliminary theoretical study, applied to a realistic scenario, using gamification for favoring *Mobility Assistance for Children* (MA4C) [Piras et al., 2015].

In Section 3.3, we discuss the lessons learned we derived from our experiences and, above all, from our wide literature review (Chapter 2). On the basis of this, we illustrate the key requirements, we identified, for the design of a framework for supporting the requirements analyst in the analysis and design of engaging software. Such requirements led us to the design of the Agon Framework we describe in Chapter 4.

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<sup>1</sup><http://www.streetlife-project.eu/>

We used these scenarios also for some case studies illustrated in the Chapter 7, where some master students carried out their master theses, under our supervision, by using the Agon framework for gamifying the related software systems.

## 3.1 Gamification for Sustainable Urban Mobility

*Sustainable Urban Mobility* (SUM) is an important dimension in a *Smart City* (see Definition 2.1), and one of the key issues for city sustainability. However, innovative and often costly mobility policies and solutions introduced by cities are liable to fail, if not combined with initiatives aimed at increasing the awareness of citizens, and promoting their behavioral change.

This study explores the potential of gamification mechanisms to incentivize voluntary behavioural changes towards sustainable mobility solutions. We present a service-based gamification framework [Kazhamiakin et al., 2015], developed within the STREETLIFE EU Project<sup>2</sup>, which can be used to develop games on top of existing services and systems within a Smart City [Kazhamiakin et al., 2015], and discuss the empirical findings of an experiment conducted in the city of Rovereto on the effectiveness of gamification to promote sustainable urban mobility [Kazhamiakin et al., 2015].

The rest of the Section is structured as follows. In Section 3.1.1 we introduce our study. In Section 3.1.2 we report on known uses of gamification in the domain of sustainable urban mobility, and indicate some recent works on frameworks and technologies to support the development of gamification solutions. In Section 3.1.3 we provide a technical overview of our service-based gamification framework. In Section 3.1.4 we outline the context and content of our experiment in Rovereto, discuss the experiment we have carried out and outline the gamification solution we have implemented. In Section 3.1.5 we discuss the most interesting empirical results that we have extracted from the experiment. Finally, in Section 3.1.6 we offer some reflections on the lessons we have learned and on future work directions on the topic of gamification in Smart Cities.

### 3.1.1 Using Gamification to Incentivize Sustainable Urban Mobility

Facilitating and promoting more *Sustainable Mobility* means and habits is an objective of increasing importance for cities across the globe [Kazhamiakin et al., 2015]. Sustainable urban mobility has captured a lot of attention as one among the principal dimensions in a Smart City Giffinger et al. [2010]. Leveraging advanced ICT assets to help reaching that

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<sup>2</sup><http://www.streetlife-project.eu/>

objective is a significant challenge and, at the same time, a great opportunity to make a city, its citizens and its governance institutions smarter, as advocated in Nam and Pardo [2011].

The promotion of *Voluntary Travel Behavior Change* (VTBC) has been indicated as a key issue for sustainable urban mobility in the scientific literature Banister [2008], Brög et al. [2009], as well as in official national and international policy documents European Commission [2011]; it is tightly coupled with the definition and execution of city-wide mobility policies. On the one hand, policies that target sustainability - and the corresponding smart mobility services - can be successful only when embraced by citizens in a convinced and continued way; on the other hand, city policies that administer effective incentives can help to break citizens' habits, affect their mobility choices, boost acceptance, and, ultimately, make a difference in the urban environment.

We have been developing a Smart City service platform [Kazhamiakin et al., 2015], which operates on both sides of that equation within the STREETLIFE European project<sup>3</sup>. We provide mechanisms to embed and implement city-level policies within a set of smart mobility services provisioned by our platform, such as journey planning and route recommendation services that are routinely used by citizens [Kazhamiakin et al., 2015]. Moreover, we provide mechanisms to incentivize citizens to take choices in accord with those mobility policies, by means of gamification. We have developed a generic, service-based gamification framework [Kazhamiakin et al., 2015], which enables to design, deploy and execute games that predicate on how citizens use the repertoire of Smart City services provisioned by - or simply interfacing with - our platform [Kazhamiakin et al., 2015]. This enables a gamification designer to conceive games that augment the citizens awareness of existing and new sustainable mobility policies and services in the city, and motivates them to embrace the corresponding enabling ICT solutions, in order to gain status and reputation in the game, and earn rewards (either virtual or material) [Kazhamiakin et al., 2015].

In the following sections, we describe the results of our approach, by illustrating an experiment we have conducted in the Fall of 2014 in the city of Rovereto, Italy, describing the gamification affordances we have developed for that experiment, and reporting the empirical findings related to the sustainable urban mobility outcomes [Kazhamiakin et al., 2015]. The results show the potential of gamification to support VTBC and indicate how a gamification framework like the one we are developing [Kazhamiakin et al., 2015] can become an important asset for the promotion of sustainable behaviors and city-wide policies related to the services made available within a complex socio-technical system like

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<sup>3</sup><http://www.streetlife-project.eu/>

a Smart City [Kazhamiakin et al., 2015].

#### 3.1.2 Research Context

Gamification is often defined as “*the use of game design elements in non-game contexts*” [Deterding et al., 2011]. Nowadays, gamification is leveraged to stimulate specific usage patterns by users or customers of an ICT system in some business domain, by injecting mechanisms and concepts typical of games within the system, even if it was not originally designed with playful intentions in mind [Deterding et al., 2011]. Among the most commonly used gamification elements there are *points*, *badges* and *leaderboards*; more advanced ones include *levels*, *paths*, *challenges*, *missions*, *feedback*, and *user powers* [Deterding et al., 2011, Piras et al., 2016, Zichermann and Cunningham, 2011].

Gamification has been successful in many domains [Hamari et al., 2014, Piras et al., 2017b]. It leverages fun, competition, rewards and game mechanics in ICT-mediated contexts for marketing, or to motivate employees to work towards specific enterprise objectives, or to incentivize virtuous behavioral changes in society at large (for example, it has been shown to motivate people to have regular physical activity [Walsh and Golbeck, 2014], or to achieve energy savings [Cowley et al., 2011]).

Gamification can influence citizens’ behaviour in relation to many *Smart Cities* concerns, such as participatory governance, tourism, culture, education, etc. Our study is in the area of gamification for *Smart and Sustainable Urban Mobility*. Some other recent works have reported promising results in this area. Merugu et al. [2009] illustrate an application to reduce traffic congestion. Hoh et al. [2012] couple gamification and crowdsourcing to incentivize citizens in sharing information about parking spaces in the city. Gabrielli et al. describe a design method for gamification and apply it to case studies carried out in four European cities [2013, 2014]. Buningh et al. [2014b] implemented a gamified system for stimulating company employees to choose sustainable means of commuting to work. Wells et al. [2014] propose a gamification model for motivating users to embrace sustainable mobility, which tracks people’s mobility behaviours and proposes challenges modulated on the basis of their current progress. Similarly, the Tripzoom platform [Holleis et al., 2012] was used in three European cities [Poslad et al., 2015] to identify mobility behavioural patterns of citizens, then propose and reward gamified personalized mobility solutions that improve CO<sub>2</sub> emissions, players’ health and time.

While gamification offers considerable promise to sustainable urban mobility and Smart Cities in general, its implementation for a given context remains difficult and

expensive [Piras et al., 2016, 2017a,b]. Most applications are tightly coupled to the specific business logic they wish to gamify, which hinders both evolution and reuse. Furthermore, they often require the gamification expert to redefine many of the concepts of the business domain in a gamified form, which leads to information duplication. For these reasons, in the last few years research has begun to focus on gamification frameworks [Piras et al., 2016, 2017a,b], that is, platforms and tool sets that can help making the design and development of gamification applications easier, faster and cheaper. Gamification frameworks are reviewed in Chapter 2.

In this study, we aim at building a *generic* and *extensible* gamification framework [Kazhamiakin et al., 2015], by leveraging the service-oriented paradigm. The key aspect of our framework [Kazhamiakin et al., 2015] is to be able to integrate in a wide array of games the ever-growing number and variety of ICT systems, applications and services that exist in a Smart City [Kazhamiakin et al., 2015]. Our goal is to provide tools to *gamify a Smart City* [Sakamoto et al., 2014], and facilitate the deployment of games which incentivize players to make use of those diverse ICT resources in ways that are beneficial to the community, thus becoming active participants in the governance of the Smart City [Kazhamiakin et al., 2015]. A distinguishing trait of our framework is that it establishes a tight and explicit link between programmable city policies and mechanisms that incentivize citizens to support those policies, embodied in gamification solutions [Kazhamiakin et al., 2015].

### 3.1.3 Technical solution

We are developing a gamification framework [Kazhamiakin et al., 2015], which must support the specification and execution of a wide variety of games within a Smart City [Kazhamiakin et al., 2015]. Figure 3.1 shows the main building blocks of our framework [Kazhamiakin et al., 2015], i.e., a Gamification Engine (GE) [Kazhamiakin et al., 2015] for the instantiation and execution of games; a wrapping layer that manages the interactions between the GE and any involved ICT systems of the Smart City; a game presentation layer that indicates to players their game progression; an extensible set of gamification plugins, which represent typical concepts that can be used in defining a game, and which encapsulate logic and idiosyncratic properties specific to each concept [Kazhamiakin et al., 2015].

A Smart City is an eminently open-boundary system, in which new and heterogeneous ICT affordances - ranging from new information systems, to sensors, to cyber-physical systems, to services, to terminals, to apps, etc. - can become available at any given time. A framework that wants to cope with (and take advantage of) this variety and dynamism must have the characteristics of *openness* and *generality*. For this reason, we have built

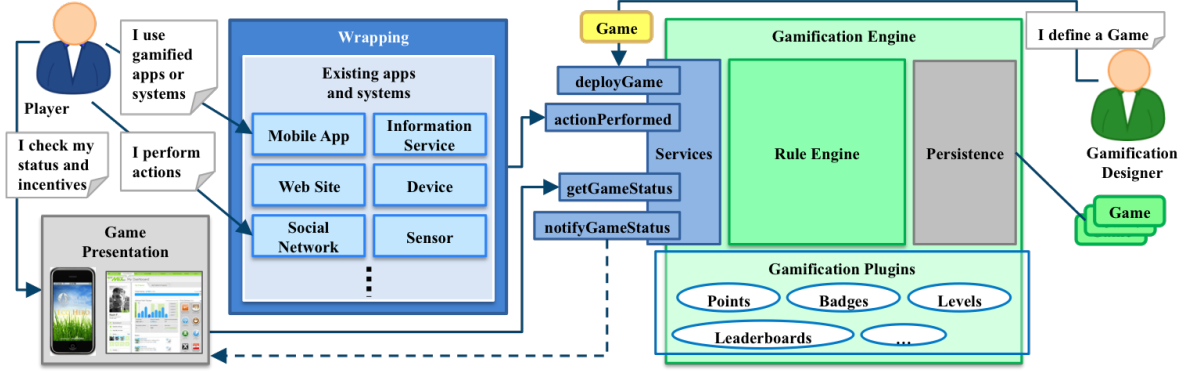


Figure 3.1: Architecture of the gamification framework [Kazhamiakin et al., 2015]

our gamification framework [Kazhamiakin et al., 2015] upon the unifying abstraction of *service*, and in accord with the architectural principles of service orientation. Service concepts and technologies are prevalent and ubiquitous in a Smart City; we assume that the resources, systems and applications that must be involved in each of the games that are developed with our framework expose game-relevant features as services (or, at least, in a way that makes possible to wrap them as services) [Kazhamiakin et al., 2015].

This is the purpose of the *wrapping layer* in Figure 3.1. Wrapping consists in integrating a lightweight Listener service, which issues notifications whenever game-relevant actions, which we call *gamifiable actions* are taken by the citizen/player, or otherwise occur on the wrapped systems.

**Definition 3.1 (Gamifiable Action).** *Action that a user can perform on a system on the basis of an existing system function, on which gamification mechanisms can be applied for decorating the function an making the related action more interesting and appealing to the user.*

It is the responsibility of the gamification designer to designate such gamifiable actions (see Definition 3.1) and the content of the corresponding notifications. The general form of a notification is [Kazhamiakin et al., 2015]:

$$\langle \text{gamifiableActionID}, \text{playerID}, \text{timeStamp}, \text{parametersMap} \rangle \quad (3.1)$$

In the notification, `gamifiableActionID` is a unique ID and the `parametersMap` contains a set of key/value pairs that are specific to that gamifiable action [Kazhamiakin et al., 2015] (see Definition 3.1). The wrapping layer issues notifications on behalf of the wrapped ICT systems through a simple `actionPerformed` service interface exposed by the GE [Kazhamiakin et al., 2015]. Moreover, the wrapping layer enables strongly decoupled

interactions between the native Smart City functionalities involved in a specific game and the GE, which is the component responsible to execute that game and managing its status [Kazhamiakin et al., 2015].

The core of the GE is a rule execution system, in which one or more games may run concurrently [Kazhamiakin et al., 2015]. In our current prototype we use the Open Source DROOLS<sup>4</sup> rule engine. Each game is thus represented by a rule set, which implements the desired game logic, which has been specified in advance by the gamification designer, and deployed onto the rule engine runtime. Game rules are fired in response to the gamifiable actions (see Definition 3.1) received through the service interface `actionPerformed`. Gamifiable actions serve as triggers for the game logic rules, which predicate upon an in-memory object base. This object base represents the game state for each participating player, as well as any global state the game may need to maintain, and is populated by instantiating *gamification plugins* [Kazhamiakin et al., 2015].

**Definition 3.2 (Gamification Plugin).** *A Gamification (or Game) Plugin is a service-oriented module that represent a gamification concept and manages all instances of that concept; it exposes service operations that can be used to interact with the gamification concept, and implements them in compliance with the concept's gamification semantics [Kazhamiakin et al., 2015].*

As a very simple example, the plugin for the *Badge Collection* concept exposes operations to assign (and possibly revoke) a badge to a player and insert it in the collection; also, since it does not make sense for a player to collect the same badge repeatedly, the implementation of the assign operation of the `BadgeCollectionPlugin` includes a guard to check whether the player has already earned that badge [Kazhamiakin et al., 2015].

The game state evolves as the right-hand side of the game rules manipulates the object base through the plugins services. Besides changing the state of the game, rules can also issue additional notifications; these notifications can be consumed by the GE rule system [Kazhamiakin et al., 2015]. To continue the example above, the completion of a badge collection can cause a new event, which is consumed by a *Player Level* concept, to move the player to the next game level. That in turn, can cause an event that unlocks new game elements such as a new *Power* or *Challenge* [Kazhamiakin et al., 2015].

Events generated internally to the GE can also be issued to external wrapped systems, including user Apps (e.g., for pushing notifications of game achievements to the players). That is one mechanism that supports the presentation of the game state to players [Kazhamiakin et al., 2015]. The presentation layer of the framework also offers a

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<sup>4</sup><http://www.drools.org>

pull mechanism, which queries the GE through a `getGameStatus` service, and retrieves information specific to the various plugins (see Definition 3.2). This can be used to generate dynamic Web pages that offer a view of the game state (for example points, leaderboards, or player’s achievements, etc.) [Kazhamiakin et al., 2015]. Furthermore, the Game Presentation layer can similarly be used to issue notifications (`notifyGameStatus` service) on the part of the GE; this is especially useful to communicate with players via interactive modes, for example to issue alerts, invitations to challenges, or other game-relevant events [Kazhamiakin et al., 2015].

The final responsibility of the gamification engine is the game persistence. That entails saving the rule base as well as checkpointing, separately, the game instances in execution, i.e. all players’ states plus any global state of each game [Kazhamiakin et al., 2015]. Our persistence layer is implemented as a NoSQL database [Kazhamiakin et al., 2015].

### **3.1.4 The Experiment and The Gamified ViaggiaRovereto App**

Rovereto is a medium-small city of about 40.000 inhabitants situated in the North-East of Italy. Despite its small size in comparison to other European municipalities, the city is exposed to a significant traffic pressure especially in the city centre. On average, each two inhabitants, one owns a car, and if we consider the modal split, the percentage of trips travelled by private vehicles is 59% Comune di Rovereto [2011]. Moreover, parked cars occupy high valued space in the city centre that could be used by pedestrians and cyclists. The occupancy rate of parking areas in certain central zones reaches 90%, and this generates additional traffic related to vehicles looking for parking.

The city invested considerable effort and resources in improving the mobility situation. For instance, Rovereto has more than 30 km of bicycle lanes and in the future the total length of the bicycle network is foreseen to be almost 75 km. In addition, in September 2014, Rovereto launched a new bike sharing system with more than 10 stations.

In Fall 2014, within the STREETLIFE EU Project<sup>5</sup>, we conducted an experiment [Kazhamiakin et al., 2015] to evaluate the impact of sustainable mobility recommendations and gamification incentives on the mobility behavior of commuters that need to travel routinely to the center of the city by car [Kazhamiakin et al., 2015]. For the experiment, we recruited a group of 40 users, who responded to invitations we sent to all people who pay a yearly fee for on-street parking permits in the central area of Rovereto, but reside outside the center [Kazhamiakin et al., 2015].

At the beginning of the experiment, we met the participants and instructed them to

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<sup>5</sup><http://www.streetlife-project.eu/>

use our routing mobile App *Viaggia Rovereto*<sup>6</sup> for their daily itinerary planning, so that we could log and store their mobility behavior during the experiment. The experiment spanned 5 weeks, and consisted of three phases [Kazhamiakin et al., 2015].

In *phase 1 (baseline)* (1 week) [Kazhamiakin et al., 2015] the end users had to simply familiarize with the App and record their regular itineraries and normal mobility behavior [Kazhamiakin et al., 2015]. The *Not Gamified* version of the ViaggiaRovereto app allows the user to plan in a multi-modal way her trips, receiving travel assistance, in the area of the Rovereto city, by elaborating solutions including all the available public and shared transports such as bus, bike sharing, car sharing, train, car pooling, park&ride [Kazhamiakin et al., 2015, Nurminen et al., 2014b]. Parts of the solutions can be elaborated also by taking into account personal bikes, cars or just walking [Kazhamiakin et al., 2015, Nurminen et al., 2014b]. In a nutshell, the most important features of the *Not Gamified* ViaggiaRovereto app are the following ones [Kazhamiakin et al., 2015, Nurminen et al., 2014b] (Figure 3.2):

1. the possibility to view, in the app, updated information concerning parking availability and public transport timetables;
2. the planning of multi-modal personalized trips with shared mobility services (e.g., bike sharing and car sharing), and with the other public transports;
3. the monitoring of saved usual routes of the user, also by receiving from the app real-time notifications for problems, strikes, timetable changes and delays;
4. the possibility for the user to be pro-active in reporting, in real-time, delays or other problems happening during the usage of public and shared transports.

In *phase 2 (recommendations without gamification)* (2 weeks) [Kazhamiakin et al., 2015] we switched on an additional Viaggia Rovereto functionality, i.e., sustainable mobility recommendations. The App started to rate the alternative routes for each itinerary requested, based on sustainability policies defined in accord with the mobility management of the city of Rovereto, and configured within our journey planner service; the App would then present the highest-rated options by highlighting them in green to the user and placing them in the first positions at the top of the list (see Fig. 3.3). The policies we implemented aimed at pushing those itinerary solutions that - besides having a low carbon impact - would either include Park&Ride solutions or promote the new bike-sharing service [Kazhamiakin et al., 2015].

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<sup>6</sup>Available on Google Play at <https://play.google.com/store/apps/details?id=eu.trentorise.smartcampus.viaggiarovereto&hl=en>

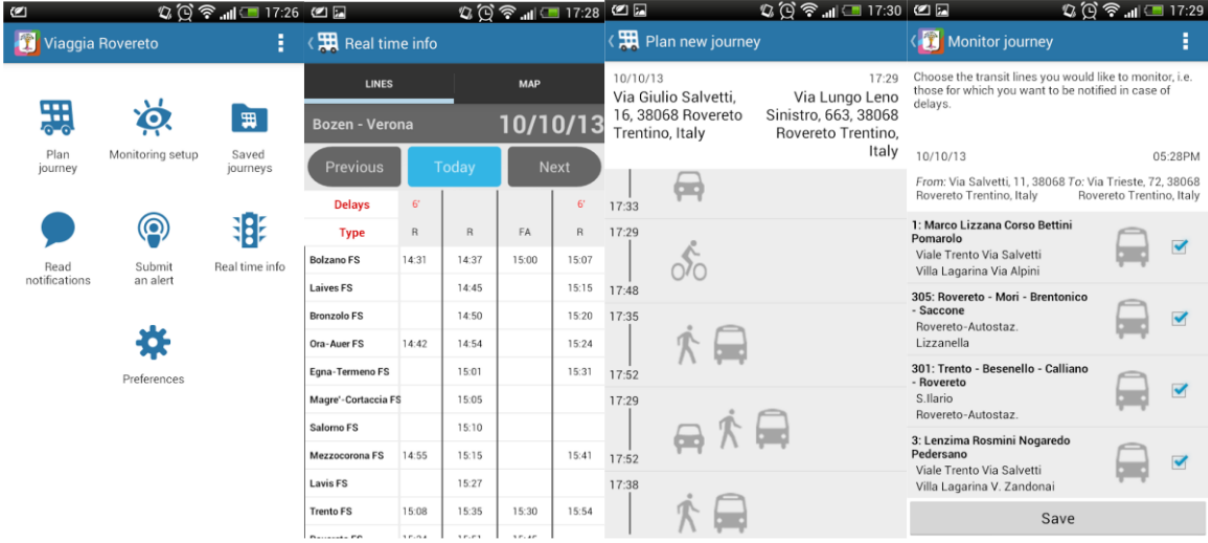


Figure 3.2: Software features of the *Not Gamified ViaggiaRovereto* mobile app [Kazhamiakin et al., 2015, Nurminen et al., 2014b]

In *phase 3 (gamification)* (2 weeks) [Kazhamiakin et al., 2015] we introduced gamification on top of the features of phase 2, and we launched the “*Green Game with ViaggiaRovereto*”. Some of the gamified software features of the *Gamified ViaggiaRovereto* app are shown in Figure 3.4. Specifically, the game included three separate types of points with the corresponding leaderboards [Deterding, 2015, Zichermann and Cunningham, 2011] (e.g., one is the leaderboard in Figure 3.4): Green Points (related to km traveled with sustainable transportation means, Figure 3.4), Health Points (related to km traveled biking or walking, Figure 3.3) and Park&Ride points (related to repeated usage of Park&Ride facilities, Figure 3.3) [Kazhamiakin et al., 2015]. We also implemented a variety of badges and badge collections [Kazhamiakin et al., 2015] (Figure 3.3 and Figure 3.4), some of which were linked to reaching certain amounts of points in the three categories above, or occupying a prominent position in one of the leaderboards [Deterding, 2015, Zichermann and Cunningham, 2011], while others (including some “Surprise Badges” [Deterding, 2015, Zichermann and Cunningham, 2011]) were awarded when the user took specific kinds of trips, or explored some mobility alternatives (e.g. when they used the designated Park&Ride facilities for the first time, tried the Bike Sharing service for the first time, etc.) [Kazhamiakin et al., 2015].

In order to outline the most important parts of the game, in the next we provide 2 of the most important use cases of the *Gamified ViaggiaRovereto* app [Kazhamiakin et al., 2015, Nurminen et al., 2014a] involving the user Patrizia, an imaginary Rovereto local

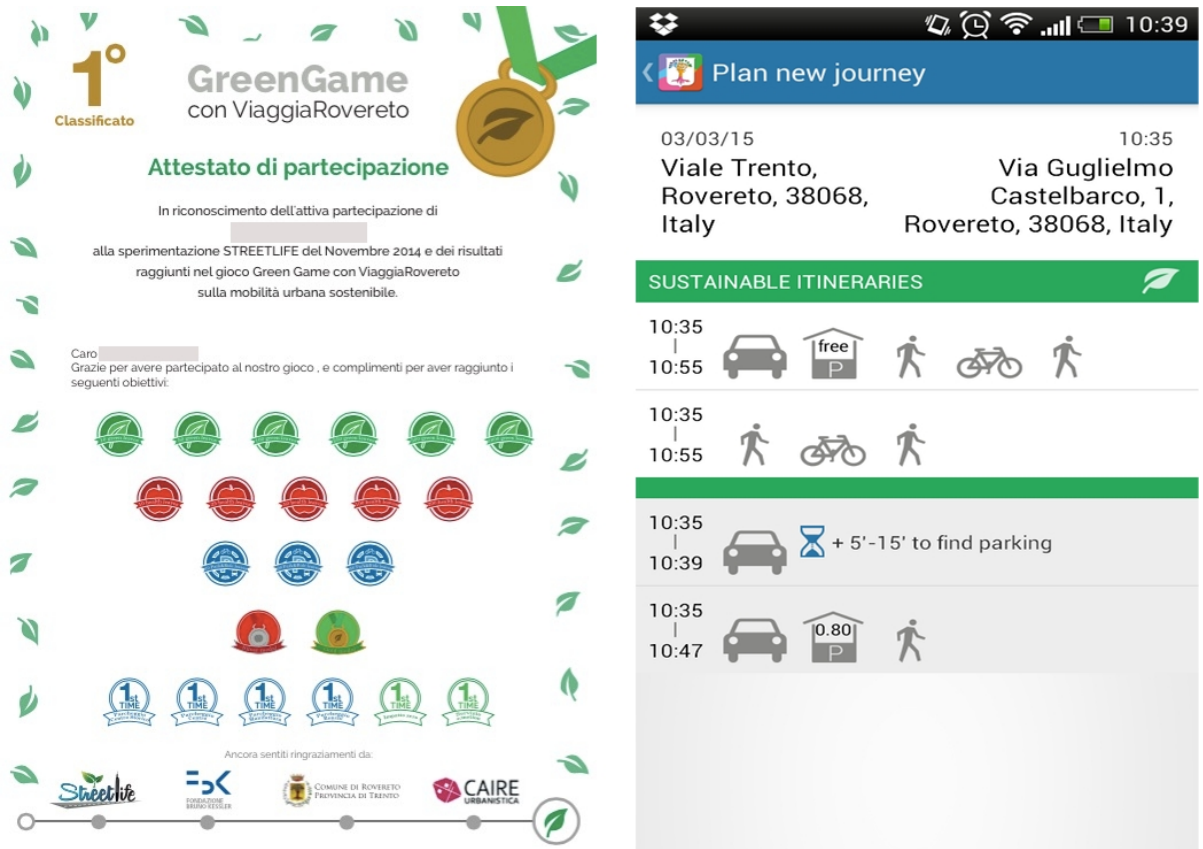


Figure 3.3: Certificate of attendance with game results (left) [Kazhamiakin et al., 2015] and recommendations from Viaggia Rovereto App (right) [Kazhamiakin et al., 2015]

person.

In the first use case, Patrizia uses daily the ViaggiaRovereto app [Kazhamiakin et al., 2015, Nurminen et al., 2014a], and she would like to visit the MART museum of Rovereto [Kazhamiakin et al., 2015, Nurminen et al., 2014a]. Thus, she starts using ViaggiaRovereto for planning her trip, and obtains different solutions. Each solutions shows different transports options and different *Green Points* to earn. Points are calculated on the basis of the carbon emissions associated to the transports included in the solution [Kazhamiakin et al., 2015, Nurminen et al., 2014a]. The lower are the emissions, the higher is the amount of points. Patrizia would like to earn as many as possible green points, in order to compete with her friends trying to reach the highest positions of the ViaggiaRovereto leaderboard [Kazhamiakin et al., 2015, Nurminen et al., 2014a]. Therefore, she decides to follow the solution with the highest amount of green points. As a result, thanks to her choice, she climbs up a few positions in the leaderboards and obtains also the *Green Hero - Level 2* badge [Kazhamiakin et al., 2015, Nurminen et al.,

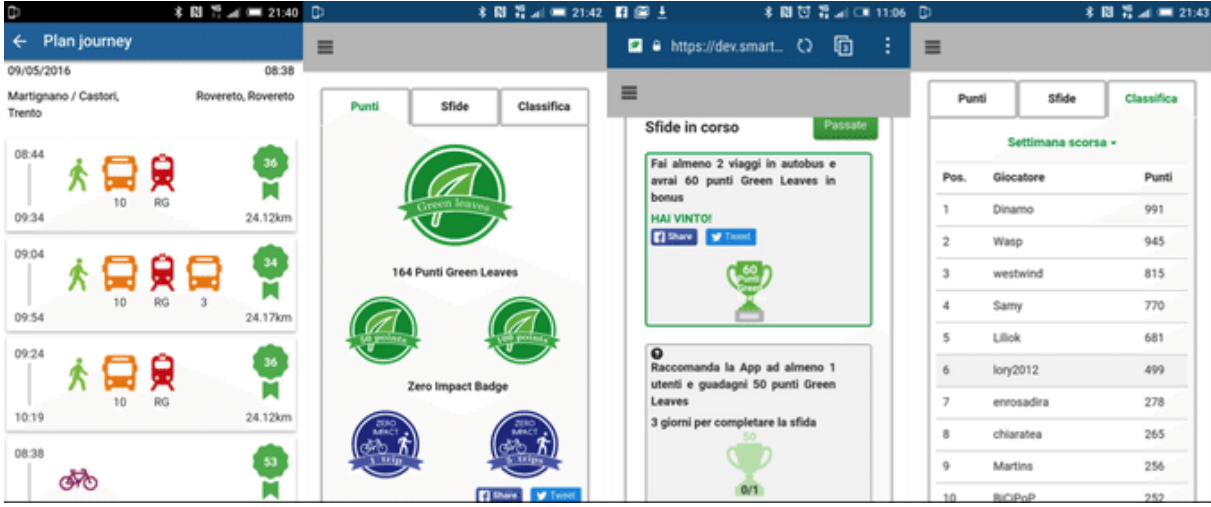


Figure 3.4: Gamified software features of the *Gamified ViaggiaRovereto* mobile app [Kazhamiakin et al., 2015, 2016, Nurminen et al., 2014b]

2014a]. She is even more satisfied than expected, because now she can also show to her friends the new badge collected, which will appear publicly in her user profile and into the leaderboard [Kazhamiakin et al., 2015, Nurminen et al., 2014a]. Furthermore, the app notifies her with a stimulating message for pushing her to complete her collection of badges, by continuing choosing sustainable solutions and, thus, climbing the ranking for staying in the highest positions [Kazhamiakin et al., 2015, Nurminen et al., 2014a]. Moreover, the app notifies her with a further incentive: if she will complete the badge collection, she can earn a reward, a weekly coupon for using the Rovereto shared transports for free [Kazhamiakin et al., 2015, Nurminen et al., 2014a].

In the second use case [Kazhamiakin et al., 2015, Nurminen et al., 2014a], it is highlighted one of the strategies for fostering users to use the Park&Ride services [Kazhamiakin et al., 2015, Nurminen et al., 2014a]. Patrizia receives a notification with a promotion stating that if she tries the Park&Ride service (the system is aware that she has never used this service before) twice this week, for reaching the center of Rovereto, she can earn one of the badges she is missing in her collection of badges, the *Mobility Explorer - Level 1*. Patrizia looks forward to achieve this badge, because she knows that by obtaining it, she can earn an award she is very interested in [Kazhamiakin et al., 2015, Nurminen et al., 2014a]. The system is able to engage her in completing activities fulfilling stakeholders' objectives (in this case the municipality of Rovereto is interested in promoting the Park&Ride service), by offering rewards and mechanisms to earn such rewards that are in line with the needs and interests of the user [Kazhamiakin et al., 2015, Nurminen et al.,

2014a]. This is possible because the system has many user information to consider, ranging from the analysis of the behavior of Patrizia in using the app and playing with it (her game status) to the characterization of Patrizia, with her needs and interests (including favorite rewards), acquired in preliminary phases [Kazhamiakin et al., 2015, Nurminen et al., 2014a].

Moreover, at the end of the game, all participants received a certificate reporting personal game achievements, like gained badges and points [Deterding, 2015, Zichermann and Cunningham, 2011] (see Fig. 3.3). The three best players were rewarded with a one-month free pass to the new bike sharing service [Kazhamiakin et al., 2015].

Across the three phases of the experiment, a total of 36 people made use of the system for planning their urban mobility itineraries. In phase 1 there were 26 active participants; in phase 2 there were 29; and in phase 3 there were 26 players in *Green Game with ViaggiaRovereto*. There were 20 participants who were active in all of the three experiment phases [Kazhamiakin et al., 2015].

### 3.1.5 Evaluation

The experiment in Section 3.1.4 has allowed us to collect and evaluate a wealth of data on the mobility behavior of participants and Rovereto citizens [Kazhamiakin et al., 2015]. We report here on a selected subset of our evaluation results [Kazhamiakin et al., 2015], for reasons of space; those empirical results speak to the effect of gamification, that is, how the mobility behavior of players taking part in the game in phase 3 of the experiment changed with respect to the other two phases. We thus address the following research questions [Kazhamiakin et al., 2015]:

- RQA** did the introduction of gamification encourage players to use the ViaggiaRovereto mobile App more frequently for their urban mobility planning needs? [Kazhamiakin et al., 2015]
- RQB** did the introduction of gamification incentivize players to select prevalently those route alternatives that were recommended by our system? [Kazhamiakin et al., 2015]
- RQC** if RQB is verified, how much did that form of VTBC impact the mode choices of the players towards more sustainable transport modes? [Kazhamiakin et al., 2015]

To address RQA [Kazhamiakin et al., 2015], we compared the distribution of the number of trips per user that were selected and saved by participants in each of the five

weeks of the experiment, as an indicator of how often users consult and make use of the App and the journey planning service; the hypothesis is that during the game weeks the App was consulted more frequently. The boxplot chart in Figure 3.5 assesses the changes in the distribution over those five weeks [Kazhamiakin et al., 2015]. The increment in App

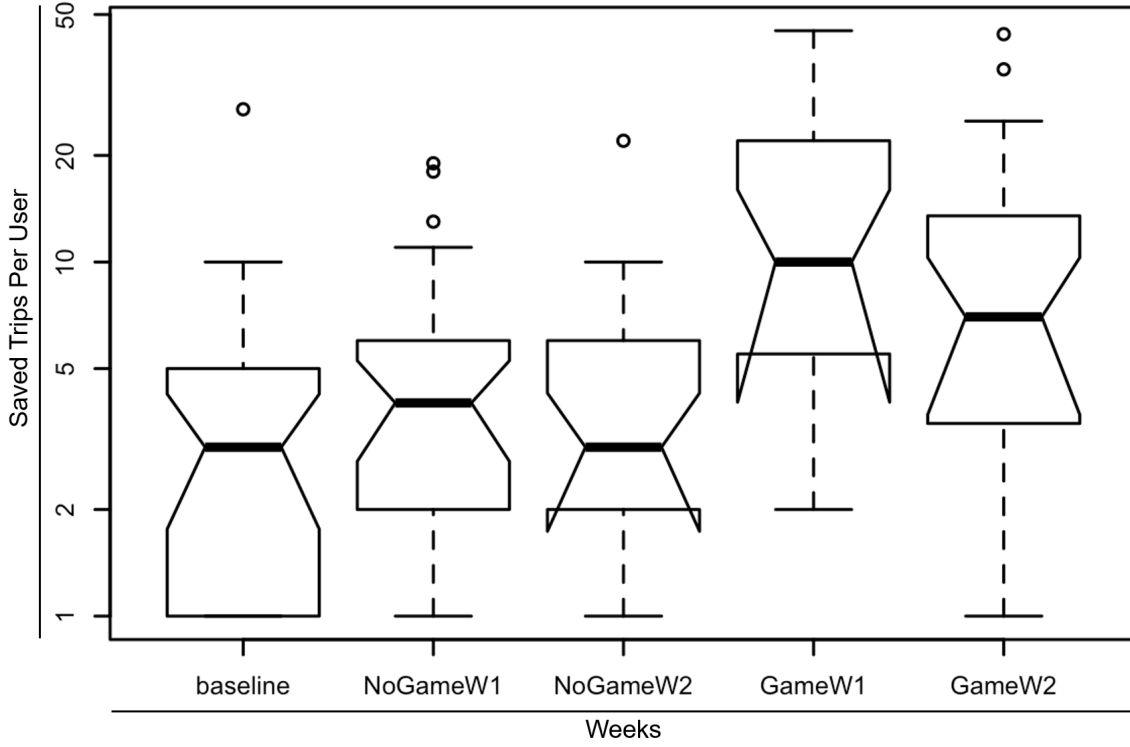


Figure 3.5: Distribution of saved trips per user during the experiment [Kazhamiakin et al., 2015]

usage during the game weeks compared to the baseline and non-game weeks is visually evident. To better understand the level of statistical significance of that difference, and since the distributions could not be considered normal, we have carried out non-parametric Mann-Whitney tests among the 5 weeks; we do not report the full crosstabs [Kazhamiakin et al., 2015], however, the results always indicate that the distributions of game weeks (4 and 5) are significantly different (greater than) the distributions of the other weeks, whereas the distributions of Weeks 1 to 3 are not statistically different [Kazhamiakin et al., 2015].

Those results are consistent with the hypothesis that *GreenGame with ViaggiaRovereto* has incentivized its players to make use of the ViaggiaRovereto App more frequently, and hence support a positive answer to RQA [Kazhamiakin et al., 2015].

To address RQB [Kazhamiakin et al., 2015], we compared the proportion of the routes chosen by users that were recommended by the ViaggiaRovereto App as sustainable during phase 3 vs. phase 2 (notice that a comparison with phase 1 was not available, because this feature was not active during the baseline phase); the hypothesis is that the game encouraged players to follow the sustainable mobility recommendations offered by the App. As shown in Table 3.1, during phase 2, the experiment participants selected sustainable routes for 42.7% of their itinerary choices. In phase 3, they selected sustainable routes 60.6% of the times [Kazhamiakin et al., 2015].

Table 3.1: Sustainable mobility recommendation acceptance [Kazhamiakin et al., 2015]

	phase 2 (no game)	phase 3 (game)
sustainable trips	105	323
total trips	246	533
ratio	42.7	60.6

We carried out a statistical proportion test on this data, to see whether the higher proportion in phase 3 is statistically significant. The results of that test are [Kazhamiakin et al., 2015]:

$$\text{X-square} = 21.1096 \quad \text{p-value} = 2.169\text{e-}06 \quad (3.2)$$

The higher proportion of sustainable route choices in phase 3 appears very significant statistically, which supports a positive answer to RQB [Kazhamiakin et al., 2015]. This is in line with our principal work hypothesis, i.e., gamification in a Smart City can be effective to instigate VTBC towards more sustainable urban mobility [Kazhamiakin et al., 2015].

To address RQC [Kazhamiakin et al., 2015], we tried to assess whether the VTBC we observed had in fact a positive effect, i.e., promoted the more sustainable modes of urban transportation in Rovereto. For that, we looked at changes in mode choice by the participants across the three phases. The hypothesis here is twofold [Kazhamiakin et al., 2015]: a) the activation of sustainable mobility recommendations in phase 2 caused significant mode shifts towards sustainability, with respect to the typical mobility habits captured in phase 1 [Kazhamiakin et al., 2015]; and b) the activation of gamification in Phase 3 further improved those mode shifts with respect to phase 2 [Kazhamiakin et al., 2015].

Figure 3.6 reports the relative share of the total Km. traveled for the six modes available to Rovereto commuters (individual car, public transport buses, train, the new

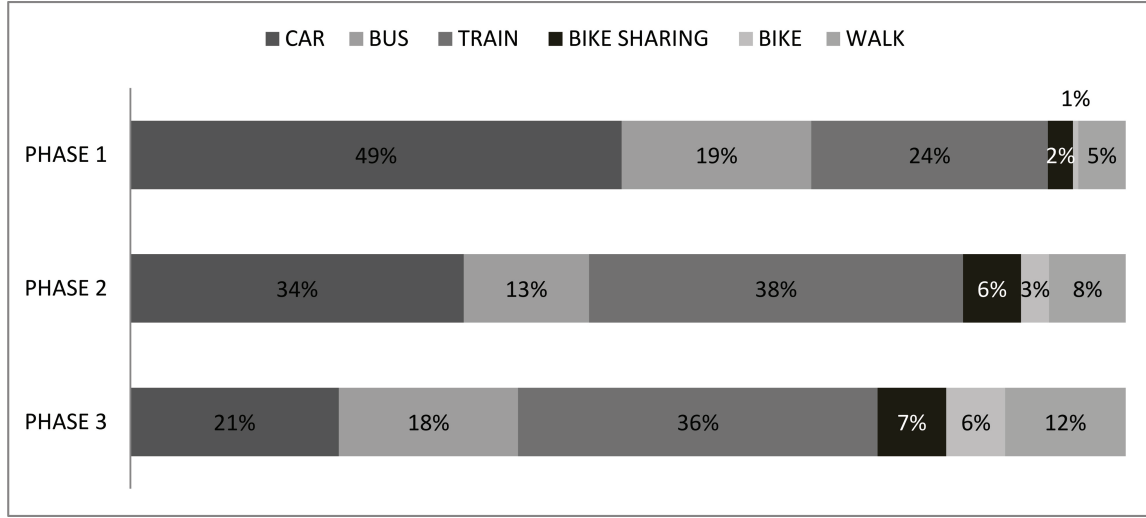


Figure 3.6: Percentage of Km traveled for each mode of transport [Kazhamiakin et al., 2015]

bike sharing service, private bicycle, and walking), and visually shows the shifts that occurred among experiment phases [Kazhamiakin et al., 2015]. In the rest of this section, we analyze in depth the significance of the shift for the car mode and the bike sharing mode, since those two modes were explicit targets of the city mobility management policies, which we strived to support [Kazhamiakin et al., 2015]. To analyze such hypothesized mode shifts, we looked first of all at the proportion of itineraries involving these two modes vs. the total number of itineraries recorded in each phase [Kazhamiakin et al., 2015].

Table 3.2: Trips using bike sharing and car modes [Kazhamiakin et al., 2015]

	phase 1 (baseline)	phase 2 (no game)	phase 3 (game)
total trips	<b>115</b>	<b>246</b>	<b>533</b>
car trips	40 (34.8%)	67 (27.2%)	90 (16.9%)***
bike sharing trips	13 (11.3%)	51 (20.7%)*	115 (21.6%)

Legend: \*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$

Table 3.2 recaps the percentage of chosen itineraries that involved at least one leg in either the car or bike sharing mode [Kazhamiakin et al., 2015]. We carried out proportion tests to understand the significance of the mode shift between each phase and the previous one. The findings obtained are the following [Kazhamiakin et al., 2015]:

- although there was a shift towards less frequent car usage between phase 1 and phase 2, that was not pronounced enough to be statistically significant given the sample (the p-value was 0.09) [Kazhamiakin et al., 2015]; however, the further shift towards less car usage during the game phase was very statistically significant, even with respect to the already reduced car usage observed in phase 2 [Kazhamiakin et al., 2015];
- there was a moderately significant shift towards more bike sharing usage between phases 1 and 2; that can be interpreted as users willing to accept the App recommendations to leverage the new bike sharing service for their mobility needs [Kazhamiakin et al., 2015]. That trend remained practically the same in phase 3; therefore, it looks like our game did not provide sufficient additional incentives to use bike sharing [Kazhamiakin et al., 2015].

Those two results point in the direction that gamification incentivized players to use their private cars less, which supports a positive answer to RQC [Kazhamiakin et al., 2015]. To further validate these findings, we then looked at the percentage of Km. traveled by each experiment participant in the bike sharing mode and car mode during each phase, and evaluated the difference between the corresponding distributions. Since those distributions are not normal, we used a non-parametric pairwise Wilcoxon test; the hypothesis is that the introduction of gamification induced a significant shift in the distributions (greater for bike sharing usage and lesser for car usage, respectively) [Kazhamiakin et al., 2015]. For both the bike sharing and the car mode, the considered population was the subset of participants who used that particular mode in either phase 2 or phase 3; this allowed us to eliminate participants that never used that transportation mode [Kazhamiakin et al., 2015].

For the bike sharing mode, we tested the distribution difference between phase 2 and phase 3 [Kazhamiakin et al., 2015]:

$$(n = 16) \ V = 80 \ \text{p-value} = 0.2809 \quad (3.3)$$

The high p-value indicates that any shift in the percentage of Km. traveled by bike sharing is not statistically significant [Kazhamiakin et al., 2015]. For comparison, we also investigated the same difference in distribution for those experiment participants who used bike sharing in both phase 1 vs. phase 2 [Kazhamiakin et al., 2015]:

$$(n = 15) \ V = 10 \ \text{p-value} = 0.02272 \quad (3.4)$$

The result above denotes a modest but moderately significant shift, which reinforces our previous observation that the sustainable mobility recommendations in phase 2 improved

the usage of bike sharing, while the game introduced in phase 3 was not able to further augment the situation in that respect [Kazhamiakin et al., 2015].

For the car mode, when we tested the distribution difference between phases 2 and 3, we obtained the following result [Kazhamiakin et al., 2015]:

$$(n = 13) \quad V = 13 \quad p\text{-value} = 0.01074 \quad (3.5)$$

which denotes a statistically significant shift towards less car traveling during the game [Kazhamiakin et al., 2015]. Since the analogous test between phase 1 and phase 2 did not produce significant results, it can be said that the introduction of gamification incentivized users to travel less with their private car, and hence supports a positive answer to RQC [Kazhamiakin et al., 2015].

Finally, a brief word on the private cycling and walk modes, which are both visibly boosted in Figure 3.6, although they were not explicit VTBC targets of our game, the shift in the walk mode is not sufficiently pronounced across phases to be statistically significant [Kazhamiakin et al., 2015]. However, the shift in private cycling can be seen as a positive - although unplanned - by-product of game participation, since it shows a statistically significant difference only between phases 2 and 3 [Kazhamiakin et al., 2015].

### 3.1.6 Summary and Future Work

Our experiment [Kazhamiakin et al., 2015] demonstrated the potential of gamification to promote sustainable urban mobility policies and VTBC [Kazhamiakin et al., 2015]. In particular, the introduction of gamification in a controlled experiment in Rovereto (Italy) has increased the reliance of the game participants on the ICT mobility services we have deployed in the city, their acceptance of the recommendations provided by those services to use new and more sustainable transportation options for their daily commuting needs, and caused a significant shift towards those options [Kazhamiakin et al., 2015].

As future work, we will continue to work on our generic service-based framework [Kazhamiakin et al., 2015] for the design and development of gamification applications for Smart Cities [Kazhamiakin et al., 2015]. We will evaluate our progress in the context of further smart urban mobility experiments; we have planned open-field, large-scale, long-running tests in Rovereto, and experiments based on a green mobility competition among local private companies [Kazhamiakin et al., 2015].

## 3.2 Gamification for Mobility Assistance for Children

In this Section, we describe a preliminary theoretical study [Piras et al., 2015], on a realistic scenario, where we propose a Virtual Coach (see Definition 2.3) for the gamification of participatory applications in complex socio-technical systems like Smart Cities (see Definition 2.1) and Smart Communities [Piras et al., 2015].

**Definition 3.3 (Smart Community).** *The Smart Community concept extend the concept of Smart City (see Definition 2.1) with an emphasis on citizens which live and work in a territory, and interact with the technologies and services of the Smart City, in order to cater to their collective interests, needs and goals [Piras et al., 2015].*

In Section 3.2.3), we consider the case of *Mobility Assistance for Children* (also known in the literature as *CIM*, standing for *Children’s Independent Mobility*) as a relevant case of smart community [Piras et al., 2015].

In such participatory applications, the user community is an active and essential component [Piras et al., 2015]. Users must voluntarily take up some tasks, in order to ensure the correct operation of the application according to its requirements and goals, which, in turn, delivers collective benefits to the community. In order to facilitate users, and support their sustained engagement in a participatory application, we use a *Missions* (see Definition 2.2) metaphor to describe those volunteering tasks [Piras et al., 2015]. Our Virtual Coach is then responsible for selecting and recommending missions to users, based on a variety of factors, including the criticality of the corresponding tasks for the application purposes, the importance of the task for the individual user that should take it up, user profile characteristics, like personal preferences and skills, and the in-game incentives the user would earn by completing the mission [Piras et al., 2015].

The rest of the Section is structured as follows. In Section 3.2.1 we introduce our study. In Section 3.2.2 we report on studies that make use of Virtual Coaches and Missions gamification concepts in different domains. In Section 3.2.3 we illustrate the *Mobility Assistance for Children* (MA4C) as a relevant case of smart community where to employ our approach. In Section 3.2.4 we describe our proposed solution and the characteristics of a our Virtual Coaches. Finally, in Section 3.2.5 we conclude this Section summarizing this preliminary theoretical study, on a realistic scenario, and our solution proposal, and outline future work.

### 3.2.1 Virtual Coaches for Mission-Based Gamified Smart Communities

Smart cities (see Definition 2.1) and smart communities (see Definition 3.3) are pre-eminent *open environments*; they are very dynamic, since services, systems, agents and devices are heterogeneous, without central ownership or control, and can appear, disappear or

change behavior at any time [Piras et al., 2015]. Moreover, they are complex, large-scale socio-technical systems, where technology aspects of functionality and performance are inextricably linked with aspects of social behavior, governance, decision-making, and people-to-people as well as people-to-technology interaction [Piras et al., 2015].

We propose a *Personalized Gamified Smart Virtual Coach (PGSVC)* [Piras et al., 2015] for the mission-based (see Definition 2.2) gamification of participatory applications in socio-technical open environments, like smart cities and smart communities [Piras et al., 2015]. A participatory application supports community self-help; community members must take up specific tasks, so that the application can progress in its operation, and ultimately deliver some benefits and services to the community as a whole [Piras et al., 2015]. Our PGSVC provides guidance in participatory applications, by presenting volunteer tasks as game-like *Missions* [Piras et al., 2015, Zichermann and Cunningham, 2011], and recommending to a user/player those missions that cater to her needs, while advancing the community objectives, and offering a fun competitive, or collaborative, experience [Piras et al., 2015]. A PGSVC is particularly valuable in open environments, since - because of their dynamism, scale and complexity - a player may not have full knowledge of the whole domain, and the tasks that need to be done [Piras et al., 2015]. A PGSVC can make dynamic decisions on the most appropriate missions for a player at a given juncture; its recommendations can be based upon multiple dimensions, including players' profiles and preferences, in-game incentives, or application state, including the collective goals and requirements of the community supported by the participatory application [Piras et al., 2015].

#### 3.2.2 Research Context

A virtual coach (see Definition 2.3) is a visible or invisible assistant that supplies the player with direct or indirect suggestions on how to do well [Piras et al., 2015]. Those suggestions may at times be tuned to the individual player with some form of personalization [Piras et al., 2015].

Virtual coaches are used in many gamification domains. For example, in the automotive sector, virtual coaches are employed to support the exploration of a vehicle Diewald et al. [2015], or to guide drivers to eco-driving styles Diewald et al. [2015], Magaña and Organero [2014] and to save fuel Magana and Munoz-Organero [2015]. Richards Richards [2014] proposed to apply invisible coaches to exergames. Kulyk et al. Kulyk et al. [2014] described guidelines for designing coaches for the gamification of physical and personal health activities. Buningh et al. Buningh et al. [2014a] implemented a gamified system, with

a coach, for stimulating company employees to choose sustainable means of commuting to work.

Some virtual coaches use the concept of missions [Piras et al., 2015] to deliver their recommendations; but most domains that are gamified by using missions and a virtual coach are *closed environments* [Piras et al., 2015]. Closed environments, such as regular information systems, or mobile and web apps, are pre-defined because their services, user interactions, goals, conditions and constraints mute rarely and incrementally [Piras et al., 2015]. Furthermore, those changes do not happen at runtime: modifications to the system are made offline, which allows offline maintenance of the virtual coach agent as well [Piras et al., 2015]. Our goal, instead, is to apply gamification to open environments, with their dynamic, large-scale user communities [Piras et al., 2015].

There are some studies on the mission-based gamification of groups of people or communities. Fitz-Walter et al. [2014] reported how, in the process of university orientation, supplying students with a mission-based gamified mobile app increases engagement and improves the experience. Dodero et al. [2014] showed how a mission-based approach can be effective for groups of primary school children. However, those works do not consider the issue of recommending missions to community participants in an automated way by means of a virtual coach [Piras et al., 2015].

### 3.2.3 Mobility Assistance for Children

We elucidate our proposal [Piras et al., 2015] using the case of a smart community of citizens who self-help about the theme of *Mobility Assistance for Children* (MA4C) [Piras et al., 2015]. MA4C in the literature is also known as *Children's Independent Mobility* (CIM) [Piras et al., 2015].

MA4C is important because being an independent and active road user is fundamental for the physical, social, cognitive and emotional development of children Beunderman [2010]. Unfortunately, most parents chauffeur by car their children, especially to school. This accounts for approximately 20% of the total daily traveling population in the EU, with implications on pollution and traffic [Piras et al., 2015]. In addition, the traffic near schools creates safety risks for children who walk or cycle to school [Piras et al., 2015]. A smart community for MA4C requires several socio-technical services that help children becoming increasingly independent during the primary school years, for example services like *Walking Bus (WB)*, *Bike Train (BT)* and *Car-Sharing (CS)* [Piras et al., 2015]. A WB is composed of volunteers that walk a group of children of age 6 to 8 to school. The route of a WB is made of stops near the children's houses. A BT is a group of children

of age 8 to 10, who ride bikes to school together autonomously. CS is for parents who live far from school, who collaborate to chauffeur by car their kids to the nearest WB stop [Piras et al., 2015].

To operate MA4C services effectively, many tasks of a participatory nature are needed [Piras et al., 2015]. They require volunteering by parents, grand parents, neighbors, teachers, kids, etc. [Piras et al., 2015] We propose to gamify these tasks as missions [Piras et al., 2015]: e.g., “Propose a safe route for a WB” [Piras et al., 2015], “Check if the proposed path is safe” [Piras et al., 2015], “Preside over a dangerous crossroad” [Piras et al., 2015]. Missions can be co-dependent: e.g., for every WB route proposed, someone must check if the proposed path is safe for kids [Piras et al., 2015].

The technical components of MA4C include smart bracelets, gateway sensors, smart-phones, apps, etc. [Piras et al., 2015] Smart bracelets track the movement of children. Gateways monitor other devices and interact with backend IT systems, such as school information systems, the MA4C system and the gamification system. For instance: the school gateway monitors children arrived at school (via their bracelets), interacts with the school system to automatically fill the logbook, and with the gamification system for updating the game state and rewards (e.g. points) of all players for their mission completion. Mobile apps are used to coordinate community members with the MA4C services [Piras et al., 2015].

Combining mission-based gamification of the participatory tasks with a PGSCV can encourage people to complete the necessary MA4C activities in a fun way, while satisfying personal and community objectives [Piras et al., 2015]. In the next section, we describe this idea in further detail.

#### 3.2.4 Characteristics of the Virtual Coaches

A PGSVC is a software agent assigned to a specific citizen [Piras et al., 2015], its *owner*. A PGSVC that can successfully recommend personalized missions in a context like MA4C - or a similar open-ended participatory application - must consider many criteria, which belong to the following three *dimensions* [Piras et al., 2015]:

1. (like most virtual coaches) criteria that have to do with the state of the individual player within the game;
2. criteria that have to do with the state of the participatory application itself, and current community needs;
3. criteria that have to do with the user profile and preferences of the player, including the role(s) she can assume in the participatory application.

A PGSVC must also consider *mission characteristics*, i.e., meta-data about the participatory tasks, which may include time urgency, difficulty, dependencies vis-a-vis other tasks, roles, skills and resources required, etc. [Piras et al., 2015]

The following example wraps up most of the previous considerations [Piras et al., 2015]. Anna is a licensed WB volunteer, but she has the flu; she uses her MA4C app to notify her absence from tomorrow’s WB. The MA4C system raises an issue because the WB does not have enough volunteers; this issue corresponds to (*dimension 2*) above. Sara, Mario, Luca and Paola are all WB licensed, so their PGSVCs consider their fit for the new mission M1: “Serve as substitute volunteer of the WB” [Piras et al., 2015]. Sara’s PGSVC knows from her health profile (*dimension 3*) that she is injured, and decides that the mission is impracticable. Mario’s PGSVC knows that he wants to win the badge of “Master of car-sharing” [Piras et al., 2015] (gamification state - *dimension 1*); since M1 does not fit that objective, the PGSVC assigns M1 a low priority. Luca’s PGSVC identifies him as a good candidate, but finds out that mission M2: “Manage the transit of a bike train in a crossroad” [Piras et al., 2015] is more urgently needed right now (MA4C context - *dimension 2*); since Luca lives near that crossroad (*dimension 3*), his PGSVC proposes to Luca mission M2. Paola’s PGSVC knows she has a son (family profile - *dimension 3*) in the WB of M1, therefore keeping that WB operational is critical to the organization of her day as a parent. Paola is proposed mission M1 and she accepts [Piras et al., 2015].

An additional aspect of PGSVC can be the calculation of personalized rewards for missions [Piras et al., 2015]. For instance, if Mario were the only available volunteer to fulfill mission M1, the PGSVC could augment his in-game incentives, to induce the desired participatory response. For example, if points for M1 are accorded based on the length of the WB route, (*dimension 2*), the home location of the volunteer (*dimension 3*) and the number of families depending on the WB (*dimension 2*), Mario’s PGSVC could decide to add a 2-times multiplier for M1, so that Mario can achieve his goal with respect to the MA4C points leaderboard (*dimension 1*) [Piras et al., 2015].

In an open environment like a smart community, the elaboration of missions is challenging: missions can require multiple sub-steps and those steps may be dynamic [Piras et al., 2015]. For example, the mission “Serve as substitute volunteer of the WB” [Piras et al., 2015] of the example requires sub-steps like: make your way to the first WB stop; check in at the stop; check the list of children joining at that stop, etc. The PGSVC should be able to produce such a plan, and also change it during execution; for example, if a citizen notifies the MA4C system that a section of the WB route is unsafe, that may require a change in the mission plan, the WB volunteer should be updated, and other missions may need to be created [Piras et al., 2015].

### 3.2.5 Summary and Future Work

We introduced a *Personalized Gamified Smart Virtual Coach* [Piras et al., 2015] for gamifying participatory applications in smart communities [Piras et al., 2015]. We use the metaphor of *missions* to stimulate engagement in participatory tasks [Piras et al., 2015]. Our PGSVC recommends appropriate missions to community members/players, by reasoning about multiple criteria related to mission characteristics, players goals, and the the smart community needs and objectives [Piras et al., 2015]. We have planned to implement this idea with a case study on *Mobility Assistance for Children* in the city of Trento (Italy) [Piras et al., 2015].

## 3.3 Requirements of a Framework for the Design of Engaging Software

In Chapter 2, we outline the wide review of the state of the art we conducted regarding acceptance and gamification. It concerns the literature and real case studies from the industry. The gamification experiences we carried out and describe in this Chapter, helped us to understand better, by employing gamification techniques to real and realistic cases, the complexity behind the analysis, design, development and delivering of engaging software systems. Moreover, our review and our experiences helped us in the design of the Agon Framework (Chapter 4). In the following, we summarize **(i)** our lessons learned [Piras et al., 2018a] and **(ii)** the key requirements we derived for designing a framework for supporting the requirements analyst in the analysis and design of engaging software [Piras et al., 2018a].

Our wide review, plus our experiences, allowed us to reflect on some aspects related to acceptance and gamification in terms of stimuli, factors, strategies, game elements and, more generally, on the need of a structured method that allows to explore in a systematic way alternative gamification solutions. We derived the next lessons learned [Piras et al., 2018a]. Hereafter, we refer to them with the acronym LL. Furthermore, in the following we outline also the connections among them and our experiences [Kazhamiakin et al., 2015, Piras et al., 2015]. We call our experiences with the acronyms: SUM standing for *gamification for Sustainable Urban Mobility* [Kazhamiakin et al., 2015], and MA4C standing for *gamification for Mobility Assistance for Children* [Piras et al., 2015].

**Lesson Learned 3.1 (Gamification Design).** *Just following current practices that suggest to employ points-based game elements or other superficial, standalone, specific game elements is not enough [Busetta et al., 2017, Kifetew et al., 2017]. These elements have to*

*be integrated with gamification concepts, mechanics, strategies and system functions, to possibly amplify the engagement effect of the users, in a coherent, well-structured design, organizing the gamification concepts by harmonizing them for constructing a homogeneous, effective gamified experience [Herzig et al., 2012, Kazhamiakin et al., 2015, Monterrat et al., 2014, Schell, 2014, Sripada et al., 2016, Zichermann and Cunningham, 2011].*

We experienced the importance of concepts behind LL 3.1 in both of our experiences [Kazhamiakin et al., 2015, Piras et al., 2015]. In fact, in order to produce a high-quality gamification solution, we had to carry out a precise gamification design, including different gamification concepts and mechanisms harmonized together, and coherently integrated in the software functions, for building an incentivizing gamification experience for the user. For instance, in SUM [Kazhamiakin et al., 2015] we designed an effective game structure made of different kinds of points associated to specific progression paths, levels, badges and badge collections for decorating the software functions, to fulfill the stakeholders' objectives (in this case the Rovereto municipality). While, in MA4C [Piras et al., 2015] we acted in an analogous way, by defining a well-structured design with a core gamification concept, the *Personalized Gamified Smart Virtual Coach* (PGSVC) [Piras et al., 2015]. Especially, PGSVCs encapsulate and manage other gamification concepts in a well-organized gamification design, mainly through missions, persuasive text messages, proposals in line with stakeholders' objectives and user interests, and rewards of different typologies [Piras et al., 2015].

**Lesson Learned 3.2 (Context).** *The previous lesson calls for rationality in the mixing of the different elements and, at the same time, for systematic methods to design the integration. Moreover, to fulfill this, it is needed to deeply understand the users and their motivations also in relation to the task they have to carry out by using the software [Simperl et al., 2013, Tokarchuk et al., 2012, Unkelos-Shpigel and Hadar, 2015]. Furthermore, this calls for a design process for extracting the profound motivations of people [Camerer, 2003, Mayo, 1949, Premack, 1965, Vroom, 1982] when engaged in a gamified task in a given context [Cuel et al., 2011, Unkelos-Shpigel and Hadar, 2015]. This enables analysts to identify which design mechanisms are concretely able to motivate the intended users in that specific context [Simperl et al., 2013, Tokarchuk et al., 2012]. This calls for the next lesson.*

The concepts mentioned in LL 3.2, as confirmed also in our experiences [Kazhamiakin et al., 2015, Piras et al., 2015], are some of the most relevant principles required for constructing a successful gamification solution. In fact, according to what expressed in the previous LL 3.1, it is needed to create an homogeneous, coherent gamification

### 3.3. REQUIREMENTS OF A FRAMEWORK FOR THE DESIGN OF ENGAGING SOFTWARE

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design made of heterogeneous elements, and LL 3.2 calls for some important aspects to consider for choosing and putting together gamification elements to employ in such design. Specifically, LL 3.2 highlights the importance to choose the gamification elements, and how to integrate them for designing effective mechanisms, able to motivate the user in a specific context. For instance, a specific context can include: **(i)** the physical context where the software is used (e.g., a company, a public institution, a district, a neighborhood, a family, etc.); **(ii)** the social context where the software is used (e.g., taking into account social aspects such as a social context made of peers or a hierarchical one); **(iii)** other people involved in the usage of the software (e.g., colleagues, friends, relations, etc.); **(iv)** software characteristics, software features to gamify, tasks the user should carry out by using the software, and related goals to be achieved fulfilling stakeholders' objectives.

Accordingly, in our experiences [Kazhamiakin et al., 2015, Piras et al., 2015], we selected precisely, on the basis of the specific context, game elements and mechanics to employ. For example, in SUM [Kazhamiakin et al., 2015], one of the most important aims of the Rovereto municipality has been to foster citizens to use sustainable urban transports (e.g., bike sharing). Accordingly, we designed gamification mechanisms for persuading the user, during the trip planning performed with the app, to choose the most sustainable solutions, and for keeping the user to prefer continuously such solutions, we devised a rewarding progression system. Especially, we designed such progression system, in a well-structured homogeneous way, including green points, rankings, and a collection of badges achievable through the demonstration of a continuous sustainable behavior. Accordingly, in MA4C [Piras et al., 2015] the PG SVCs heavily consider the context, and related different dimensions, for dynamically deciding how to stimulate the user, by proposing gamified missions, coherently to the context of the neighborhood, and to its social context made of peers that should collaborate for fulfilling stakeholders' objectives.

**Lesson Learned 3.3 (Acceptance).** *It is needed a deeper understanding of acceptance requirements [Piras et al., 2016, 2017a,b] for individuating the most suitable design elements to insert in the software functionalities [Deterding et al., 2011, Schell, 2014, Zichermann and Cunningham, 2011], for making them more attractive according to the specific context [Koivisto and Hamari, 2014b]. In fact, acceptance requirements lead to consider the context in terms of characteristics of the user [Ajzen, 1991, Compeau et al., 1999, Davis et al., 1992, Moore and Benbasat, 1991, Sheppard et al., 1988, Taylor and Todd, 1995, Thompson et al., 1991, Venkatesh and Davis, 2000, Venkatesh et al., 2003], the social context where she will use the software, which kinds of tasks are supposed to carry out with the software, which are her needs and goals tied to the software usage [Simperl et al., 2013, Tokarchuk et al., 2012], etc. Those psychological, behavioral, cognitive*

*considerations help in tailoring the software with psychological strategies and design elements, fulfilling acceptance requirements [Piras et al., 2016, 2017a,b], that can really make the software more attractive and engaging in relation to the specific context [Koivisto and Hamari, 2014b].*

LL 3.3 completes the picture depicted by the other lessons learned. In fact, on the one hand, it is needed to prepare a well-structured, not superficial, gamification design (LL 3.1). On the other hand, the context (LL 3.2), where the gamification has to be inserted, requires to be deeply considered, in order to select the most suitable gamification elements and mechanisms to employ in the design. So far, what it is missing is a even more abstract concept, it is *Acceptance* (LL 3.3). Indeed, a well-structured gamification design, completely adhering to the context where it is applied, in order to be complete and effective, needs to be the result of a deep analysis executed by characterizing also the user and individuating her needs to be fulfilled. In this way, it is possible to select the high-level psychological, behavioral, cognitive strategies that can positively affect and motivate the user. Then, these high-level strategies, being too abstract to be directly employed, have to be made concrete through an operationalization, for example gamification. Therefore, a gamification solution has to be designed to be compatible with the acceptance strategies analyzed, being able in this way to satisfy the needs of the user and, thus, convincing and motivating her to fulfill the stakeholders' objectives by using the gamified software.

Also in our experiences [Kazhamiakin et al., 2015, Piras et al., 2015] it has been fundamental to carry out the approach outlined above. This enabled us to conduct a complete analysis and gamification design producing an effective gamification solution [Kazhamiakin et al., 2015]. In fact, in SUM [Kazhamiakin et al., 2015], according to the use cases described in Section 3.1.4, the solution proposed considers the relevant user needs identified, and employs psychological strategies for satisfying them, which are based, for example, on the *Social Status*, *Achievement*, *Competition* and *Ethical* concepts. For instance, in one of the use cases, the user is pushed to make ethical choices by selecting sustainable trips, to compete in a global leaderboard of “green” users, and to achieve a public demonstrable social status through badges earned by keeping a “green” behavior. Analogously, MA4C [Piras et al., 2015] includes concepts such as *Collaboration*, *Exploration* and *Mastery*. For example, volunteers are motivated to be helpful, for the community, by collaborating each other for fulfilling the neighborhood objectives. They are requested also to explore, check and propose potential paths for children going to school.

**Lesson Learned 3.4 (Systematic Approach).** *As a main lesson, analysts, to address*

### 3.3. REQUIREMENTS OF A FRAMEWORK FOR THE DESIGN OF ENGAGING SOFTWARE

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*the above lessons learned, need a systematic approach that, at the same time, is able to promote and balance automatic support, interactive decisions and wide exploration of alternatives in the design method [Piras et al., 2016, 2017a,b].*

LL 3.4 encloses all the concepts of the lessons learned illustrated above, and highlights the importance to include all the related best practices, fundamental to design effective engaging software, with a systematic approach. It is important to note that carrying out a systematic approach, even being worthwhile and suggested for producing high-quality effective gamification solutions [Hamari et al., 2014, Pedreira et al., 2015, Piras et al., 2016, 2017a,b], requires a lot of effort and very heterogeneous skills, needing often to involve different professionals (e.g., software engineers, psychologists, sociologists, economists, etc.) by making the process very expensive. Furthermore, the space of alternatives regarding acceptance strategies, gamification best practices, concepts and mechanics is very vast and it is beneficial to have automatic tools able to support analysts. Therefore, according to LL 3.4, we need tools and methods able to support analysts in performing a systematic analysis for designing engaging systems, being guided in all the systematic phases, and receiving suggestions in the vast area of variables to consider and solutions to adopt, for reducing the total effort, costs and maximizing the effectiveness of the engaging software system designed [Piras et al., 2016, 2017a,b].

This need has being confirmed also within our experiences [Kazhamiakin et al., 2015, Piras et al., 2015], because even we succeed, the process has been very difficult, long and expensive. In both of the cases, we employed a service oriented gamification engine [Kazhamiakin et al., 2015] that helped us in just the service-oriented design of the gamification concepts, related implementation and delivery phases. However, we had to personally perform the analysis and design phases without supporting tools. Results of this phases, then, have been implemented, in a service oriented way, being helped by the gamification engine described in Section 3.1.3 [Kazhamiakin et al., 2015]. While, Agon, as we deeply describe in the next Chapters, is able to cover the very important gap related to the lack of a tool-supported framework and a systematic method for analysis and design of engaging software systems.

Therefore, on the basis of the literature, evidences from the industry, our experiences and lessons learned highlighted above, we individuated the key requirements of a framework, and a method, for supporting the requirements analyst in the analysis and design of engaging software [Piras et al., 2018a].

In detail, the key requirements we individuated are [Piras et al., 2018a]:

**R1** Systematic Approach

**R4** Context Characterization

**R2** Acceptance Orientation

**R5** Guiding Approach

**R3** Gamification Orientation

In the following we comment such requirements [Piras et al., 2018a], referring also to the Lessons Learned (LL) [Piras et al., 2018a] expressed before. The framework and the method have to be systematic [Piras et al., 2016, 2017a,b] (**R1**, LL 3.4) (**a**) allowing the exploration of most of the factors influencing the user in being motivated to use software [Koivisto and Hamari, 2014b, Piras et al., 2017a] (LL 3.3), and (**b**) employing effective techniques for analyzing those factors and designing mechanisms able to satisfy them [Piras et al., 2017b] (LL 3.1, LL 3.3).

In fact, the final aim of the method is to design engaging software for the user, thus, it is fundamental to explore most of the factors (see (**a**) above) that positively influence the user such as psychological, motivational, cognitive and behavioral factors [Piras et al., 2017a] (**R4**, LL 3.3). These are usually referred to *Acceptance Requirements* [Piras et al., 2016, 2017a,b] and related techniques [Piras et al., 2017b]. They are crucial for selecting psychological strategies as design mechanisms to use to make attractive the software [Piras et al., 2016]. Thus, the method has to be acceptance oriented [Piras et al., 2018a] (**R4**, LL 3.3).

Factors analyzed through acceptance requirements have to be mapped with gamification concepts able to fulfill such requirements. It is important to choose those concepts as well as to decide properly how to put them together in a coherent and effective gamification design [Piras et al., 2016]. Such method has to support both these requirements, namely it has to be gamification oriented (**R5**). With gamification oriented (**R5**), we mean that the method incorporates the gamification design knowledge [Piras et al., 2017b] (LL 3.1), and related techniques, able to support the designer in producing a high-quality gamification design made of concepts, satisfying acceptance requirements, organized according to gamification best practices [Piras et al., 2016, 2018a] (LL 3.1, LL 3.3).

The identification of acceptance and gamification strategies that are effective for a specific kind of user, depends strictly on the specific context variables [Piras et al., 2016, 2017a,b] (LL 3.1, LL 3.3). Thus, such method has to support the characterization (**R6**) of context variables such as the human as a user and as a player [Piras et al., 2016], the goals and needs of the user, the task that the user carries out by using the software and related positive and negative user feelings, what can be produced by using the software and in which social context [Piras et al., 2017a] (LL 3.3). Moreover, a method supporting **R6**

uses these considerations in individuating which acceptance and gamification strategies best fit the specific context [Piras et al., 2017b, 2018a] (LL 3.3).

Moreover, such method is a guidance (**R7**, LL 3.1, LL 3.3) for analysts [Piras et al., 2016, 2017a,b] meaning that it has to: **(i)** guide them in all the phases with techniques supporting all the other requirements [Piras et al., 2016, 2017b], **(ii)** make them to explore as many as possible relevant elements [Piras et al., 2017a, 2018a] and, above all, **(iii)** provide suggestions concerning psychological strategies, gamification concepts and best practices to use that are the most suitable ones for the specific context characterization [Piras et al., 2016, 2017b, 2018a] (**R6**).

In the next Chapter, we describe *Agon*, the *Acceptance Requirements Framework* we designed, and that fulfills the requirements [Piras et al., 2018a], outlined here, thanks to its *Agon Meta-Model* and *Agon Method*.

### 3.4 Chapter Summary

This Chapter describes two gamification experiences we performed. Specifically, in Section 3.1 we illustrate a gamification experiment in a real scenario, we conducted it in the context of the STREETLIFE European project<sup>7</sup>, where we applied gamification for incentivizing citizens to choose *Sustainable Urban Mobility* (SUM) solutions [Kazhamiakin et al., 2015]. In Section 3.2 we depict a preliminary theoretical study, using gamification for favoring *Mobility Assistance for Children* (MA4C) [Piras et al., 2015], in a realistic scenario. As illustrated in Chapter 7, we used these scenarios also for some case studies, where some master students carried out their master theses, under our supervision, by using the Agon framework for gamifying the SUM and MA4C software systems.

Both the experiences described in this Chapter, above all the first one, helped us to understand better, by employing gamification techniques to real and realistic settings, the complexity behind the analysis, design, development and delivering of engaging software systems. Furthermore, these experiences helped us also in the design of the Agon Framework (Chapter 4). Moreover, in Section 3.3, we discuss the lessons learned we derived from our experiences and, above all, from our wide literature review (Chapter 2). On the basis of this, we illustrate the key requirements, we identified, for the design of a framework for supporting the requirements analyst in the analysis and design of engaging software. Such requirements led us to the design of the Agon Framework we describe in Chapter 4.

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<sup>7</sup><http://www.streetlife-project.eu/>

## Chapter 4

# Agon: an Acceptance Requirements Framework Based on Gamification

In this Chapter we describe *Agon*, our *Acceptance Requirements Framework Based on Gamification*, objective of this thesis, and *Acceptance Requirements*.

In Section 4.1, we give the definition of *Acceptance Requirements* and provide some examples, coming from well-known domain such as meeting scheduling and project management, of expliciting such requirements.

In Section 4.2, we describe Agon and, above all, its *Agon Multi-Layer Meta-Model*. Furthermore, we illustrate each model composing the multi-layer meta-model by providing details, regarding how we designed them, and examples. Such models are the *Acceptance Meta-Model*, *Tactical Meta-Model*, *Gamification Meta-Model* and *User Context Model*.

### 4.1 Acceptance Requirements and Agon

It is not sufficient for a software system to merely fulfill its functional and quality requirements in order to be used (“accepted”) by its intended users. In fact, also other important requirements, *Acceptance Requirements*, oriented towards considering psychological, behavioral, and social contextual perspectives, need to be elicited, analyzed and fulfilled. For instance, living in the days of social software, acceptance requirements are particularly relevant for social software systems such as Facebook and YouTube, where the system must be accepted by a sufficient percentage of its intended user community [Piras et al., 2016]. After all, neither Facebook nor YouTube would enjoy the success they do if they did not have their billions of users [Zichermann and Cunningham, 2011].

Such *Acceptance Requirements* for software in general, and for social software as a

relevant specific case, have come to prominence in the past decade [Piras et al., 2016]. To address them, researchers have studied the human and social factors that affect acceptance [Simperl et al., 2013, Tokarchuk et al., 2012], and developed incentive mechanisms for addressing them, including gamification [Deterding et al., 2011] and other incentive-based mechanisms [Sakamoto et al., 2014, Schell, 2014, Zichermann and Cunningham, 2011]. Gamification constitutes a collection of concepts, tools and techniques for making a game out of software system use [Piras et al., 2017a]. For example, for a meeting scheduler where meeting participants are supposed to submit their time constraints, we may introduce game elements, such as getting points for submitting your time constraints early, also announcing top point-getters periodically, to encourage user acceptance [Piras et al., 2016].

This thesis presents a framework, named *Agon* (Section 4.2), that supports the analysis of *Acceptance Requirements* and the selection of gamification mechanisms for their fulfillment. Therefore, *Agon* guides the requirements analyst in a *Systematic Acceptance Requirements Analysis based on Gamification*, i.e. the *Agon* method (Chapter 5). This method is supported by the *Agon Multi-Layer Meta-Model* [Piras et al., 2017b] (Section 4.2) that captures acceptance and gamification knowledge (on the basis of the literature), and are employed for refining and operationalizing acceptance requirements. It also includes a tool (Chapter 5) that helps the requirements analyst to design gamification solutions.

In the rest of this Section, we provide the definition of *Acceptance Requirements* and apply it to some examples, for instance to the Doodle-Like Meeting Scheduler Exemplar [Piras et al., 2016, 2017a] as a realistic example for showing such requirements [Piras et al., 2017b].

#### 4.1.1 Acceptance Requirements Definition

*Acceptance Requirements* are defined over a set of **Functions**, that are supposed to be accepted, and a target set of users, **Participants**, that must use the functions [Piras et al., 2017b]. Thus, they constitute a special class of quality requirements [Li et al., 2014] represented as [Piras et al., 2017b]:

$$Acceptance[\{Functions\}, Participants] \geq N\% \quad (4.1)$$

The definition represents that  $N\%$  of intended users (**Participants**) shall use the set of functions (**Functions**). Such a requirement can be operationalized by a gamification mechanism to be selected by taking into account the intended users, the user context and other parameters. We discuss this extensively in Chapter 5 and 6. Actually, there are many solutions for operationalizing acceptance requirements (e.g., gamification, serious games,

game metaphors, advertisements, marketing strategies, persuasive messages, etc.) [Piras et al., 2016]. In this thesis, we focus on one class of such incentives, namely, gamification solutions [Deterding et al., 2011]. Therefore, we envision acceptance requirements operationalizations via game-related incentives [Piras et al., 2017b].

#### 4.1.2 Acceptance Requirements Examples

An example from the Doodle-Like Meeting Scheduler Exemplar [Piras et al., 2016, 2017a] is:

$$Acceptance[\{SubmitDates\}, Professors] \geq 80\% \quad (4.2)$$

In this case, the problem is to motivate participants of a meeting, **Professors**, to provide their time constraints so that a meeting can be scheduled. The task now for the requirements engineer is to decide how to get a sufficient percentage of intended users to use the **SubmitDates** function.

Another more complex example can be formulated in the context of project management in a company. For example, our aim could be to motivate users of a project management software system, i.e. managers of the company, to use some important system functions more frequently for taking decisions. We hypothesize that such system supports the following set of functions:

$$\begin{aligned} &\{Identify\ Critical\ Tasks, Notify\ Critical\ Tasks, Propose\ Solutions, \\ &\quad Propose\ Collaborative\ Solutions, Identify\ Risks, \\ &\quad Prioritize\ Countermeasures, Perform\ Countermeasures\} \end{aligned} \quad (4.3)$$

Them represent the process where managers should: **(i)** identify critical tasks in their projects, **(ii)** optionally notify them to other colleagues, **(iii)** propose solutions (either by themselves or in a collaborative way) for making sure that such tasks will be successful, **(iv)** identify risks related to the application of the solution, **(v)** prioritize the countermeasure activities needed to implement the solution and **(vi)** guarantee that countermeasure activities will be performed by the resources involved.

Then, the company, by analyzing the behavior of the managers, realizes that most of them neither notify to other colleagues critical task identified, nor interact with the other managers for proposing collaborative solutions, nor identify adequately risks of the solution to be applied. All of them are considered critical for the success of the company. Therefore, being needed to make these system functions more engaging, interesting and appealing, for motivating managers to accept and use them, the related acceptance requirement can

be specified as:

$$\begin{aligned} &Acceptance[\{Notify Critical Tasks, \\ &\quad Propose Collaborative Solutions, \\ &\quad Identify Risks\}, Managers] \geq 80\% \end{aligned} \tag{4.4}$$

## 4.2 An Acceptance Requirements Framework and Its Multi-Layer Meta-Model

The design of any software system requires that a high percentage of its intended users actually accept to use the system. Fulfillment of such *Acceptance Requirements* critically depends on psychological, behavioral and social factors which may influence intrinsic and extrinsic motivations. These factors can be identified, designed and fine tuned via gamification (making a game out of system usage), serious games and other techniques. In this thesis, we propose a framework, named *Agon*<sup>1</sup> [Piras et al., 2016, 2017a,b], for addressing acceptance requirements through gamification mechanisms. The framework adopts concepts and design techniques from Requirements Engineering, Human Behavior and Gamification [Piras et al., 2016, 2017a,b].

The Agon framework is composed of different abstraction layers and goal models for facilitating a systematic acceptance requirements analysis based on gamification. Those elements are organized in the *Agon Multi-Layer Meta-Model* [Piras et al., 2017b] that is shown in Figure 4.1.

The *Agon Multi-Layer Meta-Model* is composed of 4 abstraction layers [Piras et al., 2017b] and at each level there is a goal model [Chung et al., 2012]. In order to design the Agon meta-model [Piras et al., 2017b], we extended the *NFR Framework* Chung et al. [2012], and in the following Subsections we describe all the elements at each layer. At the moment of writing, the meta-model counts 352 goals and 487 relations [Piras et al., 2017b]. Full models and a glossary (concerning elements of the Agon Meta-Model) are available online at [Piras et al., a]. The meta-model represents the acceptance and gamification knowledge, and we are continuously improving it by adding new elements [Piras et al., 2017b]. This is necessary because new acceptance and gamification concepts have been continuously appearing in the literature, thus, it is important to apply updates for keeping the meta-model as much as possible close to the reality and, therefore, precise and effective [Piras et al., 2017b].

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<sup>1</sup>Agon (in Greek *Άγων*) means “game” or “competition”, as in Olympic Games (*Ολυμπιακοί Αγώνες*)

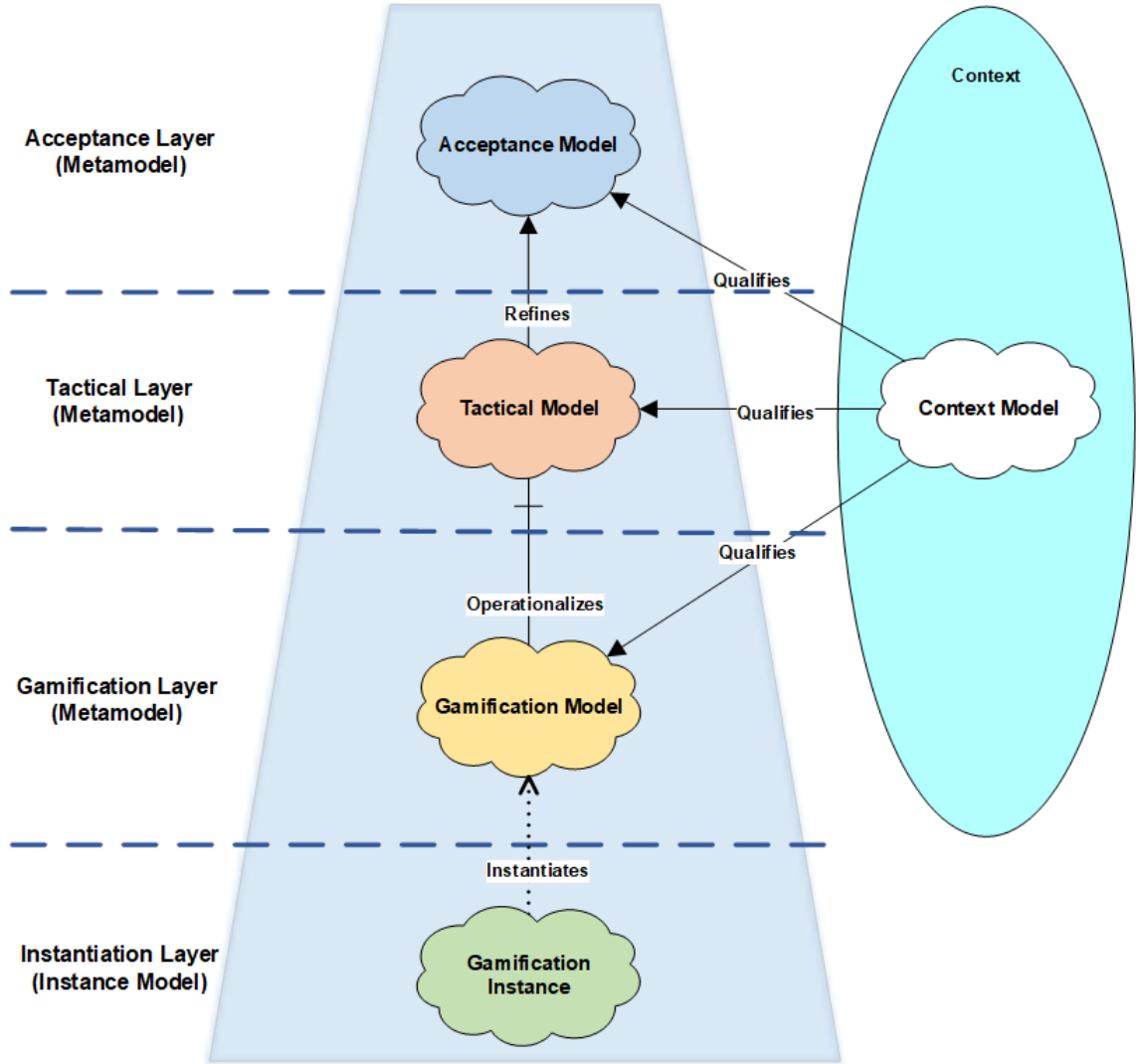


Figure 4.1: Agon models at different abstraction layers, and the context model, composing the Agon Multi-Layer Meta-Model [Piras et al., a, 2016, 2017a,b]

From the acceptance level to the gamification level (Figure 4.1) we have the *Acceptance Meta-Model* (AMM), the *Tactical Meta-Model* (TMM) and the *Gamification Meta-Model* (GMM) [Piras et al., 2017b]. They are meta-models including generic concepts not referring to a particular domain (e.g., the one of project management). In fact, they are composed of: (i) psychological strategies (AMM); (ii) tactics (TMM) as high-level goals AMM and GMM have in common; (iii) gamification solutions (GMM). In the bottom layer, there is the *Instance Model* (IM). IM is not a meta-model, it instantiates generic goals of the upper level (GMM) by specifying them in relation to the distinct domain of the system to gamify (e.g., the one of project management) [Piras et al., 2017b].

#### 4.2. AN ACCEPTANCE REQUIREMENTS FRAMEWORK AND ITS MULTI-LAYER META-MODEL

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TMM [Piras et al., 2017b] is fully shown in the Agon Meta-Model Figure, available at [Piras et al., a], as a bridge between AMM and GMM. Respectively, AMM is illustrated at the top of the Figure [Piras et al., a], while in the bottom there is GMM. TMM, being the bridge between AMM and GMM, should be represented in the middle of the 2, however, in the Figure [Piras et al., a], to minimize overlaps of relations among the models, TMM goals - i.e. tactics - are represented under AMM and under TMM.

*Acceptance Requirements* [Piras et al., 2016, 2017b] are fulfilled through solutions coming from the *Agon Multi-Layer Meta-Model* (Figure 4.1). Such solutions are obtained by following the Agon method, a *Systematic Acceptance Requirements Analysis based on Gamification* [Piras et al., 2016, 2017a,b], that performs reasoning over the Agon meta-model. Specifically, acceptance requirements are fulfilled by AMM needs at the acceptance level (Figure 4.1), which in turn are refined by TMM tactics, operationalized by gamification goals, finally, instantiated by the requirements analyst by building the *Gamification Instance* (Figure 4.1) as a customization of gamification solutions received by Agon.

In detail, the requirements analyst, following the Agon method, a *Systematic Acceptance Requirements Analysis based on Gamification* [Piras et al., 2016, 2017a,b], uses the Agon meta-model starting from the top, the most abstract layer (AMM), and going towards the bottom layers (GMM and IM) [Piras et al., 2017b]. This activity is semi-automatic because, at each layer, the analyst uses reasoning techniques applied to goal models [Nguyen et al., 2016a,b] and automatically receives suggestions related respectively to acceptance, tactical and gamification solutions to employ in the gamification of the system [Piras et al., 2016, 2017a]. This activity is also interactive, because the analyst at each layer, on the basis of suggestions received and her knowledge regarding the domain of the system to gamify, takes further decisions (e.g, discarding parts of the solutions proposed) [Piras et al., 2016, 2017a,b].

Moreover, Agon is composed also of another fundamental model, the *User Context Model* (UCM) [Piras et al., 2017b] (designed with *Context Dimension Trees* [Orsi and Tanca, 2011]), that characterizes the intended users to engage through context variables such as gender, age, expertise, kind of player [Bartle, 1996], etc. These variables [Piras et al., 2017b] are crucial elements used during the reasoning activity described above. Indeed, relations of the Agon models are annotated by *Context Dependent Rules* (CDRs) defined on UCM variables. CDRs are evaluated to decide if to keep or discard some relations and connected elements. The idea behind this, is to reason over acceptance and gamification knowledge, the meta-model, selecting the solutions (goals) that are the most suitable ones for the users to motivate [Piras et al., 2016, 2017a,b].

In the next Subsections, we describe individually, more in detail and giving also some examples, models composing the Agon Multi-Layer Meta-Model.

#### 4.2.1 The User Context Model

Different people are stimulated by different psychological factors and gamification solutions [Bartle, 1996, Koivisto and Hamari, 2014b, Venkatesh et al., 2003, Zichermann and Cunningham, 2011]. This is captured by UCM [Piras et al., 2017b], shown in Figure 4.3, that includes users' characteristics to consider for the selection of acceptance and gamification strategies that can affect positively a specific kind of user [Piras et al., 2017b]. The notation we used for designing UCM is the one of *Context Dimension Trees* [Orsi and Tanca, 2011] (Figure 4.3). Specifically, in Figure 4.3, user dimensions and sub-dimensions are represented as circles [Orsi and Tanca, 2011], while yellow hexagons are the user contexts, made of dimensions, that annotate relations of the Agon models for indicating which elements are suitable for which kind of context [Piras et al., 2017b]. For example, in Figure 4.2, C2 and C3 are contexts expressed in Figure 4.3 and used for annotating relations of the gamification meta-model (Figure 4.2). Such information guides the reasoning for selecting elements in a context-based way [Piras et al., 2017b]; we discuss in details this aspect in Chapter 5, which describes the *Systematic Acceptance Requirements Analysis Based on Gamification* [Piras et al., 2016, 2017a,b], i.e. the Agon method.

We designed UCM by including strategic dimensions [Orsi and Tanca, 2011], proven in the literature Bartle [1996], Koivisto and Hamari [2014a], Venkatesh et al. [2003], Zichermann and Cunningham [2011], that in the real life make difference in the way of people reacting to acceptance and gamification techniques. The main dimensions we treat are (Figure 4.3): **Gender**, **Age**, **Player Type**, **Employment** and **Acceptance Subject**. For instance, one important aspect is Player Type (Figure 4.3), because different kinds of players are interested and stimulated by different types of gamification concepts. For managing it, we added in UCM the Bartle's player taxonomy Bartle [1996] with 4 kinds of players (not mutually exclusive, as shown in Figure 4.3): socializer, achiever, explorer and killer. Another important aspect is the Acceptance Subject (the system to be accepted) and its sub-dimensions (Figure 4.3): **Subject Awareness** is the user's familiarity regarding the acceptance subject and it is measured by **Expertise Level**; **Acceptance Voluntariness** regards the fact that the user is obliged or not to use the acceptance subject; **Precursor Subject** is related to the existence of a previous acceptance subject different to the proposed one.

Thus, the analyst instantiates UCM on the basis of the user's characteristics and, when

#### 4.2. AN ACCEPTANCE REQUIREMENTS FRAMEWORK AND ITS MULTI-LAYER META-MODEL

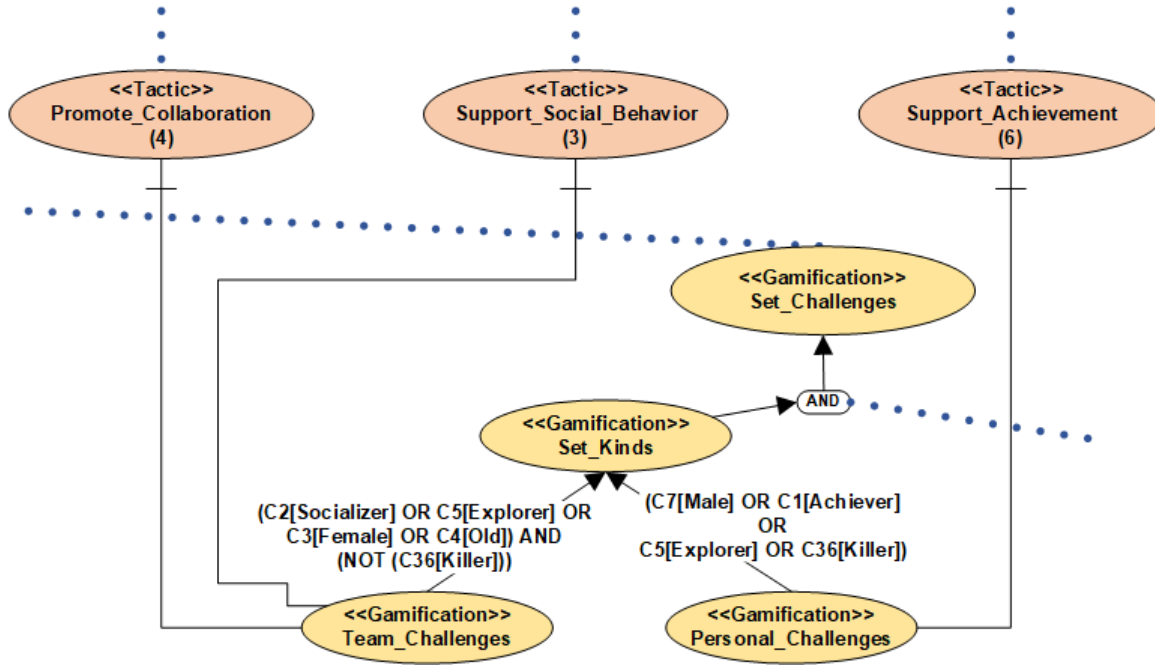


Figure 4.2: Context dependent rules, gamification goals and tactics [Piras et al., 2017b]

Agon executes reasoning over AMM, TMM and GMM, considers the UCM instantiation for evaluating CDRs (annotated in the relations of the models) to select the most suitable solutions for the intended users [Piras et al., 2017b]. CDRs are rules (we extracted them from the literature [Bartle, 1996, Koivisto and Hamari, 2014b, Venkatesh et al., 2003, Zichermann and Cunningham, 2011]) composed of expression based on the UCM variables [Piras et al., 2017b]. For example, in Figure 4.2 there is an extract from the meta-model specifying that [Piras et al., 2017b]: (i) if you are dealing with socializers (or other user's kinds expressed by the CDR starting with (C2[Socializer] OR ...)) challenges tackled in team (**Team Challenges**) are preferred [Zichermann and Cunningham, 2011]; (ii) if you are dealing with males or achiever, etc., ((C7[Male] OR C1[Achiever] ...)) personal challenges (**Personal Challenges**) are suggested [Zichermann and Cunningham, 2011].

It is noteworthy to highlight that, hereafter, when in a Figure an element of a model is specified with a number surrounded by parenthesis, i.e. “<<Goal Kind>> Goal Name (N)”, it means that such element is the nth reference of a single element identified uniquely by its name [Piras et al., 2017b] (Goal Name). For instance, in Figure 4.2, “<<Tactic>> Promote\_Collaboration (4)” represents the 4th reference of the tactic goal **Promote\_Collaboration** within the Agon Meta-Model [Piras et al., 2017b]. We use this reference mechanism, in order to reduce overlaps caused by relations for the same goal appearing in

different far parts of the Agon Meta-Model [Piras et al., 2017b].

At the moment, even we established the usefulness and effectiveness of UCM, and of the entire Agon framework as discussed in Chapter 7, in UCM there are some limitations. In fact, we have not been able to include all the elements covering all the phenomena of the universe. However, we individuated some of the most relevant ones, according to the literature, constructed the infrastructure of UCM on the basis of them, and proven the UCM effectiveness contextually to the employment of Agon (Chapter 7). We envision, for the future, that our framework and its models will be enriched by adding additional elements (as discussed in Chapter 8). For instance, several variables which are present in the TAM literature could be included (e.g. user values, motivations, predisposition towards technology, etc.) in UCM.

#### 4.2.2 The Acceptance Meta-Model

In this Subsection, we describe the Acceptance Meta-Model (AMM). AMM is fully shown in the Agon Meta-Model Figure, available at [Piras et al., a]. In such Figure [Piras et al., a], it is illustrated in the top. While, in the bottom of AMM (Figure [Piras et al., a]), it is represented the part of the *Tactical Meta-Model* (TMM) connected with AMM. Furthermore, an extract of AMM, with main structure elements of AMM, is shown in Figure 4.4. Here, we introduce also Figure 4.6, which is used for illustrating the Agon models by providing further examples. In particular, Figure 4.6 contains a project management example. Starting from here, and in the next Subsections, such example is described step by step.

In the following, we provide: **(i)** the graphical notation of main elements of AMM (see Figure 4.5); **(ii)** definitions at the acceptance level; **(iii)** the explanation of how we designed AMM; **(iv)** the description of an extract of AMM (Figure 4.4) and of the example in Figure 4.6 related to AMM.

**Definition 4.1 (Acceptance Meta-Model).** *The Acceptance Meta-Model (AMM) is a qualitative goal model representing psychological, cognitive, behavioral human needs that can be considered for favoring the acceptance of a software system from the user perspective. It is composed of acceptance needs, modeled as goals, and contribution relations (Figure 4.5). We define it formally as  $[N, C]$  where  $N$  is a set of needs and  $C$  is a set of contribution relations. It is a goal model, with different abstraction levels, where each need can receive/provide positive contributions from/to other needs. One or more acceptance needs - of the acceptance meta-model - can fulfill an acceptance requirement. Additionally, acceptance needs can be refined by tactics of the tactical meta-model.*

#### 4.2. AN ACCEPTANCE REQUIREMENTS FRAMEWORK AND ITS MULTI-LAYER META-MODEL

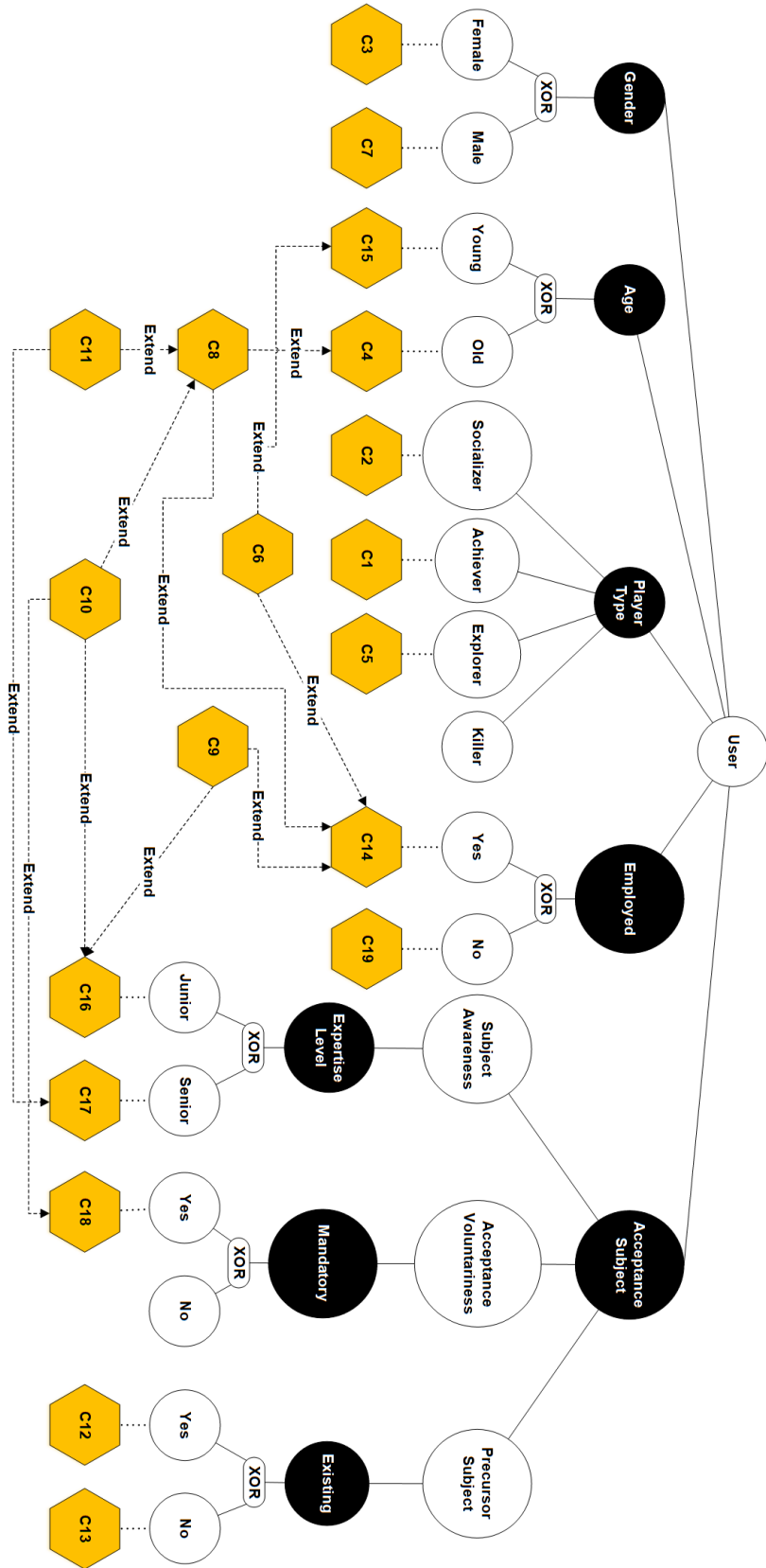


Figure 4.3: The User Context Model of the Agon Multi-Layer Meta-Model, also available at [Piras et al., a]

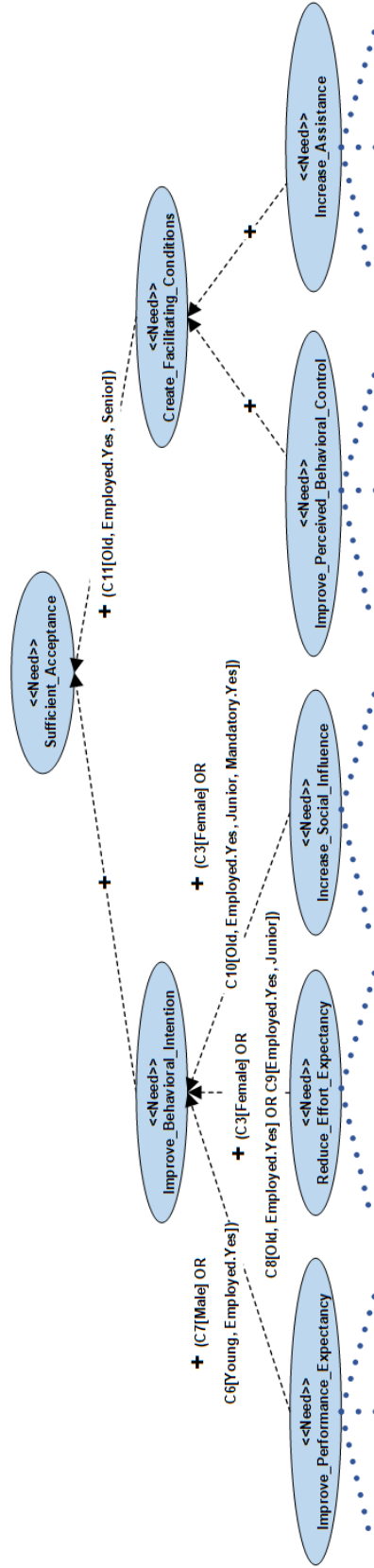


Figure 4.4: An extract of the Agon acceptance meta-model [Piras et al., 2017b] based on UTAUT [Venkatesh et al., 2003]

#### 4.2. AN ACCEPTANCE REQUIREMENTS FRAMEWORK AND ITS MULTI-LAYER META-MODEL



Figure 4.5: Graphical notation followed by main elements of the Acceptance Meta-Model

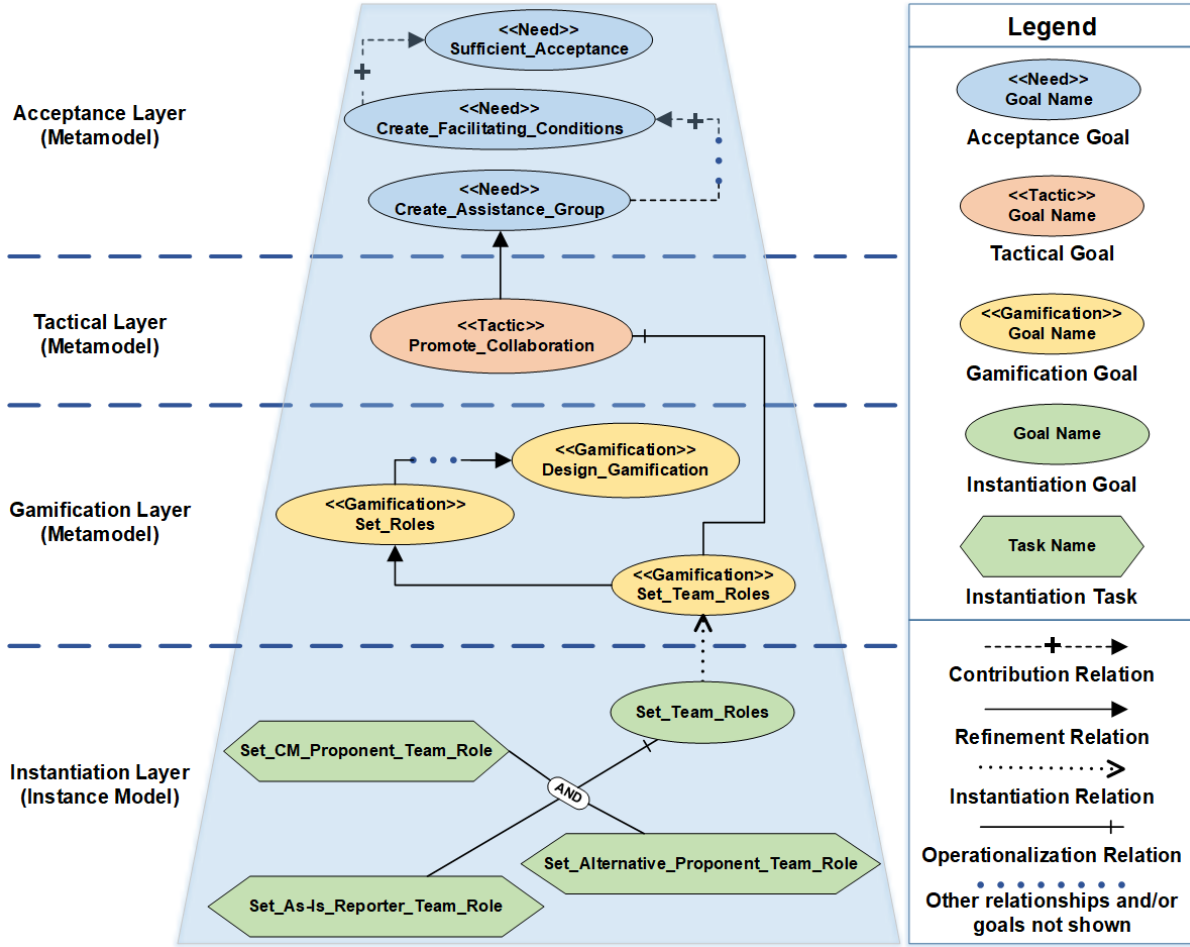


Figure 4.6: The Agon multi-layer meta-model with a project management example [Piras et al., 2017b]

**Definition 4.2 (Acceptance Need).** *An Acceptance Need (also called just Need) is a quality goal representing a psychological, cognitive, behavioral human need that can be considered for favoring the acceptance of a software system from the user perspective (Figure 4.5). One or more acceptance needs can fulfill an acceptance requirement. Additionally, an acceptance need can be refined by tactics of the tactical meta-model.*

**Definition 4.3 (Contribution Relation).** *A Contribution (graphically represented in*

Figure 4.5) is a relation  $\mathbf{a} \mathbf{C} \mathbf{b}$  where the goal  $\mathbf{a}$ , if fulfilled, contributes (contribution relation  $\mathbf{C}$ ) positively to the fulfillment of the goal  $\mathbf{b}$  [Chung et al., 2012]. For instance, at the acceptance level, goals  $\mathbf{a}$  and  $\mathbf{b}$  are needs.

Therefore, AMM is composed of *Needs* [Piras et al., 2017b] (legend in Figure 4.6) to be satisfied for maximizing the possibility that intended users accept to use the system [Piras et al., 2017b]. We designed AMM by carrying out a wide literature review of technology acceptance models (e.g., the Unified Theory of Acceptance and Use of Technology (UTAUT) [Venkatesh et al., 2003], the Technology Acceptance Model (TAM2), etc.; the related full list and reviews are provided in Chapter 2) and merging the most relevant concepts in a model, the Agon AMM. Specifically, the main structure of AMM (Figure 4.4) and related CDRs [Piras et al., 2017b] are based on the UTAUT model [Venkatesh et al., 2003]. In fact, we tried to keep most of the concepts of the UTAUT model, which is the most consolidated one in the area of Technology Acceptance, and we used it as the “backbone” of AMM. However, many concepts of UTAUT are at a very high level of abstraction. Thus, in order to design our AMM model by including also more concrete, “low-level”, elements, we refined UTAUT items by inserting some less abstract concepts coming from other technology acceptance models. We designed AMM with this aim, taking into account the literature, related guidelines, considerations and indications described for the technology acceptance models illustrated in Chapter 2 (e.g., overlaps and similarities of concepts outlined in Section 2.1.3 and Table 2.1), and above all, the ones we found in the UTAUT model paper [Venkatesh et al., 2003]. The “configuration” for an acceptance model we propose in Agon with AMM is a possible effective combination, as demonstrated in Chapter 7. However, we are not also claiming that AMM is the only possible effective solution. Our main contribution is to propose, with Agon, a framework able to support the requirements analyst, in the analysis and design of engaging software, through a method and a meta-model. Concerning the meta-model, we propose a well-structured extensible model, with a starting stable “configuration” (established as discussed in Chapter 7), which, being extensible, in the future can be made evolve by including new theories and concepts coming from the acceptance, gamification fields and also other new potential interesting fields by reusing the entire Agon framework (as discussed in Chapter 8). These considerations are valid for all the models of Agon. In the following, we describe AMM more in detail.

The root goal of AMM is the **Sufficient Acceptance** need. It is the most abstract goal and it means to make that most of the intended users accept to use a software system. This receives positive contributions (all the relations in AMM are contributions) by two high-level needs (Figure 4.4) [Piras et al., 2017b]: (i) **Improve Behavioral Intention** that

## 4.2. AN ACCEPTANCE REQUIREMENTS FRAMEWORK AND ITS MULTI-LAYER META-MODEL

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in turn receives positive contributions from **Improve Performance Expectancy**, **Reduce Effort Expectancy** and **Increase Social Influence**; (ii) **Create Facilitating Conditions** that in turn receives positive contributions from **Improve Perceived Behavioral Control** and **Increase Assistance** [Piras et al., 2017b].

Around the main high-level needs we inserted relevant concepts of other technology acceptance models [Piras et al., 2017b]. For instance, needs that provide positive contributions to **Increase Assistance** [Piras et al., 2017b] come from [Thompson et al., 1991]. Those needs are not shown in Figure 4.4 for the sake of space, but we can refer on the example in Figure 4.6, where it is shown one of them: **Create Assistance Group** [Piras et al., 2017b]. In fact, the idea is that, in order to create facilitating conditions for project managers, Agon suggests to organize their activities in virtual groups for increasing the possibility of supplying assistance each other [Piras et al., 2017b].

### 4.2.3 The Tactical Meta-Model

On the one hand, AMM is composed of abstract psychological factors. On the other hand, GMM includes more concrete (though still generic, i.e. not domain-specific) elements such as gamification solutions. Thus, it is needed an intermediate layer to fill the gap between the two (Figure 4.6). With this aim, we designed TMM (Figure 4.6) by selecting common high-level qualities able to tie acceptance and gamification goals [Piras et al., 2017b]. According to this, acceptance needs are refined by *Tactics* (goals at the tactical level) that in turn are operationalized by gamification goals (Figure 4.6) [Piras et al., 2017b].

TMM [Piras et al., 2017b] is fully shown in the Agon Meta-Model Figure, available at [Piras et al., a], as a bridge between AMM and GMM. Respectively, AMM is illustrated at the top of the Figure [Piras et al., a], while in the bottom there is GMM. TMM, being the bridge between AMM and GMM, should be represented in the middle of the 2, however, in the Figure [Piras et al., a], to minimize overlaps of relations among the models, TMM goals - i.e. tactics - are represented under AMM and under TMM. In fact, AMM needs are refined by tactics, and tactics are operationalized by GMM gamification goals. In the bottom of the Figure [Piras et al., a], it is represented the part of TMM refining AMM. While, in the bottom of the Figure [Piras et al., a], it is represented the part of TMM operationalized by GMM.

In the following, we provide (i) the graphical notation of main elements of TMM (see Figure 4.7), and (ii) definitions at the tactical level.

**Definition 4.4 (Tactical Meta-Model).** *The Tactical Meta-Model (TMM) is a qualitative goal model representing the conjunction between the acceptance and gamification*



Figure 4.7: Graphical notation followed by main elements of the Tactical Meta-Model

meta-models (respectively AMM and GMM). Its elements, i.e. tactics, are able to refine AMM acceptance needs, and to be operationalized by GMM gamification goals. It is composed of tactics, modeled as goals, refinement and operationalization relations (Figure 4.7). We define it formally as  $[T, R, O]$  where  $T$  is a set of tactics,  $R$  a set of refinement relations, and  $O$  a set of operationalization relations. It is a goal model, with different abstraction levels, where each tactic can be refined by another one.

**Definition 4.5 (Tactic).** A Tactic is a quality goal (Figure 4.7) representing a conjunction among acceptance needs and gamification goals. Specifically, a tactic is able to refine acceptance needs, and to be operationalized by gamification goals.

**Definition 4.6 (Refinement Relation).** A Refinement (graphically represented in Figure 4.7) is a relation  $Gs \ R \ b$  where  $Gs$ , a set of goals, refine (relation  $R$ ) the goal  $b$ . The relation  $R$  can be an **AND** refinement or an **OR** refinement. Thus, the fulfillment of the goal  $b$  depends on **(i)** the fulfillment of the  $Gs$  goals refining it, and on **(ii)** the boolean rationale of the relation  $R$  [Chung et al., 2012]. For example, in order to connect the tactical level to the acceptance level, refinements are used for refining acceptance needs with tactics; in this case, **goals** are tactics and  $b$  is a need.

**Definition 4.7 (Operationalization Relation).** An Operationalization (graphically represented in Figure 4.7) is a relation  $Gs \ O \ b$  where  $Gs$ , a set of goals, operationalize (relation  $O$ ) the goal  $b$ . The relation  $O$  can be an **AND** operationalization or an **OR** operationalization. Thus, the fulfillment of the goal  $b$  depends on **(i)** the fulfillment of the  $Gs$  goals operationalizing it, and on **(ii)** the boolean rationale of the relation  $O$  [Chung et al., 2012]. For instance, in order to create a conjunction between the tactical level and the gamification level, operationalizations are used for operationalizing tactics with gamification goals; in this case, **goals** are gamification goals and  $b$  is a tactic.

Continuing the example in Figure 4.6, at the AMM level Agon proposes to enable users to assist each other in groups and, at the tactical level it is refined by promoting collaboration (**Promote Collaboration**) among the project managers [Piras et al., 2017b]. This leads Agon to select gamification goals able to operationalize the collaboration promotion

(we discuss this in the next Subsection). Other tactics are shown in Figure 4.2 [Piras et al., 2017b].

#### 4.2.4 The Gamification Meta-Model

GMM [Piras et al., 2017b] is fully shown in the Agon Meta-Model Figure, available at [Piras et al., a]. In such Figure [Piras et al., a], it is illustrated in the bottom. While, under GMM (Figure [Piras et al., a]), it is represented the part of the *Tactical Meta-Model* (TMM) connected with GMM. Furthermore, an extract of GMM, is shown in Figure 4.9 and Figure 4.10. In the following, we provide **(i)** the graphical notation of main elements of GMM (see Figure 4.8); **(ii)** definitions at the gamification level; **(iii)** the explanation of how we designed GMM; **(iv)** the description of an extract of GMM (Figure 4.9 and Figure 4.10) and of the example in Figure 4.6 related to GMM.

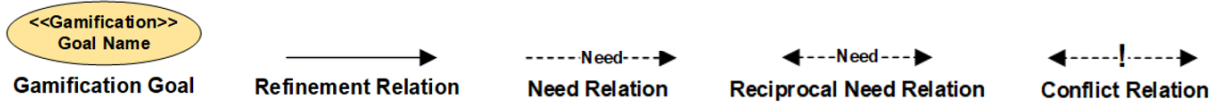


Figure 4.8: Graphical notation followed by main elements of the Gamification Meta-Model

**Definition 4.8 (Gamification Meta-Model).** *The Gamification Meta-Model (GMM) is a goal model that captures gamification concepts, strategies, best practices and guidelines, and represents them as gamifications goals. It is composed of gamification goals, refinement relations, need relations, reciprocal need relations and conflict relations (Figure 4.8). We define it formally as  $[GG, R, NR, RNR, CF]$  where  $GG$  is a set of gamification goals,  $R$  a set of refinement relations,  $NR$  a set of need relations,  $RNR$  a set of reciprocal need relations, and  $CF$  a set of conflict relations. It is a goal model, with different abstraction levels, where each gamification goal can: **(i)** be refined by another gamification goal; **(ii)** need the fulfillment of another gamification goal for its fulfillment (this can be also reciprocal); **(iii)** be in conflict with another gamification goal. Additionally, gamification goals can operationalize tactics of the tactical meta-model.*

**Definition 4.9 (Gamification Goal).** *A Gamification Goal is a goal representing gamification concepts, strategies, best practices and guidelines (Figure 4.5). One or more gamification goals can operationalize tactics of the tactical meta-model.*

The definition of the refinement relation (Figure 4.8) is analogous to the one provided for TMM. The meaning is the same, the only difference is that, in GMM, gamifications

goals are involved. While, the definition of the operationalization relation is exactly the one provided for TMM.

**Definition 4.10 (Need Relation).** *The Need Relation (graphically represented in Figure 4.8) is a relation  $\mathbf{a} \text{ NR } \mathbf{b}$  where the goal  $\mathbf{a}$  for its fulfillment needs (need relation  $\text{NR}$ ) that also the goal  $\mathbf{b}$  is fulfilled. For example, at the gamification level, goals  $\mathbf{a}$  and  $\mathbf{b}$  are gamification goals.*

**Definition 4.11 (Reciprocal Need Relation).** *The Reciprocal Need Relation (graphically represented in Figure 4.8) is a relation  $\mathbf{a} \text{ RNR } \mathbf{b}$  where goals  $\mathbf{a}$  and  $\mathbf{b}$  for their fulfillment needs reciprocally (reciprocal need relation  $\text{RNR}$ ) that both of them are fulfilled. For example, at the gamification level, goals  $\mathbf{a}$  and  $\mathbf{b}$  are gamification goals.*

**Definition 4.12 (Conflict Relation).** *The Conflict Relation (graphically represented in Figure 4.8) is a relation  $\mathbf{a} \text{ CF } \mathbf{b}$  where the fulfillment of both the goals  $\mathbf{a}$  and  $\mathbf{b}$  is in conflict (conflict relation  $\text{CF}$ ), thus, the relation requires that only one of the 2 goals is fulfilled. For instance, at the gamification level, goals  $\mathbf{a}$  and  $\mathbf{b}$  are gamification goals.*

GMM [Piras et al., 2017b] is built on gamification concepts and best practices we extracted by carrying out a wide review of the literature and of success cases from the industry (we provide reviews in Chapter 2, some of them are [Hamari, 2015, Kazhamiakin et al., 2015, Schell, 2014, Zichermann and Cunningham, 2011]). GMM supports mainly [Piras et al., 2017b]: badges, levels, paths, leader-boards of various kinds, redeemable points, reputation points, experience points, karma points, skill points, gamified trainings, gamified tutorials, game roles, unlockable powers, gamified tours, avatars, suggestions and tricks, gamified forums, team and personal challenges, gamified communities and gamified markets with redeemable rewards and making gift policies. Given that new gamification concepts and strategies have been continuously appearing, we are often updating the GMM knowledge by adding new concepts, strategies, guidelines and best practices [Piras et al., 2017b].

In Figure 4.9 there is the left part of an extract of GMM, which continues with the right part in Figure 4.10. It is related to the gamification concept of *Levels* [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011]. Usually levels are used in combination with the *Paths* gamification concept for building different gamified experiences, where the user progresses by carrying on software activities - strictly tied to software objectives - by being motivated to perform activities through the progression itself, represented by *levels* reached, and/or by offering also gamification rewards such as *Badges*, *Points*, *Powers*, *Gifts* [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011], etc.

#### 4.2. AN ACCEPTANCE REQUIREMENTS FRAMEWORK AND ITS MULTI-LAYER META-MODEL

In the left part of the extract (Figure 4.9), it is represented the *Levels* gamification concept with the root gamification goal **Set Levels**. It is refined by (i) defining levels and

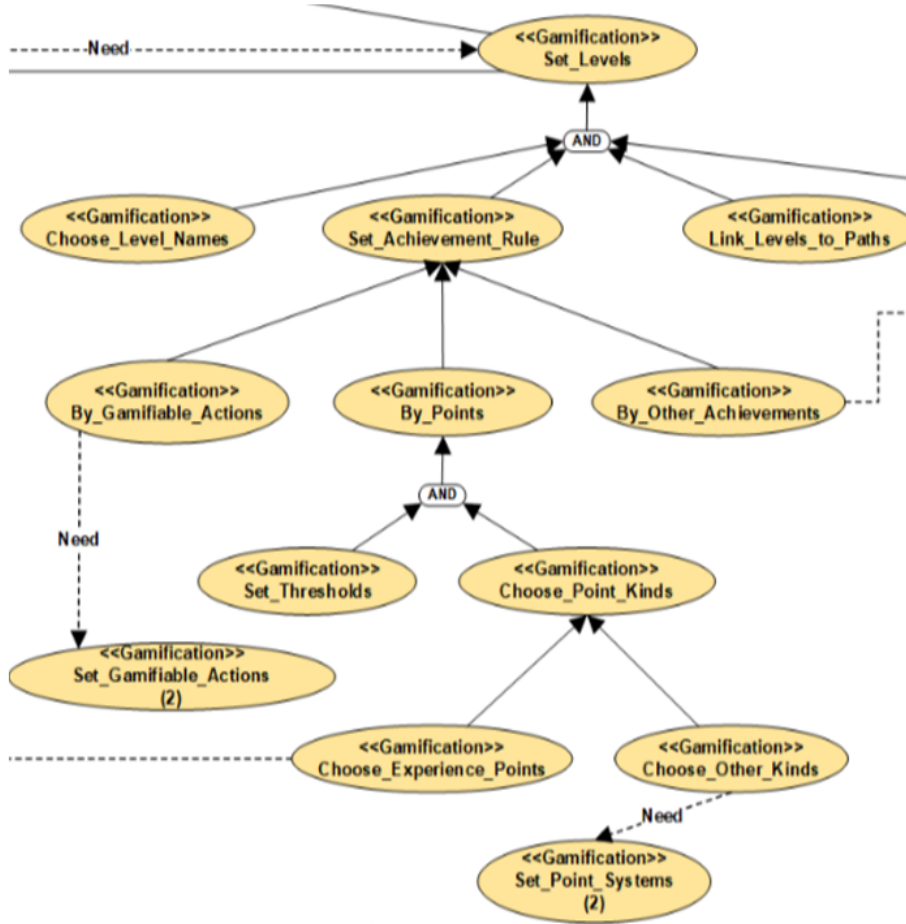


Figure 4.9: Left part of an extract of the Gamification Meta-Model (right part in Figure 4.10) related to the gamification concept of *Levels* [Piras et al., 2017b]

assigning a name to each level (**Choose Level Names** in Figure 4.9), (ii) defining conditions for reaching the levels (**Set Achievement Rules** in Figure 4.9), (iii) linking levels to the corresponding paths (**Link Levels to Paths** in Figure 4.9), and (iv) specifying progression difficulty among levels concerning the entire path (**Define Difficulty Among Levels** in Figure 4.10).

In Figure 4.9, rules for reaching levels (**Set Achievement Rules**) are refined by one or more of the following elements [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011]: software actions that can be gamified (**Gamifiable Actions**), points (**By Points**) and other gamification concepts (**By Other Achievements**, such as *Badges*,

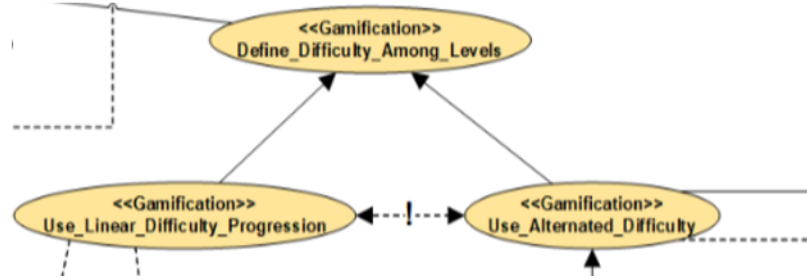


Figure 4.10: Right part of the extract of the Gamification Meta-Model (left part in Figure 4.9) related to the gamification concept of *Levels* [Piras et al., 2017b]

*Powers, Gifts, etc.*). In case of gamifiable actions [Kazhamiakin et al., 2015, Piras et al., 2017b] (**Gamifiable Actions**, see Definition 3.1 [Kazhamiakin et al., 2015]), the set of software actions that can be gamified need to be defined in another part of GMM (**Set Gamifiable Actions**). In case of points (**By Points**), thresholds have to be defined (**Set Thresholds**), i.e. a specific amount of points to be collected in order to pass to the next level [Piras et al., 2017b, Schell, 2014]. Furthermore, kinds of points have to be selected (**Choose Points Kinds**), e.g. experience points (**Choose Experience Points**) or other kinds of points [Piras et al., 2017b, Zichermann and Cunningham, 2011] (**Choose Other Kinds** that needs to design other point systems, in another part of GMM represented by **Set Point Systems**; for instance, another kind that could be chosen is *Skill Points* [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011]).

In Figure 4.10, it is illustrated the right part of the GMM extract related to *Levels*, where it is needed to specify the progression difficulty among levels belonging to the same path (**Define Difficulty Among Levels**). The simplest and cheapest way of defining such progression - fulfilling tactics such as **Fast Design** and **Low Cost Design** - is to use a linear progression among levels (**Use Linear Difficulty Progression**), i.e. difficulties that increase linearly level by level. While, if we prefer to give the user more stimuli with unpredictable difficulties within levels (fulfilling the **Increase User Surprise** tactic), we select **Use Alternated Difficulty**.

The main relationship used at the GMM level (Figure 4.6 and Figure 4.2) is that of refinement [Piras et al., 2017b]. Furthermore, gamification goals operationalize tactics [Piras et al., 2017b] (Figure 4.2). For instance, the challenges concept is represented in Figure 4.2 (**Set Challenges**) with [Piras et al., 2017b]: **Team Challenges** and **Personal Challenges**. According to the CDRs indicated, team challenges are suggested for socializers, explorers, etc., and them operationalize the **Promote Collaboration and Support**

## 4.2. AN ACCEPTANCE REQUIREMENTS FRAMEWORK AND ITS MULTI-LAYER META-MODEL

**Social Behavior** tactics [Piras et al., 2017b]. While, personal challenges fit mainly males, achievers, etc., and them operationalize the **Support Achievement** tactic [Piras et al., 2017b].

Continuing the project management example in Figure 4.6, at the tactical level Agon suggests to promote collaboration and, at the gamification level, it is operationalized by arranging teams and team roles (**Set Team Roles**) for project managers [Piras et al., 2017b].

We have chosen to use goals at this level, because most of the gamification concepts included in GMM are generic and, in some cases, abstract (even though some ones are more, and some ones are less). Furthermore, in any case, them need to be instantiated, and further refined, by the analyst, according to aspects not currently considered by Agon. Some of these aspects regard needs to take into account concerning the specific domain of the software to gamify. In the next Section, we discuss this more in detail, by providing also some examples. For instance, it is explained how **Set Team Roles**, in Figure 4.6, is instantiated according to team roles making sense and being beneficial for the characteristics and purposes of the specific domain of the software to gamify, in this case the project management domain.

### 4.2.5 The Instantiation Model

Solutions obtained at the gamification level are the result of acceptance and tactic reasoning and are the most suitable for the intended users, but are generic, independent from a specific domain [Piras et al., 2017b]. Therefore, GMM goals need to be instantiated in relation to the specific domain of the system to gamify [Piras et al., 2017b]. So far, the process is semi-automatic and interactive, while at the instantiation level the analyst has to create the IM [Piras et al., 2017b]. Agon helps the analyst by providing her with a notation [Piras et al., 2017b] based on the *NFR Framework* Chung et al. [2012] supporting goals, tasks, and relations such as instantiations, refinements and operationalizations (Figure 4.11).

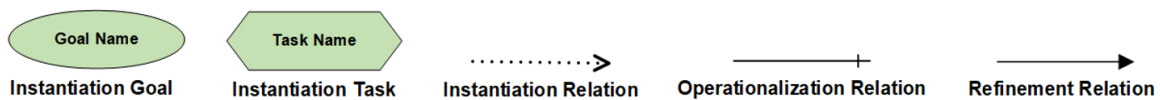


Figure 4.11: Graphical notation offered by Agon for instantiating the gamification solutions suggested by building the instantiation model

Concluding the project management example (Figure 4.6), in order to create facilitating conditions to users, Agon proposes to enable users to assist each other in groups for promoting, in this way, collaboration. At the gamification level, Agon suggests to operationalize the collaboration through the definition of teams and team roles for the users. The solution suggested by Agon is valuable and suitable for the intended users, but it is still abstract. It has to be instantiated in the specific domain of the project management system. Therefore, the analyst creates the IM (Figure 4.6) by instantiating the **Set Team Roles** gamification goal and defining the purposes of each team roles. Those purposes are specific of the project management domain. For instance, **Set CM Proponent Team Role** describes a team where project managers have the role to propose and carry on a change in critical tasks for improving some company procedures. While, **Set As-Is Reporter Team Role** defines a team responsible for reporting the current situation (activities) of procedures to be improved. Finally, **Set Alternative Proponent Team Role** describes a team in charge of proposing alternative solutions for improving procedures.

In summary, during the entire usage of Agon and its method, the analyst is the person in charge of considering the specific domain of the software to gamify, and to take decisions compatible with it. In fact, Agon has been not designed to completely fulfill this aspect. This is due to the fact that its meta-model is made of generic reference models annotated by user CDRs. However, Agon, on the basis of its design, can supply the analyst with another crucial factor that is equally important. Specifically, Agon supports the analyst through suggestions regarding how to engage intended software users, with acceptance strategies and gamification solutions that are the most suitable ones for such users. Moreover, this process is semi-automatic, indeed the analyst can interact with Agon, during each phase, by deciding either to keep or to discard (even to modify) Agon suggestions. However, some relevant factors that the analyst considers, when takes those decisions, are related to the specific domain of the software. Thus, the fact that Agon cannot consider precisely the domain is one of the current limitations of Agon. As a future work, we envisage to make it to evolve also by including this important aspect. In the next Chapter, we describe the Agon methodology, the Agon-Tool, and, thus, we show more in detail how Agon supports the analyst by giving suggestions, and which are the benefits obtainable from using the framework.

### 4.3 Chapter Summary

This Chapter describes *Agon*, our *Acceptance Requirements Framework Based on Gamification*, objective of this thesis, and *Acceptance Requirements*. Specifically, we start

defining acceptance requirements, exposing also some realistic examples. Then, we illustrate Agon, the framework we designed, able to deal with acceptance requirements and to provide gamification operationalizations for them. Moreover, we describe its *Agon Multi-Layer Meta-Model* and related abstraction layers and models.

A more detailed summary of Sections content is the following.

In Section 4.1, we give the definition of *Acceptance Requirements* and provide some examples, coming from well-known domain such as meeting scheduling and project management, of expliciting such requirements.

In Section 4.2, we describe Agon and, above all, its *Agon Multi-Layer Meta-Model*. Furthermore, we illustrate each model composing the multi-layer meta-model by providing details, regarding how we designed them, and examples. Such models are the *Acceptance Meta-Model*, *Tactical Meta-Model*, *Gamification Meta-Model* and *User Context Model*.

# Chapter 5

## The Agon Method and Tool

In this Chapter we describe the *Systematic Acceptance Requirements Analysis Based on Gamification*, i.e. the method provided by Agon to the requirements analyst for the analysis and design of engaging software systems. We outline also the *Agon-Tool*, the software supporting the requirements analyst in using Agon and its meta-model for performing a systematic acceptance requirements analysis based on gamification.

In detail, next Sections contains the following content.

- Section 5.1 describes the method provided by Agon to the requirements analyst for the analysis and design of engaging software systems. The *Systematic Acceptance Requirements Analysis Based on Gamification* of Agon is illustrated by showing the method in action for gamifying the famous Meeting Scheduler exemplar, which comes from the Requirements Engineering Community. For this occasion, we propose a more collaborative, social version of the meeting scheduler, inspired to Doodle<sup>1</sup>, and we name it as: the *Doodle-Like Meeting Scheduler Exemplar*. Therefore, in this Section, we show both the Agon method, and the gamification of the Doodle-Like Meeting Scheduler Exemplar, which is part of a case study we carried out [Piras et al., 2017a] and illustrate in Chapter 8.
- Section 5.2 outlines the *Agon-Tool* and illustrate its architecture, main components and other technical details. The Agon-Tool is the software supporting the requirements analyst in using Agon and its meta-model for performing a systematic acceptance requirements analysis based on gamification. Moreover, we show also the Agon-Tool in action, by describing how it can be used for such analysis activities.

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<sup>1</sup><https://doodle.com>

## 5.1 The Agon Method

In this Section, we describe the *Systematic Acceptance Requirements Analysis Based on Gamification*, the method provided by Agon to the requirements analyst for the analysis and design of engaging software systems [Piras et al., 2016, 2017a,b]. We illustrate the method in action for the gamification of the famous Meeting Scheduler exemplar, which comes from the Requirements Engineering Community. For this occasion, we propose a more collaborative, social version of the meeting scheduler, inspired by Doodle<sup>2</sup>, and we name it as: the *Doodle-Like Meeting Scheduler Exemplar* (DLMSE) [Piras et al., 2016, 2017a]. Therefore, in this Section, we show both the Agon Method [Piras et al., 2016, 2017a,b], and the gamification of the DLMSE [Piras et al., 2016], which is part of a case study we carried out [Piras et al., 2017a] and illustrate in Chapter 8. Moreover, in Chapter 6 we illustrate a real case study, where we applied the Agon method, for the gamification of a platform in the context of a European project. It is the Participatory Architectural Change Management in ATM Systems (PACAS<sup>3</sup>) European project, we describe the related case study in Chapter 6.

The full models of the example for gamifying the Doodle-Like Meeting Scheduler can be found in Piras et al. [a]. Figures shown in this Section have not colored goals as the ones shown in Chapter 4, this is due to the fact that for the example we used a first version of Agon having no colored elements. Later, we updated the Agon models with the colors presented in Chapter 4.

In the following, we describe phase by phase the steps of the Agon Method and, in the last subsection, we briefly illustrate a summary of the full gamified solution Piras et al. [a] obtained by using our framework [Piras et al., 2016, 2017a]. Decisions taken by the analyst during the example, concerning choosing elements to keep/modify/discard, are made also on the basis of a glossary regarding elements of the Agon Framework Piras et al. [a]. In fact, in each phase, the analyst can decide whether to accept suggestions generated by Agon using the Agon model glossary Piras et al. [a]. The entire process is supported by the Agon-Tool (outlined in Section 5.2), a reasoning tool based on Constrained Goal Models [Nguyen et al., 2016a,b] that selects optimal gamification solutions for a given set of acceptance requirements and a context [Piras et al., 2016, 2017a]. Moreover, in the following we show the process in a linear way, but it can be also performed in an iterative manner. Accordingly, it is also possible to come back to previous steps, take different decisions and re-execute some phases for improving incrementally the solution [Piras et al.,

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<sup>2</sup><https://doodle.com>

<sup>3</sup><http://www.pacasproject.eu/>

2016, 2017a].

In the following, we first present our Doodle-Like Meeting Scheduler Exemplar (DLMSE) [Piras et al., 2016, 2017a], then describe all the phases of the Agon method [Piras et al., 2016, 2017a], providing also examples coming from the case study where we gamified our exemplar [Piras et al., 2016, 2017a]. We conclude this section with a summary of the gamification solution, we designed by using Agon, for solving the acceptance problem of our exemplar [Piras et al., 2016, 2017a].

### 5.1.1 The Doodle-Like Meeting Scheduler Exemplar (DLMSE)

In this Subsection, we describe the *Doodle-Like Meeting scheduler Exemplar* [Piras et al., 2016, 2017a] (DLMSE). We designed our exemplar as a goal model [Piras et al., 2016, 2017a], it is fully available at [Piras et al., a]. In summary, the requirements for this meeting scheduler include scheduling of meetings, after taking into account participant constraints [Piras et al., a]. In addition, the system should be used by the majority of intended users. Specifically, they should use a Doodle<sup>4</sup> table to input their time constraints for the period when the meeting is to be held [Piras et al., a]. The scenario used in this case study is a meeting scheduled for full professors at a university [Piras et al., a, 2016, 2017a].

In a nutshell, following the DLMSE goal model available at [Piras et al., a], main goals are: choosing potential participants, creating a Doodle defining possible dates, notifying participants asking them to compile the Doodle by filling preferred dates, etc. Thus, these goals are refined until the definitions of tasks, but in the case of **Convince Potential Participants to Compile Dates** we have a non-refined goal, that is strictly tied to **Submit Dates**. This is a typical acceptance problem and in the following Subsections we show how Agon can support, guide and help the analyst in finding acceptance and gamification requirements for favoring the possibility to solve it [Piras et al., 2016, 2017a].

Furthermore, in the DLMSE, we specify also the characterization of the users involved and the social context in which they act [Piras et al., 2016, 2017a]. It is represented in Figure 5.1 by using an instance of the Agon UCM. Therefore, such scenario is a meeting scheduled for full professors at the university. The representative characterization, we provide in Figure 5.1, is a group of people composed mostly of senior, male, professors, achievers as potential players Bartle [1996] and employed in a university; the users are not experts regarding use of Doodle or similar software, and it is not mandatory for them to fill the Doodle [Piras et al., 2016, 2017a]. Finally, they have never used software similar

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<sup>4</sup><https://doodle.com>

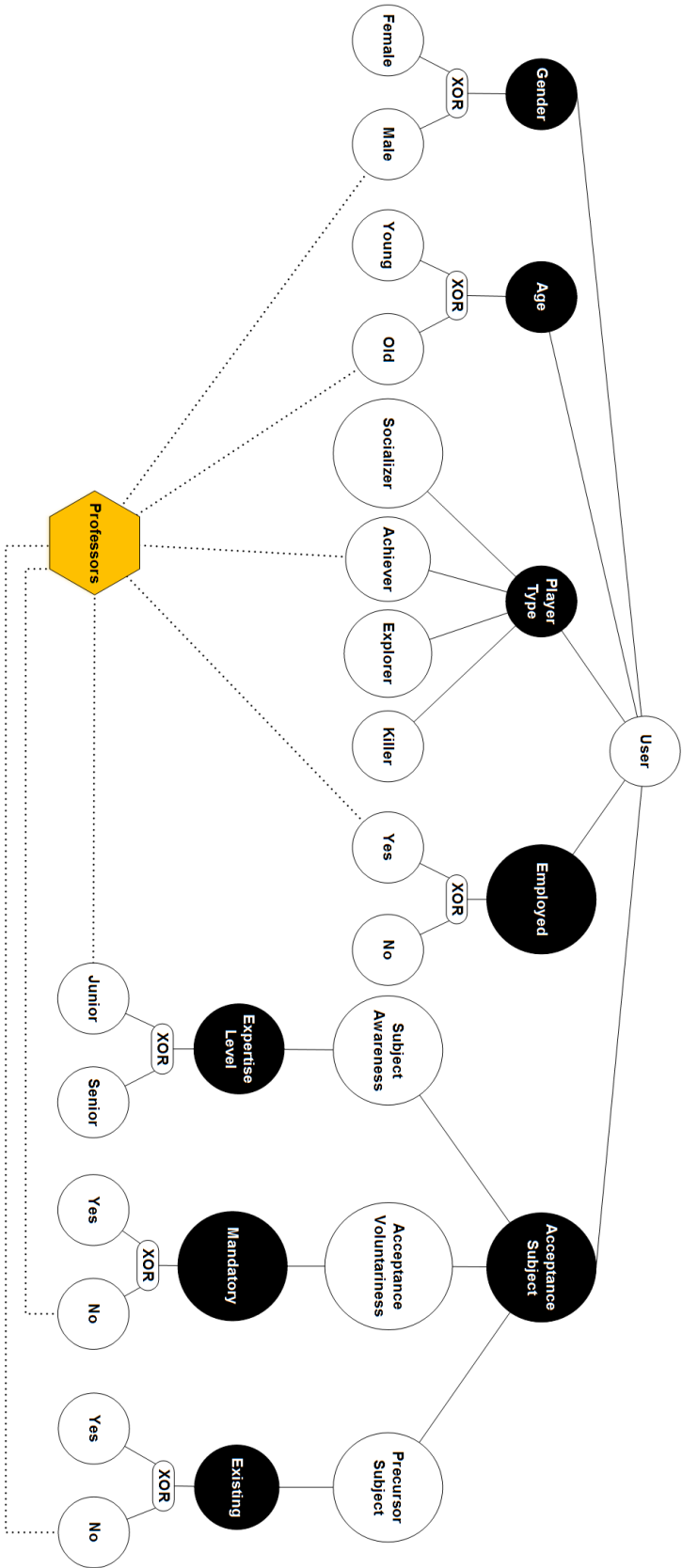


Figure 5.1: The target group of users (professors), of the Doodle-Like Meeting Scheduler case study [Piras et al., 2017a], defined by instantiating the User Context Model of Agon [Piras et al., a, 2016, 2017a]

to Doodle [Piras et al., 2016, 2017a].

Moreover, in the DLMSE, we suggest also the acceptance requirement to fulfill [Piras et al., 2016, 2017a]. It is the following ones, we revisit it from Section 4.1:

$$Acceptance[\{SubmitDates\}, Professors] \geq 80\% \quad (4.2 \text{ revisited})$$

Therefore, the acceptance problem is to motivate meeting participants, **Professors**, to provide their time constraints (**SubmitDates** function of the system) so that a meeting can be scheduled [Piras et al., 2016, 2017a].

### 5.1.2 Phase 1: Base System Requirements

In the first phase of the Agon method [Piras et al., 2016, 2017a], the requirements analyst uses Agon for modeling the (to-be or as-is) software to be gamified as a goal model [Chung et al., 2012, Horkoff et al., 2017, Li et al., 2013, Mylopoulos et al., 1992]. The analyst represents requirements, goals, tasks, and relations such as refinements and contributions [Chung et al., 2012, Horkoff et al., 2017, Li et al., 2013, Mylopoulos et al., 1992].

For instance, we represent the DLMSE system as the goal model [Piras et al., 2016, 2017a] available at [Piras et al., a].

### 5.1.3 Phase 2: Acceptance Requirements Elicitation and Analysis

Then, the analyst has to identify, by analyzing the goal model, the functions that need to be gamified and define, on the basis of them, the acceptance requirements [Piras et al., 2016, 2017a,b]. Moreover, Agon provides the analyst with guidelines for finding functions. Thus, Agon suggests to define acceptance requirements by identifying, among all the functions of the software, the ones that:

- cannot be fulfilled automatically by IT procedures;
- need human contributions;
- require to stimulate, engage the human for carrying out the activity (e.g., the activity is boring, complex, repetitive, etc.);
- contribute positively to the achievement of critical purposes of the system and depend on the human contribution to be fulfilled.

Thanks to the previous phase, the analyst has designed a goal model having all these elements highlighted, and, by analyzing it, she can identify more easily those important functions [Piras et al., 2016, 2017a].

For example, in the case of the DLMSE, the most critical element, fulfilling the guidelines specified above, is to motivate meeting participants to provide their time constraints by using the system function for submitting dates (**SubmitDates**), so that a meeting can be scheduled. Accordingly, we specify the acceptance requirement for DLMSE as [Piras et al., 2016, 2017a]:

$$Acceptance[\{SubmitDates\}, Professors] \geq 80\% \quad (4.2 \text{ revisited})$$

However, for concluding the definition of acceptance requirements, the analyst needs also to characterize the participants (**Professors**), as we outline in the next phase [Piras et al., 2016, 2017a].

In summary, so far, **(i)** in “*Phase 1: Base System Requirements*”, Agon allows the analyst to create a goal model, representing the software to gamify, by using a notation (made of goals, tasks, relations, etc.) close to the one of the NFR framework [Chung et al., 2012, Li et al., 2013, Mylopoulos et al., 1992]; **(ii)** then, in “*Phase 2: Acceptance Requirements Elicitation and Analysis*”, Agon pushes the analyst to reason over such goal model, by providing the analyst with also guidelines for understanding how to analyze the model, for individuating the candidate functions to be part of acceptance requirements.

However, the guidelines for identifying candidate functions provided by Agon in “*Phase 2: Acceptance Requirements Elicitation and Analysis*”, at the moment, are given in textual form, i.e. in a similar way to the text and the list written above (at the beginning of this Section describing this phase). In fact, the analyst is the only person that knows how to categorize, on the basis of the Agon guidelines, the functions of the system to gamify. This is because she has the knowledge of the as-is/to-be software to gamify, for example concerning the behavior and presentation of software functions, interactions among functions, importance/priority of the functions regarding the fulfillment of stakeholders’ goals, and other important correlated aspects. Therefore, at the moment, this is a “manual” activity in charge of the analyst with minimal support from Agon. This is one of the current limitations of Agon.

Moreover, we have already started a future work, by involving also a master student within his master thesis, aiming at finding ways for semi-automatizing this phase. The main idea is to ask the analyst to semantically annotate software functions, on the basis of annotations supported by Agon, giving more semantic elements to Agon for reasoning over the model. In this way, Agon will be able to reason, over the annotations and over an

objective function to satisfy (either a default function, or a function that can be customized by the analyst), and to suggest candidate functions to the analyst.

#### 5.1.4 Phase 3: Context Characterization

For solving an acceptance problem, it is important to define the characteristics of the users to engage Piras et al. [2016]. Therefore, in order to characterize the users to motivate, the analyst instantiates the UCM provided by Agon. After this instantiation, the analyst will give in input to Agon the UCM instance representing the characterization of our participants group, and this instance will guide the reasoning over abstraction layers [Piras et al., 2016].

For instance, in DLMSE, the scenario used is that of university professors who have to schedule a meeting. Thus, we instantiate UCM for characterizing the intended group of people to convince as in Figure 5.1 [Piras et al., 2016, 2017a]: senior employed males that are achievers as kinds of players [Bartle, 1996], they are not experts regarding using Doodle or similar software, it is not mandatory for them to fill the Doodle and they have not scheduled meetings by using IT systems previously [Piras et al., 2016, 2017a].

#### 5.1.5 Phase 4: Context-Based Analysis of Acceptance Requirements

This phase regards context-based reasoning over the acceptance model. It is context-based reasoning, because it takes into account the user characterization provided and the rules annotating the acceptance model [Piras et al., 2017a]. Therefore, Agon starts working on AMM and, by using the UCM instance guiding the reasoning, produces an acceptance solution (results available at [Piras et al., a]) having acceptance needs that best suit the context [Piras et al., 2016]. For example, as in Figure 5.2, **Increase Social Influence** is effective if you are dealing with females Venkatesh et al. [2003] and since we are dealing with males, this option is not considered by Agon [Piras et al., 2016, 2017a]. Instead,

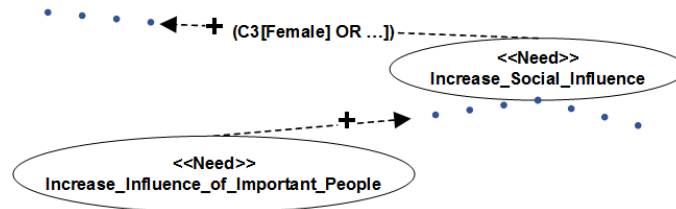


Figure 5.2: Acceptance Need contributions annotated by CDRs [Piras et al., 2016]

Agon selects **Reduce Effort Expectancy** because there is an annotated rule saying that elderly users are influenced positively if that need is satisfied Venkatesh et al. [2003].

Furthermore, the analyst can interact by selecting needs she prefers to maintain (complete analyst's decisions available at [Piras et al., a]). In the DLMSE example, concerning **Increase Outcome Expectations** (Figure 5.3), the analyst may remove **Improve**

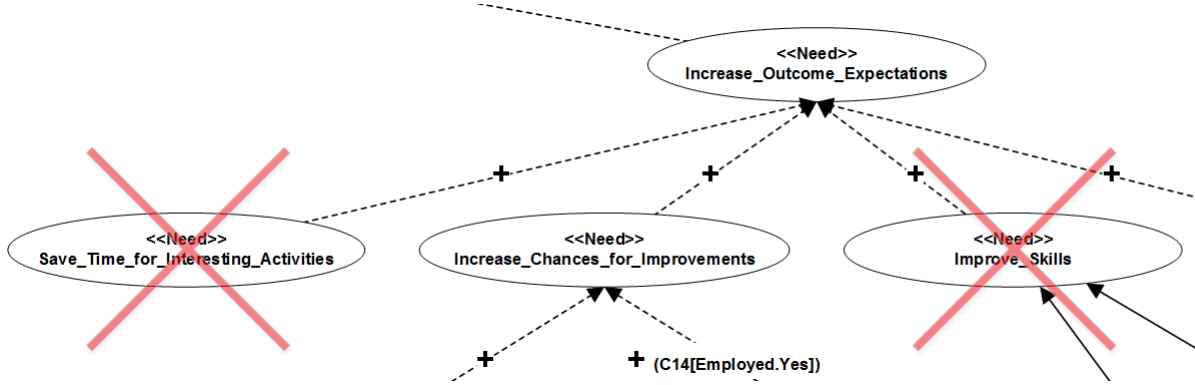


Figure 5.3: Example of elements discarded by the analyst during “Phase 4: Context-Based Analysis of Acceptance Requirements” [Piras et al., a, 2016, 2017a]

**Skills** because it is an overkill to include training in the gamified solution for something as simple as meeting scheduling. Accordingly, we keep **Improve Perceived Ease of Use** (Figure 5.4) to be achieved through a simple introduction to the tool [Piras et al., 2016,

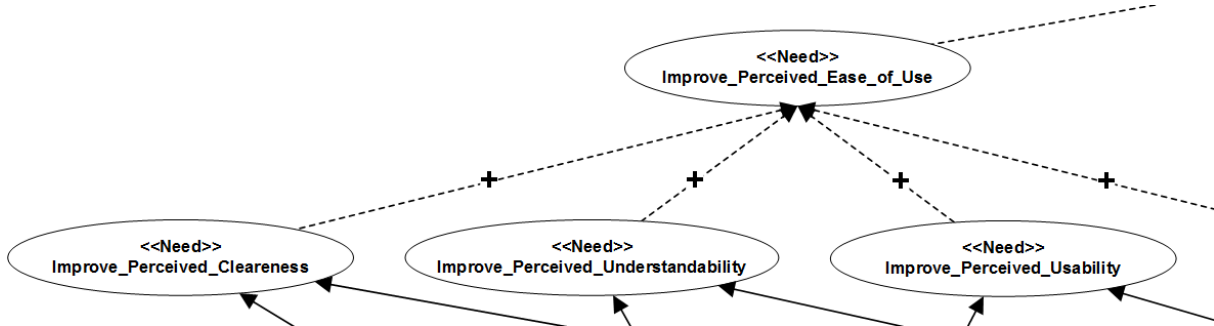


Figure 5.4: Example of elements confirmed by the analyst during “Phase 4: Context-Based Analysis of Acceptance Requirements” [Piras et al., a, 2016, 2017a]

2017a].

The chosen acceptance solution is added to the specification of the (to-be or as-is) system [Piras et al., 2016, 2017a]. Figure 5.12 presents the acceptance solution obtained at the conclusion of this phase, i.e. the result of Context-Based reasoning over the Acceptance Model and analyst's decisions. Elements discarded by the reasoning or by the analyst have been removed in the Figure to have a clear view of the result [Piras et al., a].

### 5.1.6 Phase 5: Acceptance Requirements Refinement

In this phase, there are decisions to be made at the tactical and gamification levels of the framework involving interactively the analyst. On the basis of the acceptance solution, Agon shows tactics that can be used for refining acceptance needs [Piras et al., 2016, 2017a]. For example, as shown in Figure 5.5 for the DLMSE example, Agon proposes Support Achievement, Improve Perceived Status and Improve System Perception via IT. The analyst may discard some of them reducing the solution space. In DLMSE, we decide to keep all of them [Piras et al., 2016, 2017a] (Figure 5.5).



Figure 5.5: Elements proposed by Agon to the analyst during “*Phase 5: Acceptance Requirements Refinement*” [Piras et al., a, 2016, 2017a]

Then, Agon finds high-level techniques that can operationalize those tactics [Piras et al., 2016, 2017a] (Figure 5.6): e.g., Design Gamification, Design Tangible Incentives and Design Serious Games. In DLMSE we keep only gamification (Figure 5.6). This



Figure 5.6: Operationalizations proposed by Agon to the analyst during “*Phase 5: Acceptance Requirements Refinement* (red Xs are the analyst’s decisions)” [Piras et al., a, 2016, 2017a]

is due to the fact that, in this thesis we focus exclusively on gamified solutions [Piras et al., 2016, 2017a], thus, gamification is, at the moment, the only possible choice;

however, as future work, Agon will support different operationalizations [Piras et al., 2016]. For instance, considering the elements in Figure 5.6, the difference among designing gamification and serious games is that, even though they use similar game concepts and mechanisms, the second one adds a further dimension, a virtual environment where the user should be immersed in a way analogous to the one of a video-game [Deterding et al., 2011, Schell, 2014, Zichermann and Cunningham, 2011] (however, in the next, we highlight also some differences between serious games and video-games). Additionally, serious games are complete software games, while gamification can be applied either to the entire software or even to just some specific critical parts where it is needed to engage the user. Gamification has not the requirement of the virtual dimension, indeed gamification elements can be directly included in the graphical user interface of the software to be gamified [Deterding et al., 2011, Zichermann and Cunningham, 2011]. Furthermore, both of them are designed for a purpose, and not just for the fun of the user (as pure video-games). The main aim of gamification is to change the user behavior by making her to embrace positive ways of acting in line with the software and stakeholders' objectives [Deterding et al., 2011, Zichermann and Cunningham, 2011].

Moreover, precisely speaking, also the concepts of video-games and serious games do not coincide [Deterding et al., 2011]. In fact, the first ones have, as primary objective, to make the user to have fun, to be entertained [Deterding et al., 2011, Zichermann and Cunningham, 2011], while the latter are designed for different purposes related to behavior change, as well as gamification, for instance for training the user regarding some activities [Deterding et al., 2011, Zichermann and Cunningham, 2011].

Therefore, we foresee, for the future evolution of the Agon framework, to add new models able to capture other specialized operationalizations [Piras et al., 2017b]. This will enrich the framework making it even more flexible and able to provide a wider range of solutions [Piras et al., 2017a], which could be employed singularly or even in a mixed way [Piras et al., 2016]. We envisage even more operationalizations than the ones in Figure 5.6, for instance also game metaphors, game-inspired design, marketing strategies, advertisement, persuasive messages, nudge theory [Piras et al., 2016, 2017a,b], etc. We discuss these opportunities more in detail, as an important future work, in Chapter 8.

Coming back to the description of this phase, gamification has been selected, according to the discussion related to Figure 5.6, and, then, Agon discovers that gamification can fulfill, besides tactics selected before, also other tactics that could be added in this phase to our specification [Piras et al., 2016, 2017a]. Additional tactics could contribute to engage users, but it is not guaranteed that they solve the acceptance problem, due to the fact they were not selected in previous phases by Agon [Piras et al., 2016]. Furthermore, the other

particular tactics suggested by the framework, being related to gamification aspects, even not guaranteeing to solve the acceptance problem, can improve the gamified experience of the user [Piras et al., 2017a]. For instance, as illustrated in Figure 5.7 for the DLMSE example, we add some of those tactics to the specification: Increase User Surprise,

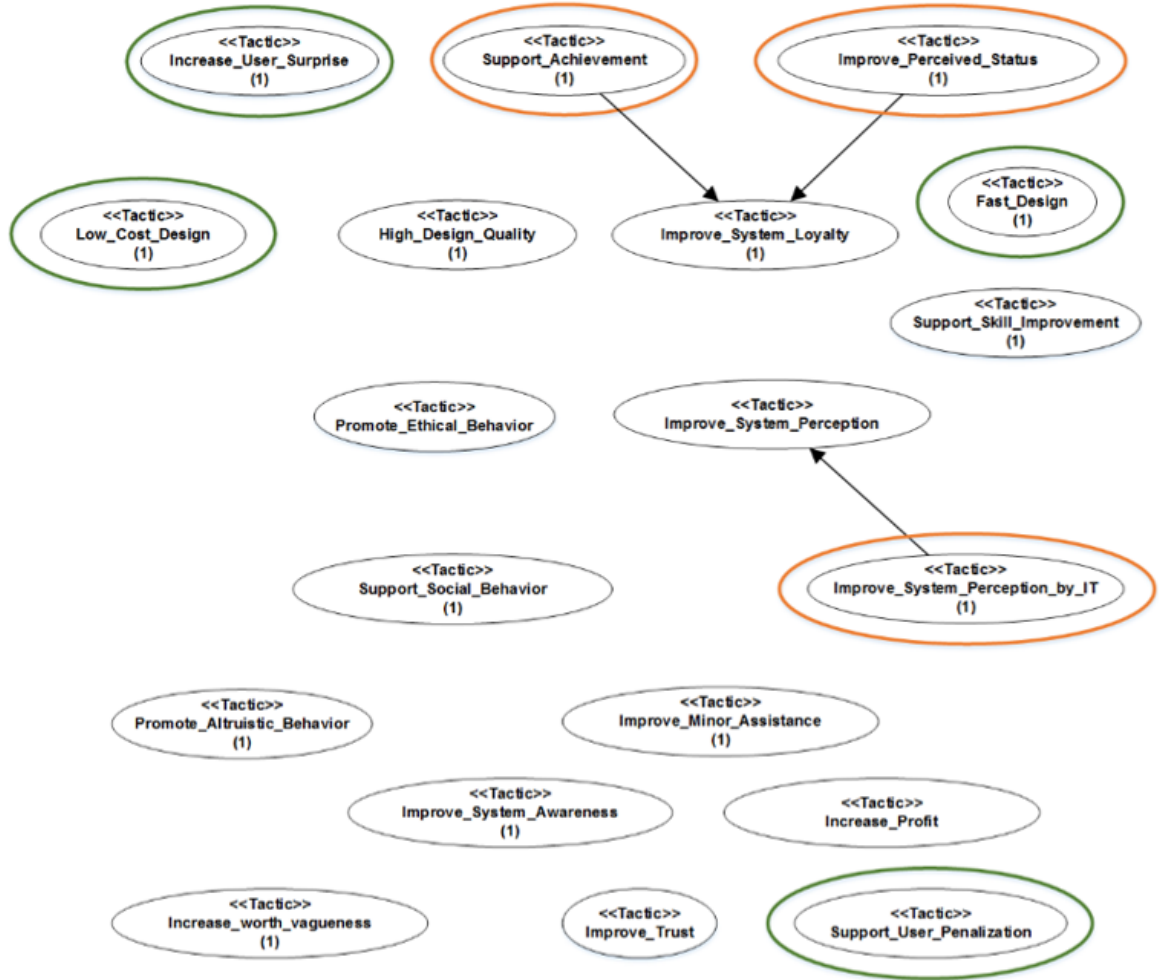


Figure 5.7: Additional elements proposed by Agon to the analyst during “Phase 5: Acceptance Requirements Refinement” (the elements circled in green are the additional ones selected now, and the elements circled in orange are the ones chosen previously) [Piras et al., a, 2016, 2017a]

Support User Penalization, Fast Design and Low Cost Design [Piras et al., 2016].

The solution designed so far is updated with tactics selected in this phase, and the operationalization chosen (represented by its high-level goal to be fulfilled shown

in Figure 5.6, i.e. **Design Gamification**). Figure 5.13 presents the updated solution obtained at the conclusion of this phase [Piras et al., a].

In summary, **(i)** in “*Phase 5: Acceptance Requirements Refinement*”, Agon supports the analyst by suggesting the tactics that can refine *Non Functional Requirements* (NFRs) expressed in AMM at the acceptance level, i.e. needs; **(ii)** while, in “*Phase 6: Context-Based Operationalization via Gamification*”, Agon supports the analyst by suggesting how, in turn, to operationalize tactics with gamification goals. Therefore, the support for the analyst comes from the reasoning (performed by Agon) over the models, on the basis of the instantiation of the context (UCM variable instances) and the needs and tactics suggested (by Agon) and selected (by the analyst). Specifically, in other words and from another point of view, the support comes from the reasoning (executed by Agon) over the acceptance and gamification knowledge, represented and captured by the Agon models, considering the specific user context (specified by the analyst over the UCM model of Agon). All the phases are interactive, indeed the analyst can take decisions over these suggestions. The entire process is performed semi-automatically and interactively at design time.

### 5.1.7 Phase 6: Context-Based Operationalization via Gamification

This phase regards context-based reasoning over the gamification model. It is context-based, because it takes into account the user characterization and the rules annotating the gamification model [Piras et al., a, 2016, 2017a]. Moreover, the gamified solution produced by Agon, available at [Piras et al., a], is computed by selecting gamification elements able to fulfill acceptance and tactical requirements selected in previous phases [Piras et al., 2017a]. For example, in Figure 5.8, because of the rule that says that when dealing with elders it is better to use publishable badges instead of private ones, and because they operationalize **Support Social Behavior** Piras et al. [2016], which is desired by elders, and the **Set Publishable** gamification goal related to badges operationalizes one of our confirmed tactic (**Improve Perceived Status**), Agon selects **Set Publishable** [Piras et al., 2016].

Furthermore, the analyst can take further decisions over the suggestions generated automatically by the framework. For example, she can keep gamification goals, remove some of them or even add new goals and tasks (hexagons in Piras et al. [a]) as shown in the next phase [Piras et al., 2016].

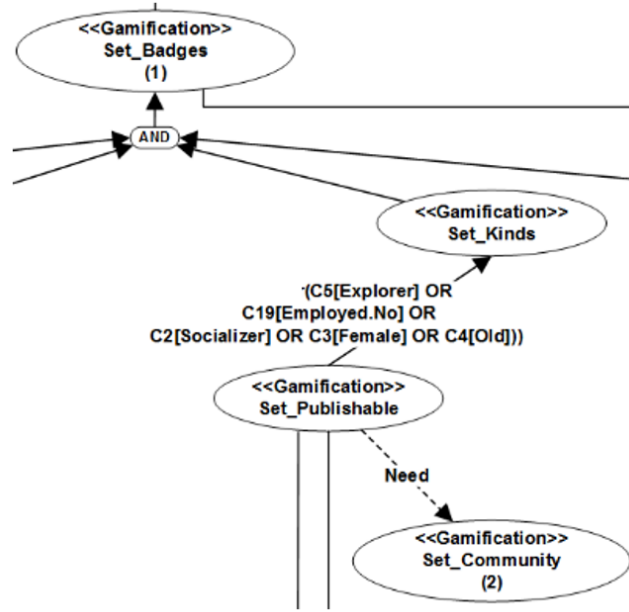


Figure 5.8: Solution proposed by Agon, after reasoning over the gamification model (“Phase 6: Context-Based Operationalization via Gamification”), in relation to the Badge gamification concept [Piras et al., a, 2016, 2017a]

### 5.1.8 Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms

The solution produced so far by Agon is a valuable specification including elements for favoring acceptance, on the basis of user characterization indicated, through gamified strategies, but has still a little abstraction [Piras et al., 2016]. In fact, this final step is required to create a final working solution having elements specific to the analyst’s domain [Piras et al., 2016]. The analyst uses the solution as a guidance including best gamification practices and she has just to complete it with elements specific of her domain [Piras et al., 2016]. Thus, the analyst has to select gamification goals she prefers to maintain, optionally modify/substitute they and, above all, operationalize them by adding goals and tasks (hexagons in Piras et al. [a]) [Piras et al., 2017a].

Furthermore, this last phase concerns the gamification instantiation made by the analyst over the gamified solution produced by Agon [Piras et al., 2017a]. It is important because Agon models are generic reference meta-models that do not refer to a particular domain [Piras et al., 2016]. Therefore, it is the responsibility of the analyst to adapt the valuable gamification solution generated to the constraints of her domain [Piras et al., 2017a].

The gamification solution designed after concluding this last phase, where the analyst instantiated and customized gamification suggestions of Agon [Piras et al., a, 2016, 2017a], is available at [Piras et al., a]. For instance, in DLMSE, we change the way leader-boards are computed [Piras et al., 2017a] (Figure 5.9). Even though Agon suggests to calculate

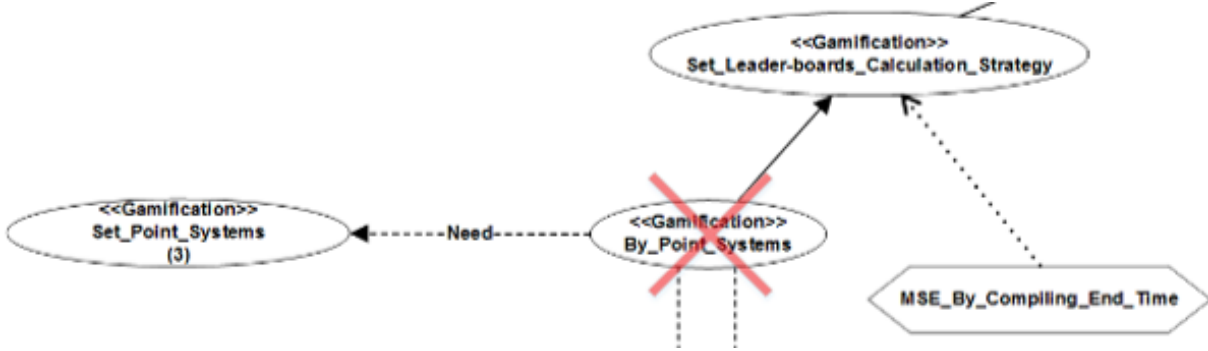


Figure 5.9: Example of customization and instantiation of gamification solutions proposed by Agon, performed in “Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”, regarding the Leader-boards gamification concept [Piras et al., a, 2016, 2017a]

them on the basis of points, a generic best practice [Zichermann and Cunningham, 2011], we prefer a more precise solution, that better fits the meeting scheduler domain, and could not be inferred by Agon (due to its generality) [Piras et al., 2016]: to reward the first users that indicate their favorite dates [Piras et al., 2017a]. Thus, for instantiating our decision, we substitute By Points with By Compiling End Time as task for fulfilling the Set Leader-boards Calculation Strategy gamification goal [Piras et al., 2016] (Figure 5.9).

### 5.1.9 The Gamified Doodle-Like Meeting Scheduler in a Nutshell

This is the summary of the full gamified solution Piras et al. [a] obtained by using Agon for solving the DLMSE acceptance problem [Piras et al., 2016, 2017a].

In the game designed, potential participants can have a tour of the system features and compile the Doodle (Gamifiable Actions) [Piras et al., 2016, 2017a]. The tour is proposed before compiling (Propose Tour Before Compiling) and optionally can be skipped (Set Skip The Tour feature). If the tour is completed, as shown in Figure 5.10, the user acquires expertise concerning the system and win a badge representing it (Win Doodle Meeting Scheduler Expert Badge). Actually, this expertise is more a perceived knowledge, because she just sees a demo describing main features of the system, without

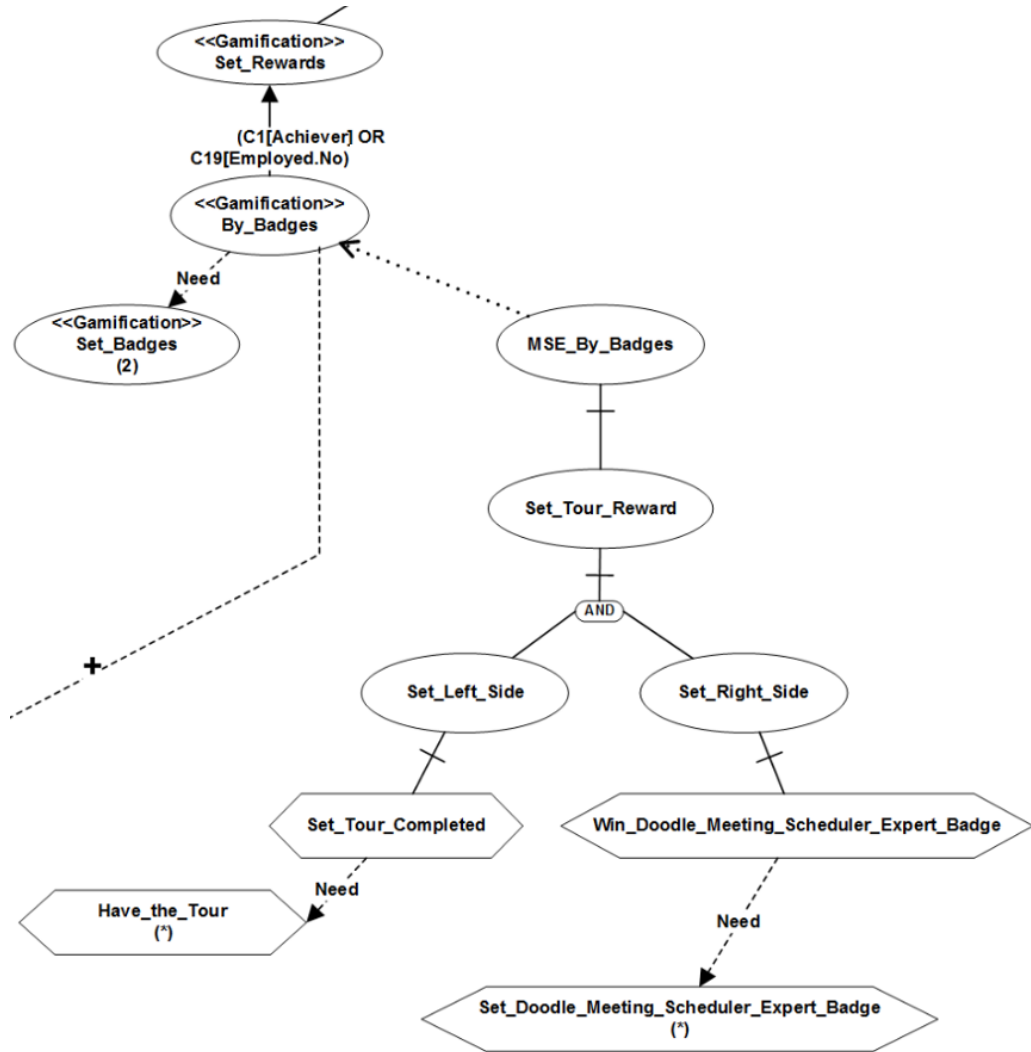


Figure 5.10: Example of instantiation and customization of gamification solutions proposed by Agon, performed in “Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”, regarding rewards achieved (badges) after completing a gamified tour [Piras et al., a, 2016, 2017a]

having, for instance, a complex training (**Define Training Paths**) that could lead to have a deep knowledge of a system. In this case it is enough, because we desire a solution with soft training [Piras et al., 2016, 2017a]. In fact, in the different phases, we have confirmed the employment of the **Improve Perceived Ease of Use** need that is refined by the **Improve System Perception** via IT tactic which in turn is operationalized by soft training such as the **Provide Tours** gamification goal [Piras et al., 2016, 2017a]. Instead, if it was preferred an hard training, it would be selected the **Support Skill**

Improvement tactic that is operationalized by Define Training Paths, which needs Provide Tutorials, namely active tasks with well-defined learning paths [Piras et al., 2016, 2017a].

Continuing the game description, the first 3 players that compile the Doodle are winners in the podium (Set Traditional Podium) of the leader-board (Set First Doodle Compilers LB) [Piras et al., 2016, 2017a]. Here, the idea is to stimulate people to fill the Doodle as soon as possible [Piras et al., 2017a]. This concept is emphasized also by the fact that these winners are awarded Redeemable Points (RP) and badges [Piras et al., 2017a]. The instantiation related to redeemable points is shown in Figure 5.11. In fact,

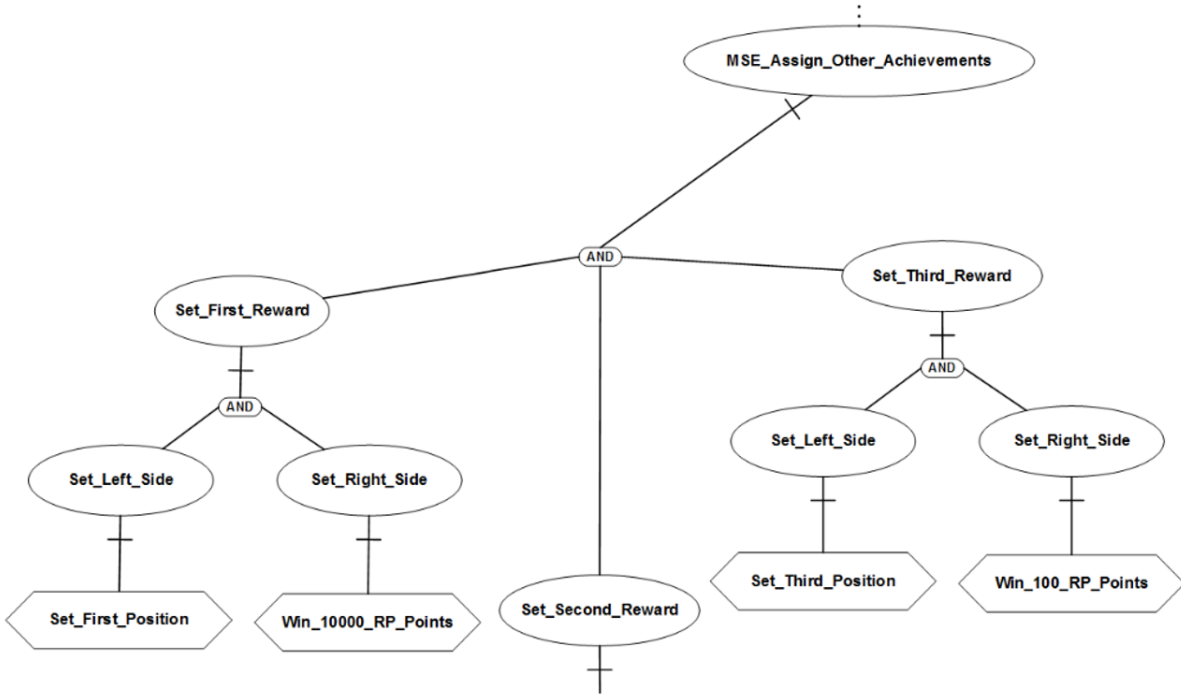


Figure 5.11: Example of instantiation and customization of gamification solutions proposed by Agon, performed in “Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”, concerning Redeemable Points (RP) achievable through Leader-boards [Piras et al., a, 2016, 2017a]

the first wins Set First Compiling Badge and Win 10000 RP Points, the second Set Second Compiling Badge and Win 1000 RP Points, the third Set Third Compiling Badge and Win 100 RP Points [Piras et al., 2016] (Figure 5.11).

RP points collected are redeemed in a gamified market (Set Market) with tangible rewards (Add Tangible Rewards) thanks to a redeeming policy (RP Define Exchange

Points Rewards), one of the market rules (Set Market Policies) [Piras et al., 2016, 2017a]. Moreover, all the badges are publishable, as expressed through Set Publishable (Figure 5.8), and this operationalizes one of our specification tactic: Improve Perceived Status [Piras et al., 2016, 2017a]. Badges earned can be published in a community (Set Community) having different social actions (e.g., Suggest Meeting) rewarded by redeemable points (Win 10 RP) [Piras et al., 2016, 2017a].

#### 5.1.10 Final Remarks

The example illustrated in this Section [Piras et al., 2016, 2017a], for describing the Agon method [Piras et al., 2016, 2017a], is part of the case study we carried out in [Piras et al., 2017a] and reported in Chapter 8. In such case study, we compare the solution provided here, with a solution obtained through the employment of the Motivational Antecedents Framework (MAF) Simperl et al. [2013], Tokarchuk et al. [2012]. MAF is a framework coming from the Organizational Behavior field Simperl et al. [2013], Tokarchuk et al. [2012]. That case study helped us in comparing the different methodologies supported by Agon and the other framework, plus other aspects (e.g., the context variables supported), so we were able to provide the guidelines for extending Agon and for integrating it, as future work, with other frameworks and methodologies [Piras et al., 2017a] (e.g., the Motivational Antecedents Framework or the Design Thinking method outlined in Chapter 8).

Moreover, we employed DLMSE as subject for other case studies, conducted by involving master students as illustrated in Chapter 7.

## 5.2 The Agon-Tool

We have developed the Agon-Tool, a web application supporting the Agon framework and method. Here we describe the Agon-Tool. Specifically, in Section 5.2.1, we delineate how we designed the tool, outline technologies used and illustrate its architecture. In Section 5.2.2, we show the Agon-Tool in action, by describing how it can be used for performing an *Acceptance Requirements Analysis Based on Gamification*, described in Section 5.1, and highlight the support and suggestions provided by Agon.

### 5.2.1 The Agon-Tool Architecture and Technologies

The Agon-Tool is the web application we built for supporting the Agon framework and method. Currently, the tool is at a prototype stage [Piras et al., a] (Figure 5.14). For



Figure 5.12: Acceptance solution obtained at the conclusion of “*Phase 4: Context-Based Analysis of Acceptance Requirements*”, i.e. the result of Context-Based reasoning over the Acceptance Model and analyst’s decisions [Piras et al., 2016, 2017a] (elements discarded by the reasoning or by the analyst have been removed to have a clear view of the result); Figure available at [Piras et al., a]

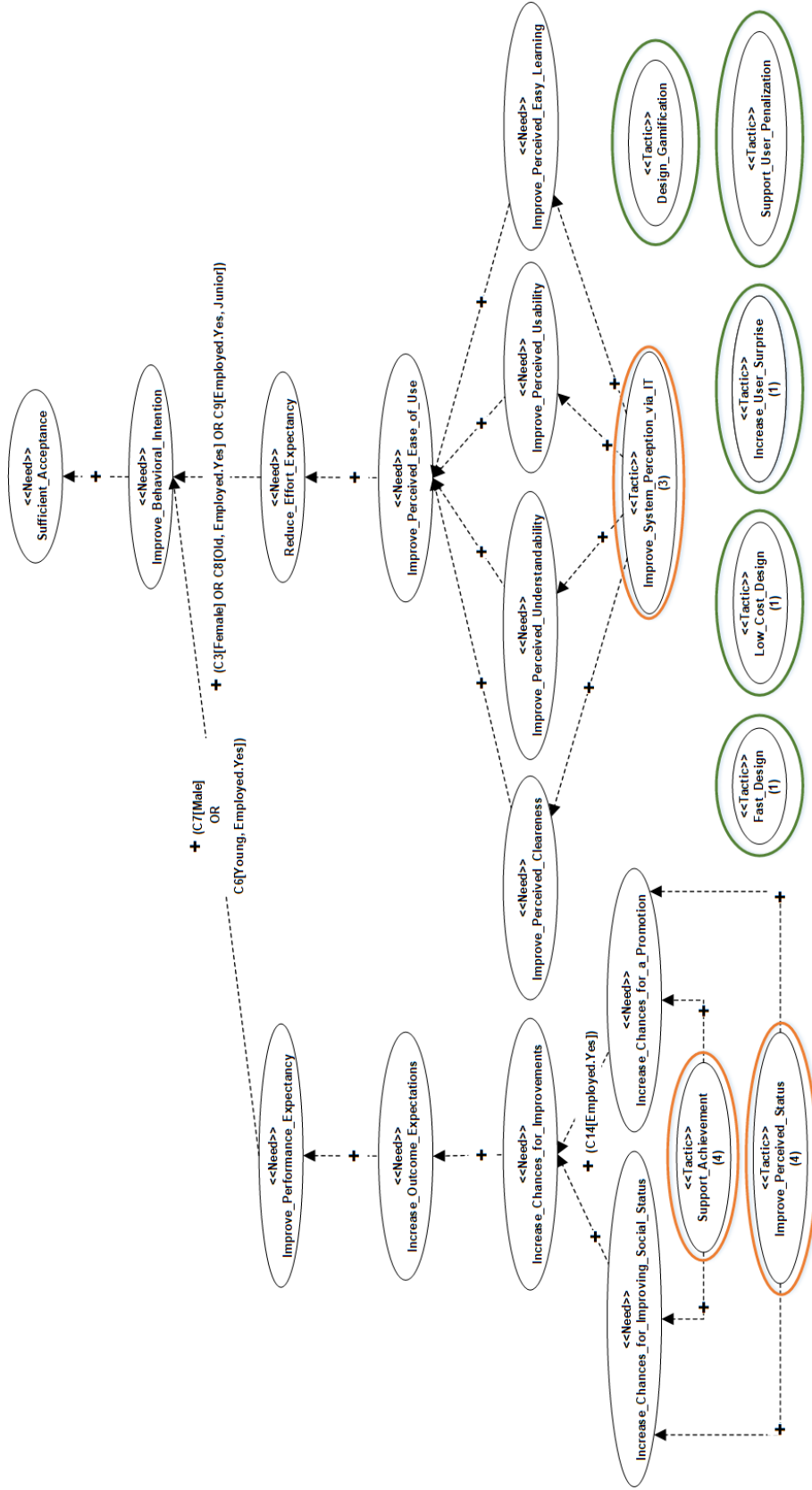


Figure 5.13: Solution obtained at the conclusion of “Phase 5: Acceptance Requirements Refinement” (elements circled in orange and green are the selected tactics; green ones are the additional tactics chosen in the last part of this phase) [Piras et al., a, 2016, 2017a]

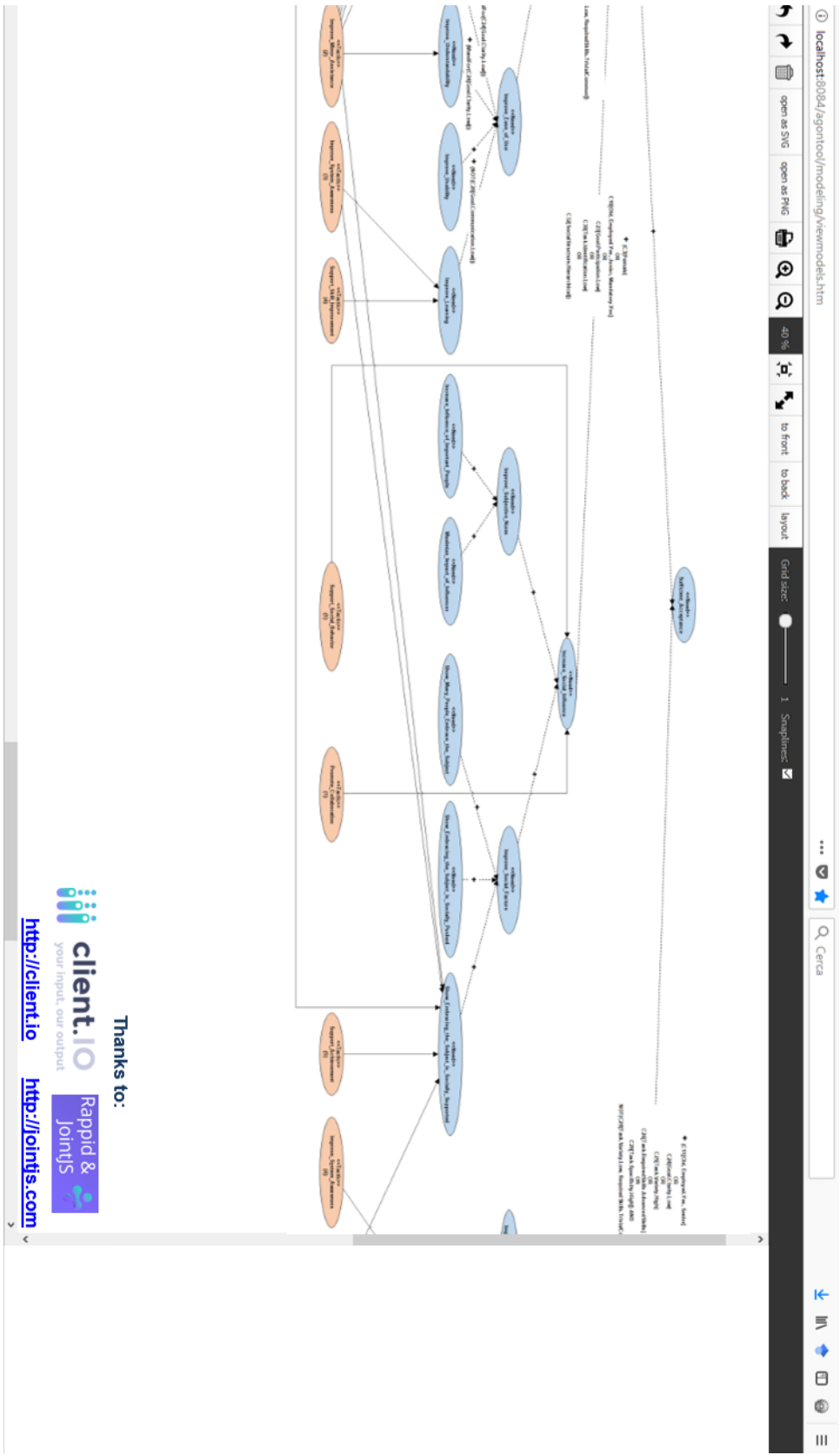


Figure 5.14: Agon-Tool: the prototype that supports the usage of Agon and its method

the development of the Agon-Tool, we extended some components of the CGM-Tool<sup>5</sup>. Specifically, the ones supporting formal modeling and reasoning with goal models [Nguyen et al., 2016a,b].

The Agon-Tool (Figure 5.15) can be executed over different operating systems such as Windows, Linux and OSX. To run, it requires a Java Runtime Environment, the OptiMathSAT<sup>6</sup> solver (that runs on Windows, Linux and OSX), and the Apache Tomcat Web Server.



Figure 5.15: Architecture of the Agon-Tool Java web application

The Agon-Tool is built on the Spring Framework<sup>7</sup> (Figure 5.15) and uses many Spring

<sup>5</sup><http://www.cgm-tool.eu/>

<sup>6</sup><http://optimathsat.disi.unitn.it/>

<sup>7</sup><https://spring.io/>

libraries (e.g., Spring MVC, Spring Web, Spring Expression, Spring Beans, Spring Context, Spring ORM, etc.).

The Agon-Tool components (Figure 5.15) we have implemented are a *Web Graphical Editor*, supporting the systematic acceptance requirements analysis based on gamification, that shows during all the phases of the Agon method the Agon meta-models and, above all, provides the analyst with the possibility to take decisions over models after receiving reasoning results. The editor supplies also the possibility to instantiate the gamification meta-model in the last phase of the method. Furthermore, the web graphical editor and related functions use Javascript and HTML5 diagramming libraries, in particular “*Rappid & JointJS*”<sup>8</sup> as illustrated in Figure 5.15 and in the graphical interface of the Agon-Tool shown in Figure 5.14. In conjunction with this libraries, we used also jQuery<sup>9</sup>, BackboneJS<sup>10</sup>, UnderscoreJS<sup>11</sup> and other javascript libraries for dealing with SVG images concerning Agon models.

We have implemented also the *Guidance Module*, the *Analysis Module* and the *Document Generation Module* (Figure 5.15). The *Guidance Module* is responsible for supporting and guiding the analyst in all the Agon method phases, by providing her with related supporting functions and interfaces (by using the *Web Graphical Editor* for the Agon Meta-Models, and the *Analysis Module* for reasoning aspects). The *Analysis Module* supports the *Guidance Module* concerning the reasoning activities applied to the Agon meta-models. For this, the *Analysis Module* interacts with the *Agon Models Manager*, and, above all, makes use of the *Reasoning Module* that is in charge of doing pre-processing activities over the Agon models and to translate them before asking to OptiMathSAT to execute the actual reasoning. Finally, the *Document Generation Module* will print a complete description of the acceptance requirements analysis and gamification design carried out by the analyst.

### 5.2.2 Using the Agon-Tool

In this Section, we show the Agon-Tool in action, by describing, phase by phase, how it can be used for performing an *Acceptance Requirements Analysis Based on Gamification* (the Agon method described in Section 5.1), and highlight the support and suggestions provided by Agon, also by showing and commenting tool screenshots.

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<sup>8</sup>Thanks to client.io (<http://client.io>) for supplying us with an academic license for the Rappid & JointJS diagramming libraries (<http://jointjs.com>)

<sup>9</sup><https://jquery.com/>

<sup>10</sup><http://backbonejs.org/>

<sup>11</sup><http://underscorejs.org/>

### Phase 1: Base System Requirements

At beginning of the process, the analyst has to design a goal model, the *Base System Requirements Model*, representing the (to-be/as-is) software to gamify. As shown in Figure 5.16, Agon provides the analyst with an editor for designing such goal model, by offering elements (in a stencil on the right part of Figure 5.16) from a notation close to the one of the NFR framework [Chung et al., 2012, Li et al., 2013, Mylopoulos et al., 1992]. Specifically, as illustrated in Figure 5.16, the analyst can construct the model by “drag

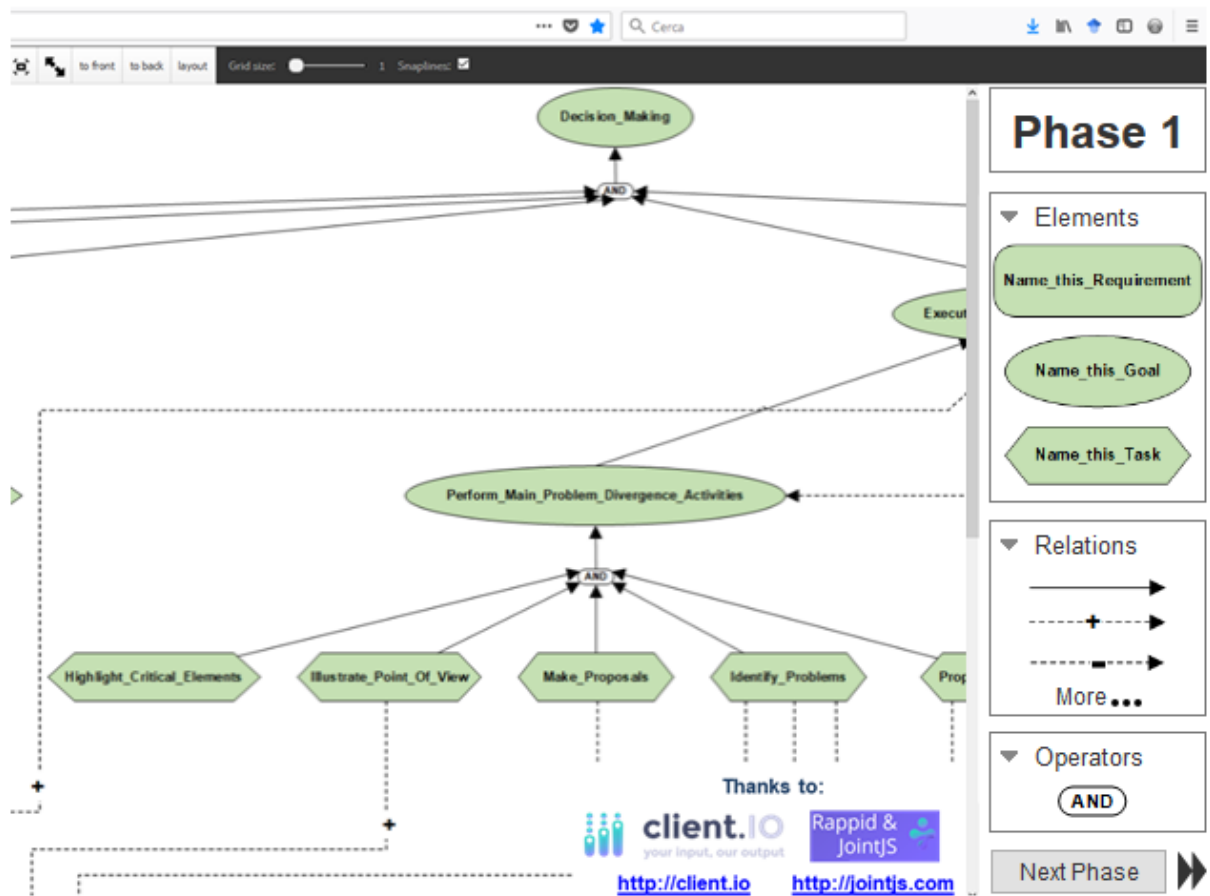


Figure 5.16: Support provided by the Agon-Tool to the requirements analyst in “Phase 1: Base System Requirements” [Piras et al., a, 2016, 2017a]

and drop” actions applied to the elements in the stencil (i.e. Requirements, Goals and Tasks in Figure 5.16).

Analogously, the analyst can use relations (e.g., Refinements and Positive/Negative Contributions) and operators for connecting in the editor the various elements (Figure 5.16). By clicking on the More link (Figure 5.16), other relations are available, for

instance the **Need** and **Conflict** relations. Concerning the operators, the **AND** operator has to be used explicitly, by dragging it from the stencil, while the **OR** operator, according to the CGM-Tool<sup>12</sup> [Nguyen et al., 2016a,b], is obtained just connecting (through relations) more than one element to another element (similarly to **Improve Ease of Use** in Figure 5.4). This way of employing operators is used also in all the Agon models.

Most of the goals and tasks, designed in this model, are tied to the activities that the user can carry out, by using functions of the software system (Figure 5.16), fulfilling stakeholders' objectives. In the following phase, some of them will be included, as candidate functions to be gamified, for expressing acceptance requirements. To proceed, the analyst can click on the **Next Phase** button in the right of the interface (Figure 5.16).

## Phase 2: Acceptance Requirements Elicitation and Analysis

In this phase, the Agon-Tool starts by showing to the user the window in Figure 5.17, with guidelines for helping the analyst in the selection of candidate functions to be gamified. After clicking the **OK** button, the analyst passes from the screen of Figure 5.17 to the one of Figure 5.18. In the screen of Figure 5.18, the analyst sees again the *Base System Requirements Model* she designed in the previous phase.

Moreover, as shown in Figure 5.18, being the Agon method iterative, the analyst has the possibility, by clicking on the **Previous Phase** button, to come back to the preceding phase. For instance, in this case, the analyst could need to revise/improve the model designed previously. Alternatively, she can complete this phase and click on the **Next Phase** button to proceed to the following phase. In all the phases of the Agon method, it is possible either to come back to the previous phase, or to continue with the next one.

Thus, the analyst analyzes the goal model, by following the guidelines supplied by Agon (Figure 5.17), for individuating the candidate functions to be gamified. If she needs, she can read again the Agon suggestions by clicking on the **Guidelines** button in Figure 5.18, which will show the window of Figure 5.17. Then, the analyst fills the **Functions** text-area (Figure 5.18), with the exact names, separated by commas, of the goal/tasks she identified as candidate functions to be gamified. For example, in the screenshot of Figure 5.18 the analyst has chosen the task **Propose Alternatives**, shown also in the model, and inserted exactly the name of such task in the text-area, with other selected functions.

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<sup>12</sup><http://www.cgm-tool.eu/>

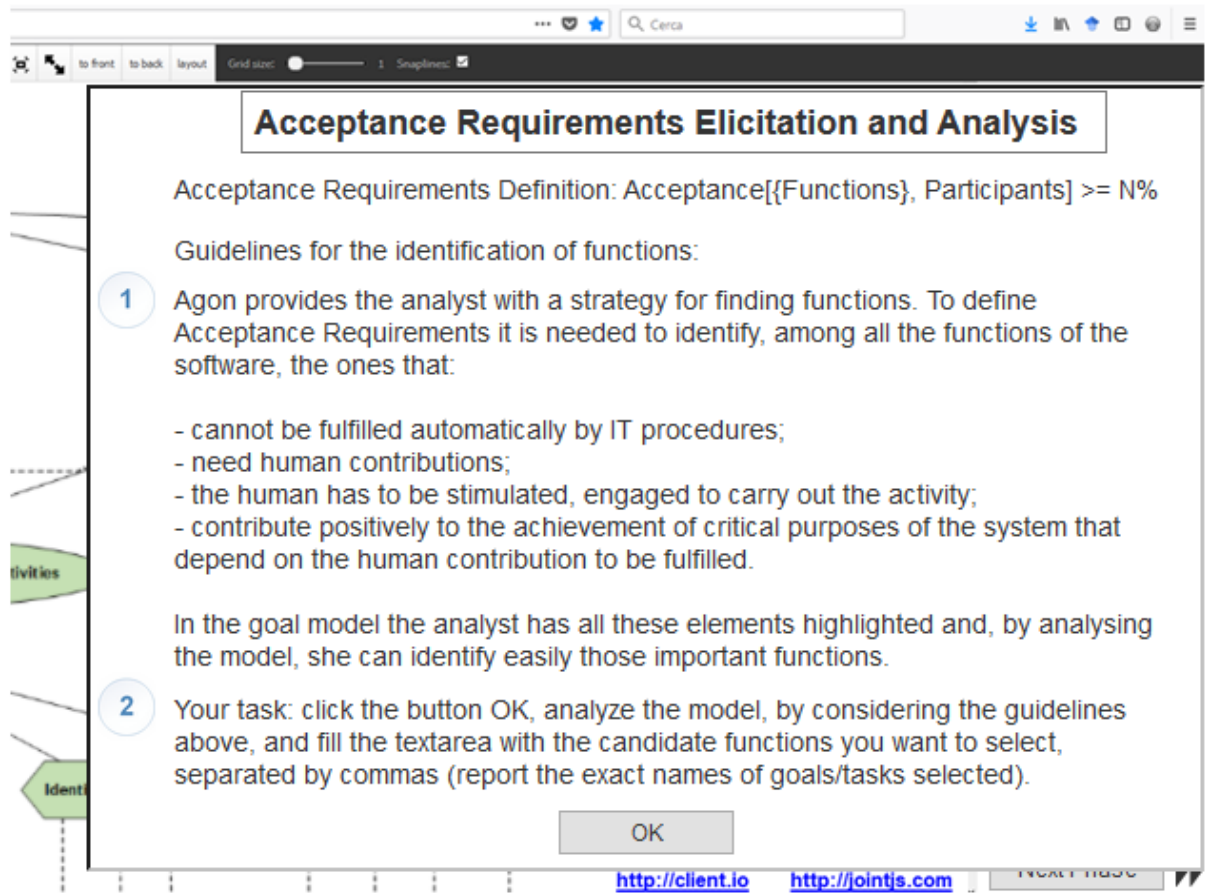


Figure 5.17: Support provided by the Agon-Tool to the requirements analyst in “*Phase 2: Acceptance Requirements Elicitation and Analysis (first part: guidelines)*” [Piras et al., a, 2016, 2017a]

### Phase 3: Context Characterization

In the previous phase, the analyst individuates functions to be gamified [Piras et al., 2016, 2017a,b]. While, in this phase the Agon-Tool supports the analyst in carrying out another strategic task, by guiding her to consider another very important aspect: to characterize the users to engage and their context [Piras et al., 2017b]. In order to give support, the tool provides the analyst with UCM (Figure 5.19) and its relevant user context variables to be instantiated [Piras et al., 2017a]. Moreover, the instantiation produced in this phase, as explained in detail in previous parts of this thesis, is used by Agon in the following phases for reasoning over the Agon meta-model and providing the analyst with the most suitable elements (e.g., needs, tactics, gamification goals), according to the pertinent abstraction level, for the user to motivate [Piras et al., 2017b].

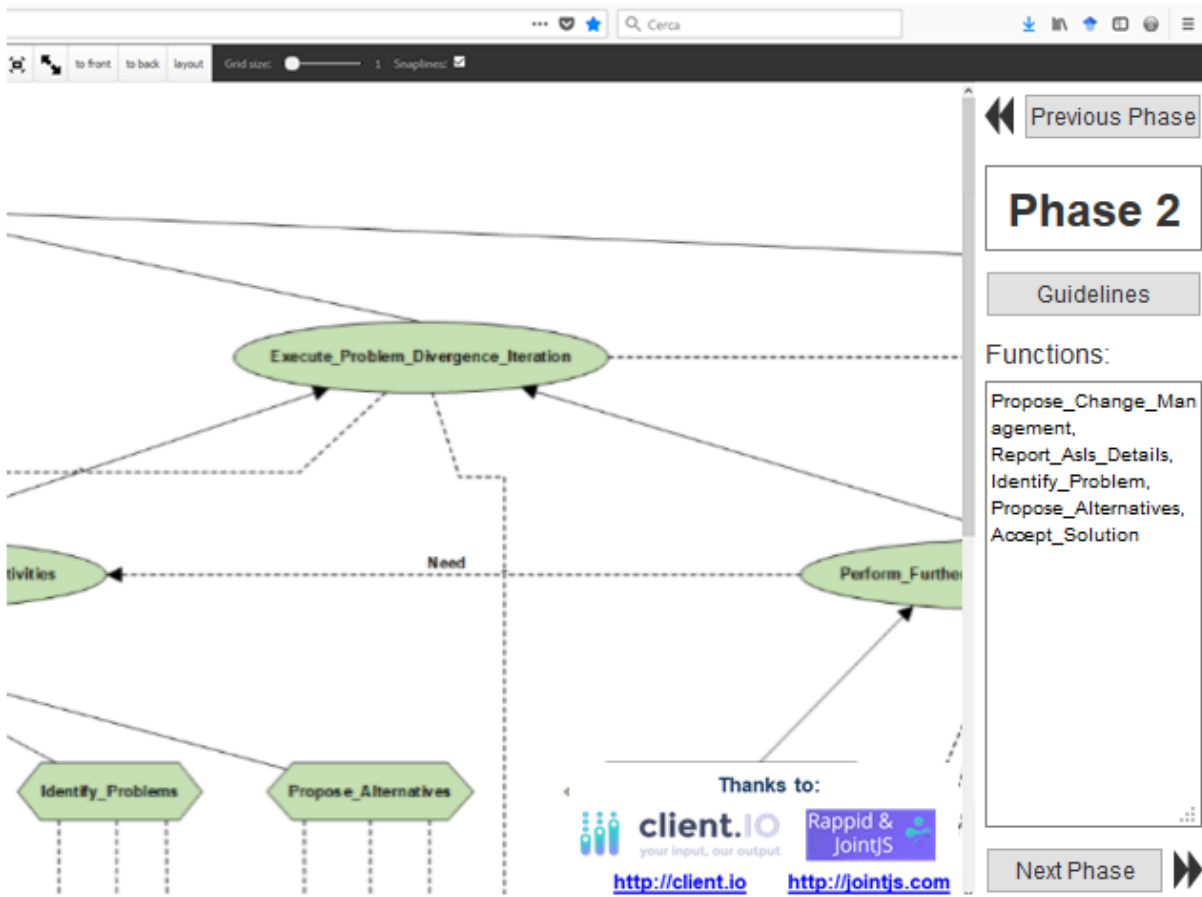


Figure 5.18: Support provided by the Agon-Tool to the requirements analyst in “*Phase 2: Acceptance Requirements Elicitation and Analysis (second part: functions selection)*” [Piras et al., a, 2016, 2017a]

Specifically, in this phase, as illustrated in the screenshot of Figure 5.19, the Agon-Tool shows UCM to the analyst and invites her to instantiate its variables. Specifically, she can instantiate them with the final elements of UCM. For instance, in Figure 5.19, the **Player Type** can be instantiated with **Socializer**, **Achiever**, **Explorer** and/or **Killer** [Bartle, 1996]. Another element to be instantiated, shown in Figure 5.19, is the **Employed** variable, which can be instantiated with **Yes** or **No**, indicating respectively if the user is employed. In order to proceed to the next phase, it is required to instantiate all the variables of UCM, also the ones not visible in Figure 5.19.

Practically speaking, the analyst can instantiate the UCM variables by dragging and dropping the **Instantiation** relation, from the stencil of Figure 5.19, and using it for linking the yellow hexagon with the value intended to instantiate a UCM variable.

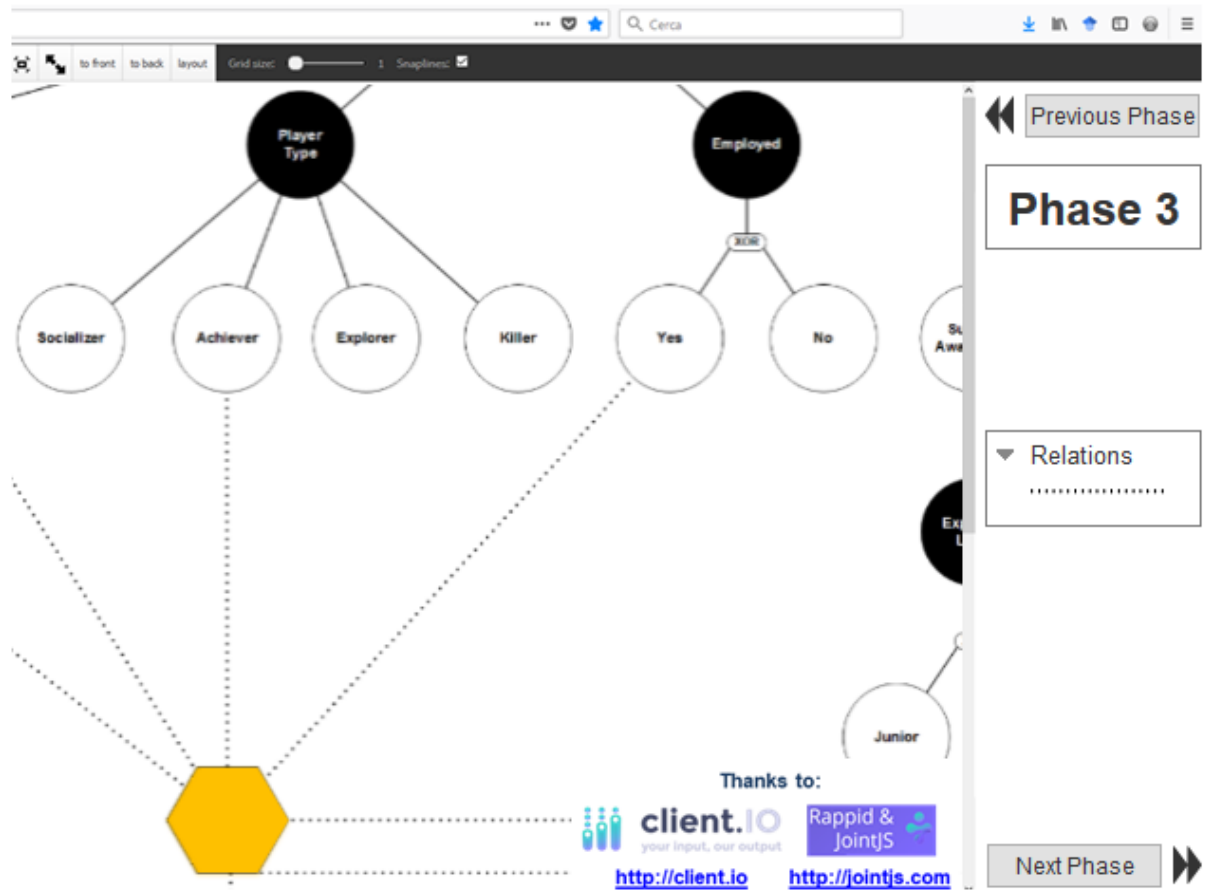


Figure 5.19: Support provided by the Agon-Tool to the requirements analyst in “Phase 3: Context Characterization” [Piras et al., a, 2016, 2017a]

Furthermore, the hexagon represents a UCM instance [Piras et al., 2017b]. For example, in Figure 5.19, for specifying the typology of the user as a player, **Player Type** is instantiated with **Achiever**, through the instantiation relation connected with the hexagon. Furthermore, in the case of the **Player Type**, being a not mutually exclusive variable (indeed a player can be a mix of the illustrated types [Bartle, 1996]), it is possible to instantiate more than one typology (e.g., indicating both **Socializer** and **Achiever**). In other cases, the **XOR** relation expresses that such variable can be instantiated exclusively by one value (e.g., the **Employed** variable is instantiated exclusively with **Yes** in Figure 5.19).

#### Phase 4: Context-Based Analysis of Acceptance Requirements

The Agon-Tool uses the UCM instance for reasoning, over AMM and its CDRs, at the acceptance level [Piras et al., 2016, 2017a,b]. The aim of Agon is to suggest, to the

analyst, the most suitable needs for the specific context [Piras et al., 2017b] (instantiated by the analyst in the preceding phase). Those suggestions are provided by the tool, to the analyst, in the form of a goal model (Figure 5.20), resulting from the reasoning applied to AMM. Thus, such model is a sub-set of AMM, including needs, selected by Agon, able to stimulate the characterized user on the basis of its context [Piras et al., 2016, 2017a].

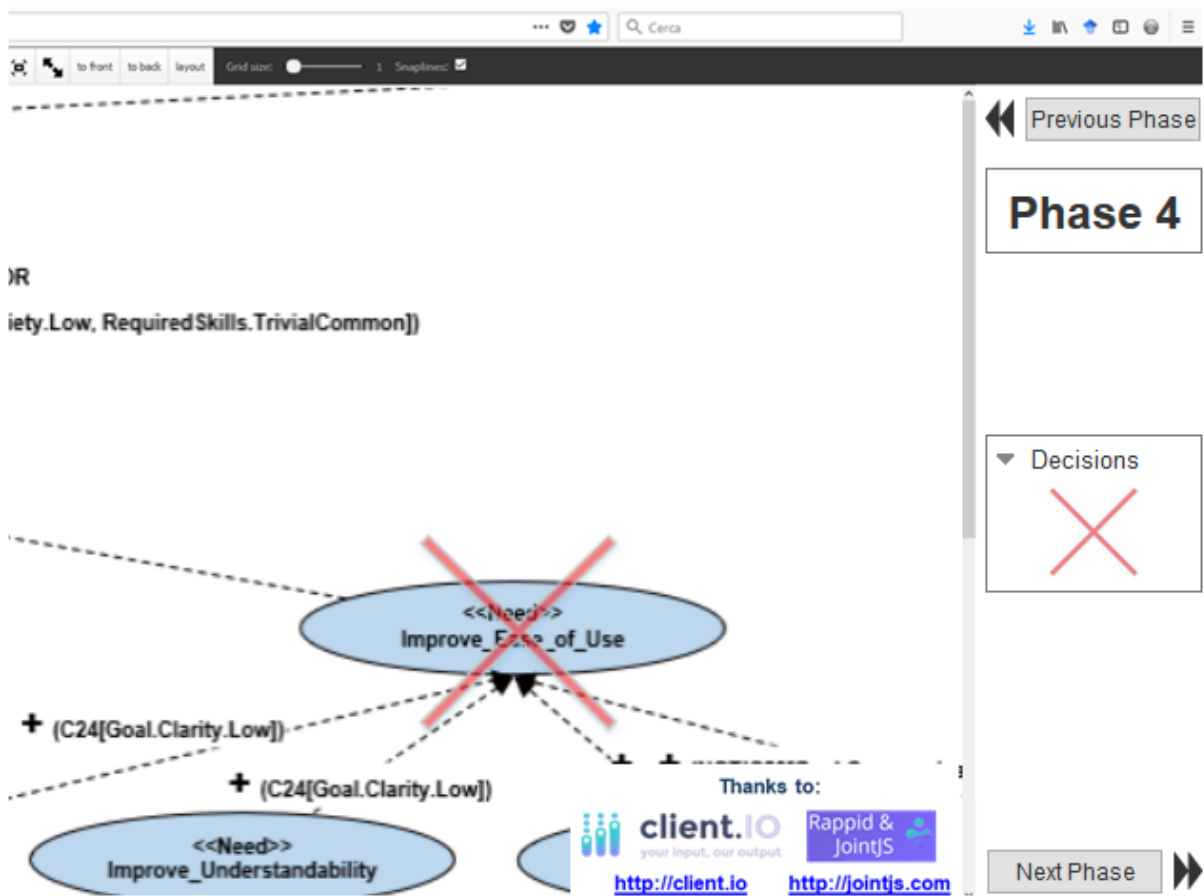


Figure 5.20: Support provided by the Agon-Tool to the requirements analyst in “Phase 4: Context-Based Analysis of Acceptance Requirements” [Piras et al., a, 2016, 2017a]

In order to provide suggestions to the analyst, the Agon-Tool reasons over the Agon Meta-Model having a total of 53 CDR expressions annotated to its relations and composed of 848 terms referring to UCM variables.

Specifically, in Figure 5.20, the tool shows, to the analyst, the complete model derived from the original AMM (in that screenshot, it is illustrated only a part of the full solution), obtained after the Agon reasoning. Agon proposes goals, as needs, that best fit the context instance [Piras et al., 2017a]. They are connected, by means of **Contribution**

relations, in a hierarchical way, from the most abstract ones to the less abstract ones, and annotated by CDRs [Piras et al., 2017b] (Figure 5.20). The analyst, in this phase, can take further decisions over the set suggested by Agon, by evaluating if to remove part of the solution [Piras et al., 2016]. As discussed in detail in previous parts of this Thesis, such analyst's decisions can be beneficial, for instance, in the case that some needs, chosen by Agon, do not fit the specific constraints of the domain of the software to be gamified [Piras et al., 2016]. In fact, at the moment, Agon cannot consider those aspects; this is a current limitation of Agon. Indeed, Agon does reasoning by considering current supported UCM variables [Piras et al., 2017b]. In the future, the set of UCM variables will be enlarged, for increasing the suitability and precision of Agon suggestions [Piras et al., 2017a].

In practice, the analyst can decide to remove a need by dragging the red X element, from the stencil in Figure 5.20, and dropping it over the need she wants to discard. When the X is released, the editor attaches it “magnetically” to the center of the element to discard. In the editor, the X can be resized, remaining centered to the element. For instance, in Figure 5.20 the analyst has discarded the **Improve Ease of Use** need.

Optionally, it is possible for the analyst even to apply changes to the model, by using the editor (e.g., removing needs and/or using existing relations for connecting needs in different ways). This applies also to the models offered by Agon in the next phases [Piras et al., 2016, 2017b]. However, if the analyst performs those changes, it is no more guaranteed that Agon can provide valuable results in the following phases [Piras et al., 2016]. This is due to the fact that the Agon meta-model has been designed by us in a precise way, with the right balance and homogeneity among its heterogeneous elements, on the basis of the literature, and this guarantees to produce high-quality solutions [Piras et al., 2017a]. However, sometimes the analyst has to take into account very specific aspects coming from the domain of the software to gamify, which Agon cannot capture having generic reference models [Piras et al., 2017b]. Therefore, giving her decision flexibility can be useful in particular situations [Piras et al., 2017a]. Furthermore, the more you proceed towards less abstract levels (e.g., the gamification level), the more having this flexibility is useful, because the final solution, to be applied to the system, becomes more and more concrete, and, thus, there could be required some modifications to the model, to be applied manually by the analyst [Piras et al., 2016]. Moreover, our suggestion is to apply changes not before than reaching the gamification level, because, in this way, it is guaranteed to receive, from Agon, solutions as linear as possible to the results of the literature Agon is based on [Piras et al., 2017b].

### Phase 5: Acceptance Requirements Refinement

The aim of this phase is to proceed towards the tactic level, to receive - as suggestions - the tactics selected by Agon, and to take further decisions over them. In the Agon-Tool this phase is divided in 2 sub-phases: 5a and 5b.

In phase 5a, Agon selects the tactics that can refine the AMM needs selected by the analyst in the previous phase [Piras et al., 2016, 2017a], and shows them to the analyst, as illustrated in the screenshot of Figure 5.21. The analyst can decide either

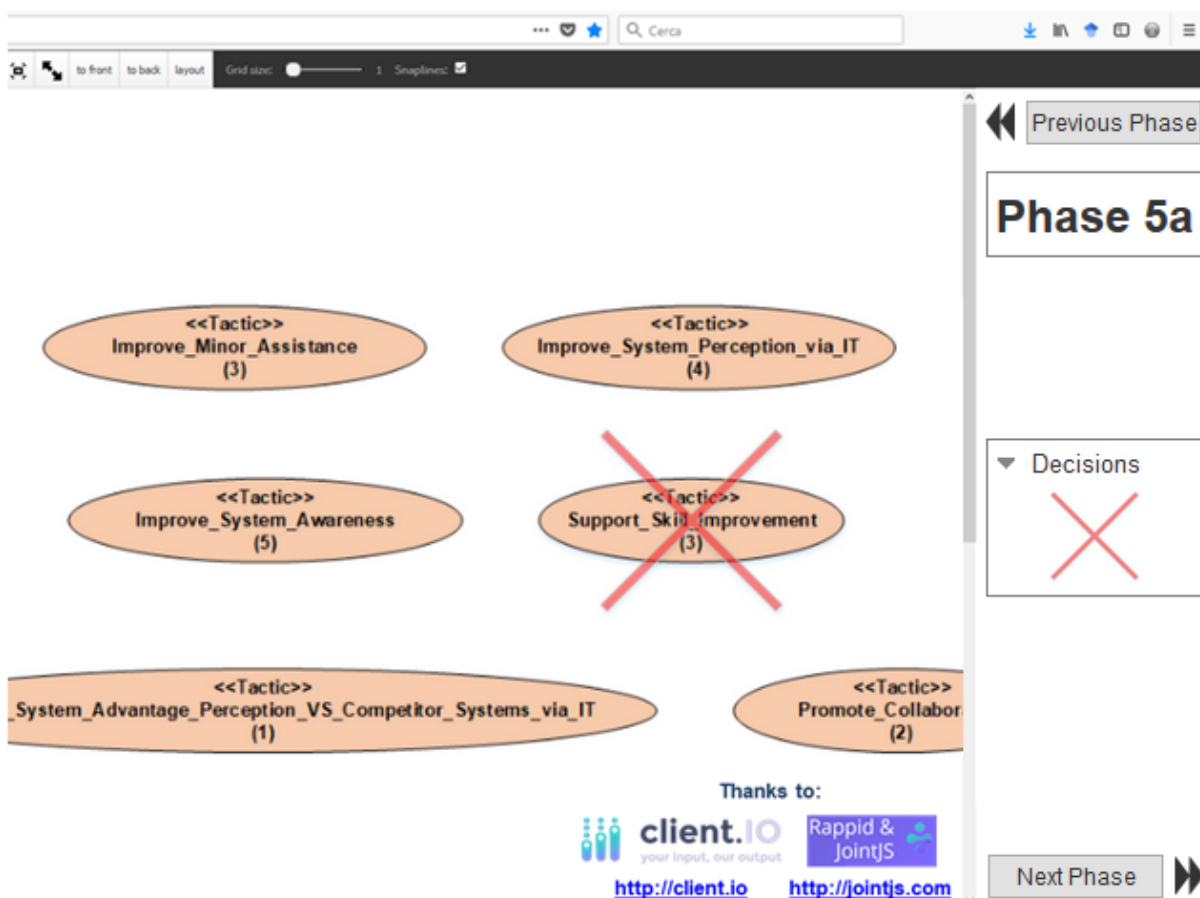


Figure 5.21: Support provided by the Agon-Tool to the requirements analyst in “*Phase 5: Acceptance Requirements Refinement (part “a”: selection of tactics)*” [Piras et al., a, 2016, 2017a]

to keep all of those suggested elements, or to remove some of them [Piras et al., 2016, 2017a]. For instance, in Figure 5.21 the analyst has decided to remove **Support Skill Improvement** [Piras et al., 2017b]. In order to do this, the analyst acts analogously to the previous phase, i.e. just by dragging and dropping red Xs over the tactics she decides to

discard (Figure 5.21).

When the analyst clicks on the **Next Phase** button in Figure 5.21, she moves to the sub-phase 5b of Figure 5.22. Here, the tool represents with orange ellipses (Figure 5.22)

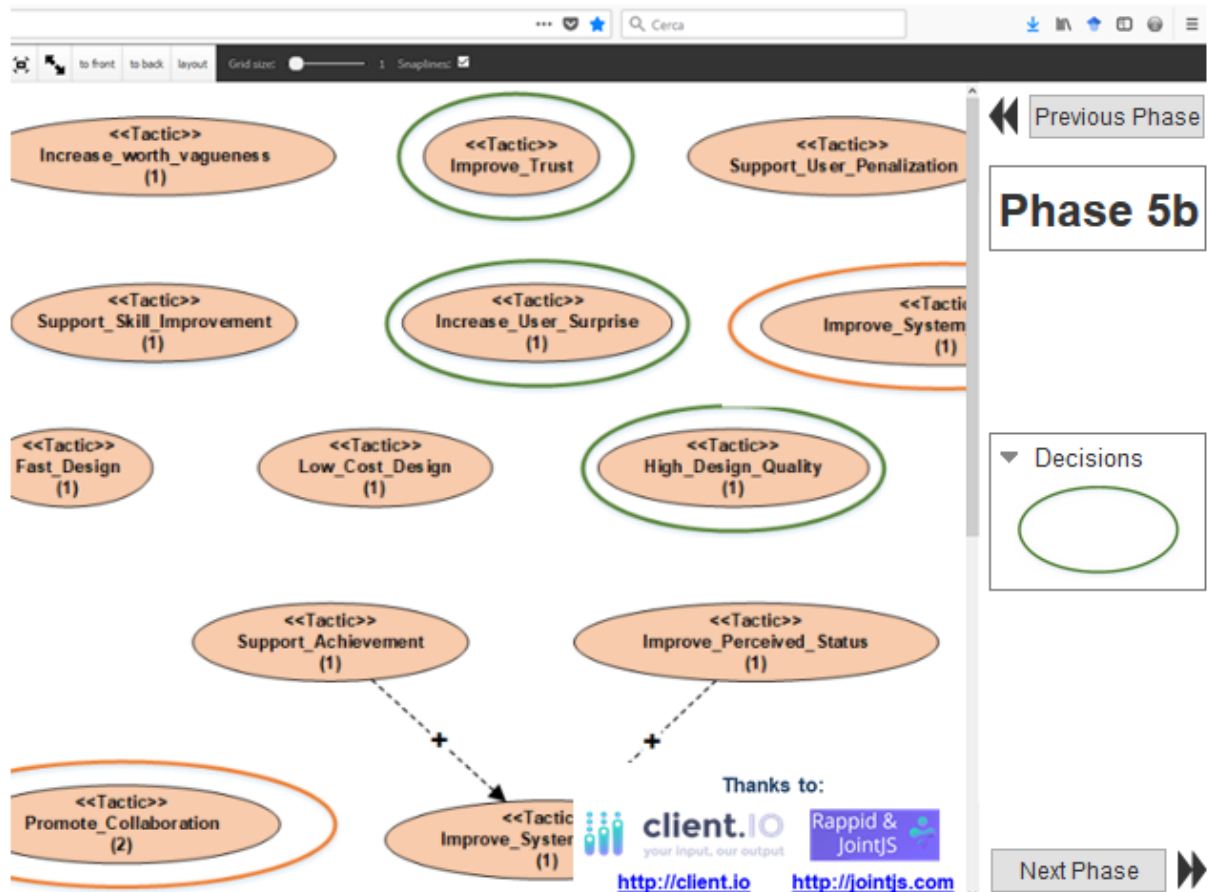


Figure 5.22: Support provided by the Agon-Tool to the requirements analyst in “Phase 5: Acceptance Requirements Refinement (part “b”: selection of additional tactics)” [Piras et al., a, 2016, 2017a]

the tactics kept in the previous sub-phase. Furthermore, the Agon-Tool starts preparing all the necessary elements for moving towards the next phase, and it requires to collect a complete set of tactics to consider [Piras et al., 2016, 2017a]. Therefore, in addition to the ones, confirmed by the analyst in 5a, that can refine AMM needs selected, Agon finds additional tactics relevant for the gamification space [Piras et al., 2016]. Such tactics are close to the world of gamification, and could positively affect the user to engage [Piras et al., 2017a]. However, even though being valuable tactics, it is not guaranteed that they can favor acceptance [Piras et al., 2016, 2017b]. Thus, the analyst can decide to add some

of them to improve the gamification experience of the user [Piras et al., 2016, 2017a,b]. In order to do this, the analyst has to activate the “Selection Mode” by clicking on the green ellipse in the right part of Figure 5.22. Then, she can click on all the tactics she decides to add, which will be bounded by the editor with the green ellipse (Figure 5.22). For example, in Figure 5.22 the analyst has decided to add the following additional tactics: **Improve Trust**, **Increase User Surprise**, and **High Design Quality** [Piras et al., 2017b].

### Phase 6: Context-Based Operationalization via Gamification

In this phase, the Agon-Tool uses the UCM instance for reasoning, over GMM and its CDRs, at the gamification level by considering also the tactics selected in the preceding phase [Piras et al., 2016, 2017a,b]. The aim of Agon is to suggest, to the analyst, the most suitable gamification goals for the specific context [Piras et al., 2017b]. Those suggestions are provided by the tool, to the analyst, in the form of a goal model (Figure 5.23), resulting from the reasoning applied to GMM. Thus, such model is a sub-set of GMM, including gamification goals, selected by Agon, able to stimulate the characterized user on the basis of its context [Piras et al., 2016, 2017a].

Especially, in Figure 5.23, the tool shows, to the analyst, the complete model derived from the original GMM (in that screenshot, it is illustrated only a part of the full solution), obtained after the Agon reasoning. Agon proposes gamification goals that best fit the context instance [Piras et al., 2017a]. They are mainly connected, by means of **Refinement** relations, in a hierarchical way, from the most abstract ones to the less abstract ones, and annotated by CDRs [Piras et al., 2017b] (Figure 5.23). Other relations are employed in GMM, for instance the **Need** and **Conflict** relations. The analyst, in this phase, can take further decisions over the set suggested by Agon, by evaluating if to remove part of the solution [Piras et al., 2016]. According to what discussed in “*Phase 4: Context-Based Analysis of Acceptance Requirements*” for AMM, analyst’s decisions are beneficial also at the gamification level, for example, in case that some gamification goals, chosen by Agon, do not fit specific constraints of the domain of the software to be gamified [Piras et al., 2016]. In fact, at the moment, Agon cannot consider those aspects; this is a current limitation of Agon. Indeed, Agon does reasoning by considering current supported UCM variables [Piras et al., 2017b]. In the future, the set of UCM variables will be enlarged, for increasing the suitability and precision of Agon suggestions [Piras et al., 2017a], and applied also to GMM by adding new CDRs.

By using the Agon-Tool, the analyst can decide to remove a gamification goal by dragging the red X element, from the stencil in Figure 5.23, and dropping it over the

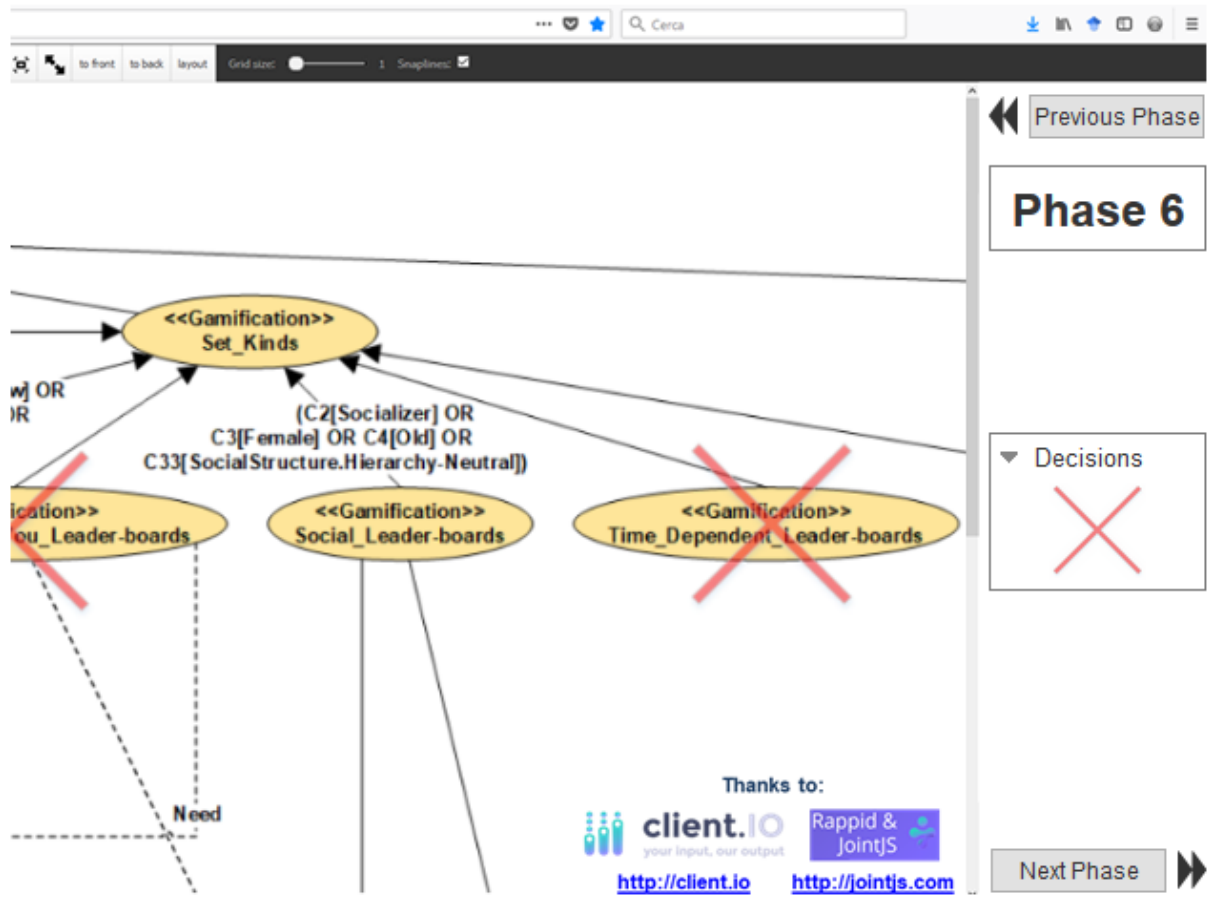


Figure 5.23: Support provided by the Agon-Tool to the requirements analyst in “*Phase 6: Context-Based Operationalization via Gamification*” [Piras et al., a, 2016, 2017a]

gamification goal she wants to discard. When the X is released, the editor attaches it “magnetically” to the center of the element to discard. In the editor, the X can be resized, remaining centered to the element. For instance, in Figure 5.23 the analyst has discarded the **Time Dependent Leader-Boards** gamification goal.

Moreover, as already discussed in “*Phase 4: Context-Based Analysis of Acceptance Requirements*” for AMM, it is possible, optionally, for the analyst even to apply changes to the model obtained also at the gamification level, by using the editor (e.g., removing gamification goals and/or using existing relations for connecting goals in different ways). However, this is the last phase where Agon provides results coming from its reasoning. Therefore, if the analyst has not applied particular changes to the models in the previous phases, suggestions obtained by Agon are as linear as possible to the results of the literature Agon is based on [Piras et al., 2017b]. Thus, in general, In order to keep this knowledge

intact, we suggest to do not apply particular changes, at least if it is not needed because of particular constraints of the domain of the software to gamify [Piras et al., 2017b]. However, at this level to apply some changes could be beneficial for the analyst. This is because sometimes the analyst has to take into account very specific aspects coming from the domain of the software to gamify, which Agon cannot capture having generic reference models [Piras et al., 2017b]. In this case, the Agon-Tool gives to the analyst a level of decision flexibility that can be useful in particular situations [Piras et al., 2017a]. In any case, in the next phase the analyst will be able to instantiate the generic solution obtained, supplied by Agon and suitable for the specific context, according to specific domain constraints [Piras et al., 2016]. Therefore, we suggest, if it is possible, to avoid changing models in this phase and in the previous ones, and to leverage on the last phase for fulfilling particular domain constraints by instantiating GMM [Piras et al., 2017b]. In this way, the main structure and suggestions provided by Agon, based on the literature, will be kept in the final gamification solution, resulting from the instantiation performed in the following phase [Piras et al., 2017b].

### **Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms**

This is the last phase, the analyst can use the Agon-Tool to instantiate the gamification solution obtained in the preceding phase [Piras et al., 2016, 2017a,b]. Such solution is the result of all the Agon reasoning steps, and analyst’s decision taken over Agon suggestions [Piras et al., 2016, 2017a]. Due to the fact that Agon uses generic reference models annotated with CDRs, the solution provided by Agon is made of the most suitable gamification goals, for the context instantiated by the analyst [Piras et al., 2017b], but it is still abstract and requires to be instantiated by the analyst in this phase [Piras et al., 2016]. Specifically, the analyst instantiates the valuable suggestions obtained by Agon, by considering how to make them more concrete on the basis of characteristics and constraints of the domain of the software to gamify, and other aspects that Agon currently does not consider [Piras et al., 2016, 2017a,b].

As shown in the screenshot of Figure 5.24, Agon supports the analyst with an editor showing the gamification solution obtained in the previous phase, and a stencil (right part of Figure 5.24) with elements, relations and operators to be used for performing the instantiation. The notation supported in this phase is similar to the one of “*Phase 1: Base System Requirements*”, and close to the one of the NFR framework [Chung et al., 2012, Li et al., 2013, Mylopoulos et al., 1992]. Thus, the way of using the editor and stencil is analogous to what explained for “*Phase 1: Base System Requirements*”. In addition, the

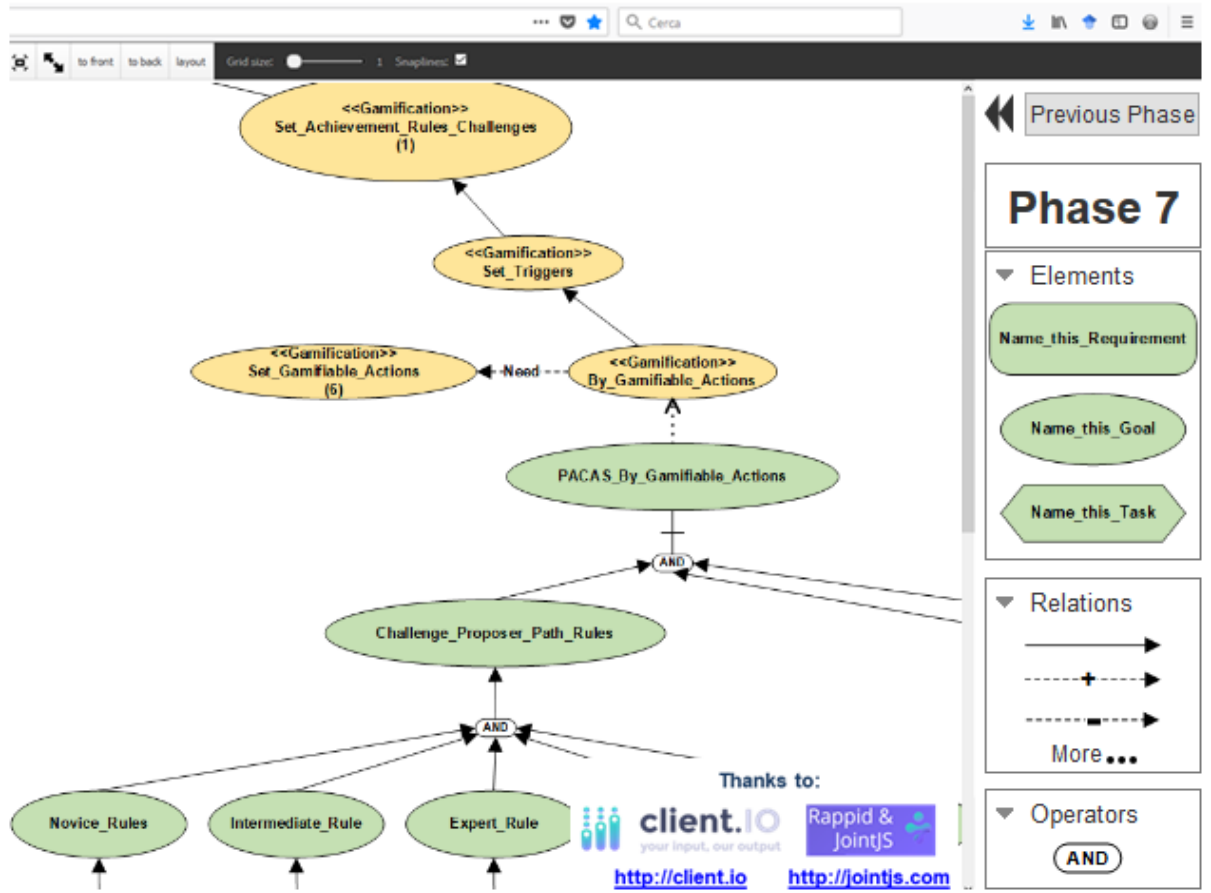


Figure 5.24: Support provided by the Agon-Tool to the requirements analyst in “Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms” [Piras et al., a, 2016, 2017a]

analyst by clicking on the More link can find relations very useful for this instantiation phase, such as the Instantiation and Operationalization relations. For example, in Figure 5.24, the analyst instantiates the By Gamifiable Actions gamification goal with a new goal named PACAS By Gamifiable Actions that in turn is operationalized with a hierarchy of other elements (this example is deeply explained in the case study of Chapter 6, where we gamify the PACAS platform by using Agon).

### 5.3 Chapter Summary

This Chapter describes the *Agon Method*, i.e. the *Systematic Acceptance Requirements Analysis Based on Gamification*, and the *Agon-Tool*.

Concerning the *Agon-Tool*, the chapter illustrates its architecture, main components and other technical details (Section 5.2). The Agon-Tool is the software supporting

the requirements analyst in using Agon and its meta-model for performing a systematic acceptance requirements analysis based on gamification. Furthermore, we show also the Agon-Tool in action, by describing how it can be used for such analysis activities.

Moreover, this Chapter describes the method provided by Agon to the requirements analyst for the analysis and design of engaging software systems (Section 5.1). The *Systematic Acceptance Requirements Analysis Based on Gamification* of Agon is illustrated by showing the method in action for gamifying the famous Meeting Scheduler exemplar, which comes from the Requirements Engineering Community. For this occasion, we propose a more collaborative, social version of the meeting scheduler, inspired to Doodle<sup>13</sup>, and we name it as: the *Doodle-Like Meeting Scheduler Exemplar*. Therefore, we show both the Agon Method, and the gamification of the Doodle-Like Meeting Scheduler Exemplar, which is part of a case study we carried out [Piras et al., 2017a] and illustrate in Chapter 8. Moreover, in the next of the Thesis, we illustrate a real case study, where we applied the Agon method, for the gamification of a platform in the context of a European project. It is the Participatory Architectural Change Management in ATM Systems (PACAS<sup>14</sup>) European project, we describe the related case study in Chapter 6.

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<sup>13</sup><https://doodle.com>

<sup>14</sup><http://www.pacasproject.eu/>

# Chapter 6

## Applying Agon to a Real Case

In this Chapter we describe the main case study of this thesis, a real case study in the context of a European project, where we applied Agon for the gamification of a software platform. The *Participatory Architectural Change Management in ATM Systems* (PACAS) European project<sup>1</sup> is such project. In particular, we analyzed the complex context of PACAS and delivered an engaging platform for motivating decision makers to collaborate in a participatory way by using such platform. We explain how we employed Agon for the analysis and design of this engaging platform.

In Section 6.1, we introduce the PACAS European project, its context and the PACAS platform. Then, in Section 6.2 we describe the case study where we gamified the PACAS platform by using Agon, and the gamification solution we designed and implemented. Finally, in Section 6.3, we describe more in detail the gamification mechanisms implemented in the PACAS platform and provide further details concerning the analysis, design and implementation of the gamification solution in the platform.

Results and details concerning the evaluation of this real case study are discussed in Chapter 7.

### 6.1 Participatory Architectural Change Management in ATM Systems (PACAS)

In the following, we introduce the *Participatory Architectural Change Management in ATM Systems* (PACAS<sup>1</sup>) European project (ATM stands for Air Traffic Management) and its context (Subsection 6.1.1). Then, in Subsection 6.1.2, we outline the platform supporting the PACAS process.

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<sup>1</sup><http://www.pacasproject.eu/>

### 6.1.1 The PACAS European Project

The change management dealt in PACAS is related to context of EATMA [Piras et al., 2017b]. The European Air Traffic Management Architecture (EATMA) is composed of many procedures that are continuously discussed, innovated and improved concerning safety, security, organizational and economical aspects [Piras et al., 2017b]. This requires complex architectural change management activities involving many heterogeneous stakeholders from various institutions, agencies, and companies [Piras et al., 2017b]. The stakeholders, decision makers having different expertise, to find a solution, deal with many concurrent multidisciplinary variables, needs and constraints coming from different realities [Piras et al., 2017b]. They should collaborate and participate actively to the decision making process for finding an agreement fulfilling safety, security, organizational and economical aspects [Piras et al., 2017b]. Thus, the critical part is to guarantee that all the stakeholders participate actively and continuously to the process for designing high-quality solutions [Piras et al., 2017b].

### 6.1.2 The PACAS Platform

The process described in Subsection 6.1.1 is enacted by using a platform for managing EATMA architectural changes. Such platform is the PACAS platform [Piras et al., 2017b]. Therefore, for such a system it is crucial to motivate people to participate in the discussion, bringing ideas, evaluating problems and finding solutions by collaborating [Piras et al., 2017b]. In the following, we outline the phases of the iterative PACAS decision process supported by the PACAS platform. We gamified the PACAS platform by using Agon and describe this case study [Piras et al., 2017b] in Section 6.2).

The first step initiates a new Change Management (CM) process for improving a particular ATM procedure [Piras et al., 2017b]. Then, experts from different institutions, agencies and companies are identified and are invited to participate in the process. These are decision makers from the safety, security, economics and organizational fields. Next, they describe in detail the current situation by creating an “As-Is Model” [Piras et al., 2017b]. The next step concerns “Problem Divergence” where experts identify problems and threats, explore alternatives and make proposals [Piras et al., 2017b]. It is possible also that someone asks to other experts to evaluate a particular aspect or highlight that a specific aspect is considered only for one sector (e.g., the security one) and not in other ones (e.g., safety, organizational or economics ones) where there could be important impacts [Piras et al., 2017b]. The final step is “Solution Convergence” where experts, after many iterations and evaluations of alternatives, find a common ground for a solution

that fulfills requirements for all relevant perspectives (safety, security, economics and organizational ones) [Piras et al., 2017b].

## 6.2 Gamification for Architectural Change Management in ATM Systems

When arise the necessity for a change in a ATM procedure (e.g., the introduction of a new technology) many heterogeneous users are involved. They start interacting for evaluating all the impacts regarding the new procedure and, finally, after many complex iterative discussions and activities, find a solution that is able to satisfy the safety, security, economical and organizational aspects implied by the new procedure. The entire process is iterative and refers to the European Air Traffic Management Architecture (EATMA) context. This context and the related change management problem has been dealt within the *Participatory Architectural Change Management in ATM Systems* (PACAS<sup>2</sup>) European project (introduced in Section 6.1). The outcome of the PACAS project is the PACAS software system, a platform for managing EATMA architectural changes that supports all the users involved, pushing them in collaborating in a participatory way.

We gamified the PACAS platform for engaging decision makers to participate more actively and collaboratively to the related decision process. In this section, we outline the case study where we applied Agon for the gamification of the PACAS platform. Therefore, in this Section we show the Agon method in action in a real case study. The description allows us to provide also more details and examples concerning the Agon method and models.

### 6.2.1 Case Study: Agon Applied to the PACAS Platform

We gamified the PACAS platform that is a participatory system to support collaborative decision-making for Air Traffic Management (ATM) experts innovating current ATM procedures. For such a system it is crucial to motivate people in participating in the discussion, bringing ideas, evaluating problems and finding solutions by collaborating. Agon supported us in the analysis and design of incentive strategies to improve such system for making it more stimulating, attractive and interesting. The next Subsections represent the phases of the Agon method applied to PACAS. Full models referred in the next Subsections are available at Piras et al. [a]. Finally, in the last subsection, we describe the gamification solution we designed and implemented.

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<sup>2</sup><http://www.pacasproject.eu/>

### Phase 1: Base System Requirements

First of all, to start dealing with an acceptance problem, it is important to understand the characteristics of the system to gamify. The outcome of this phase is a goal model [Chung et al., 2012, Piras et al., a] representing the PACAS platform requirements and features. The resulting model, available at [Piras et al., a], represents exactly the description provided in Section 6.1.2.

### Phase 2: Acceptance Requirements Elicitation and Analysis

Next, we analyzed the PACAS goal model [Piras et al., a] for defining acceptance requirements, according to the criteria of our definition (Formula 4.1). We defined the acceptance requirement [Piras et al., a, 2017b]:

$$\begin{aligned} &Acceptance[\{Propose\ Change\ Management, Report\ AsIs\ Details, \\ &\quad Identify\ Problem, Propose\ Alternative, \\ &\quad Accept\ Solution\}, Decision\ Makers] \geq 80\% \end{aligned} \quad (6.1)$$

Thus, we identified the set of crucial functions of the platform [Piras et al., a] that need full users' participation to satisfy platform objectives. For instance, from the previous formula, we decided to motivate decision makers, above all, concerning the usage of the platform for proposing a new change management, reporting collaboratively details of the procedures to be improved, finding problems and parts to be enhanced and proposing alternative solutions [Piras et al., a].

Therefore, the goal **Propose Change Management** [Piras et al., a] and the others in the set are the goals that need analysis of psychological, cognitive and behavioral factors to stimulate in order to motivate participants. Participants, as specified in the acceptance requirement, are decision makers and we need to characterize them (next phase).

### Phase 3: Context Characterization

We instantiated the Context Model [Piras et al., a] for characterizing the decision makers category and their context as follows. Decision makers are mostly male (due to the fact that the sector is mainly “male based”, e.g., the PACAS advisory board is all male) and largely seniors, in relation to age. Regarding player type, they are achievers, socializers with skills to convince other partners and explorers whose job is to innovate the ATM sector. They have a job because they are managers in some organizations. They have used previously platforms similar to PACAS, are obliged to use PACAS and their expertise

level in using such a system is high. Regarding the goal, the communication and the participation levels are high, while goal clarity is low. Concerning the task, task variety is high because they have to deal with change managements of ATM procedures, also specificity and identification are high and the required skills are highly specific. The social structure is hierarchy-neutral because it is a community of peers (from different institutions, agencies and companies) such as no-one can impose the radical change, but a high commitment from all the partners is required. Eventually, the good produced is public.

#### Phase 4: Context-Based Analysis of Acceptance Requirements

On the basis of acceptance requirements and context, Agon selected most suitable psychological factors [Piras et al., a] by applying reasoning (guided by constraint rules, CDRs, annotated on the models) over the acceptance model. The result is available at [Piras et al., a]. For example, since users have used before other platforms similar to PACAS, convincing users that using PACAS has important advantages constitutes a major factor for acceptance. In fact, as illustrated in Figure 6.1, Agon selects [Piras et al.,

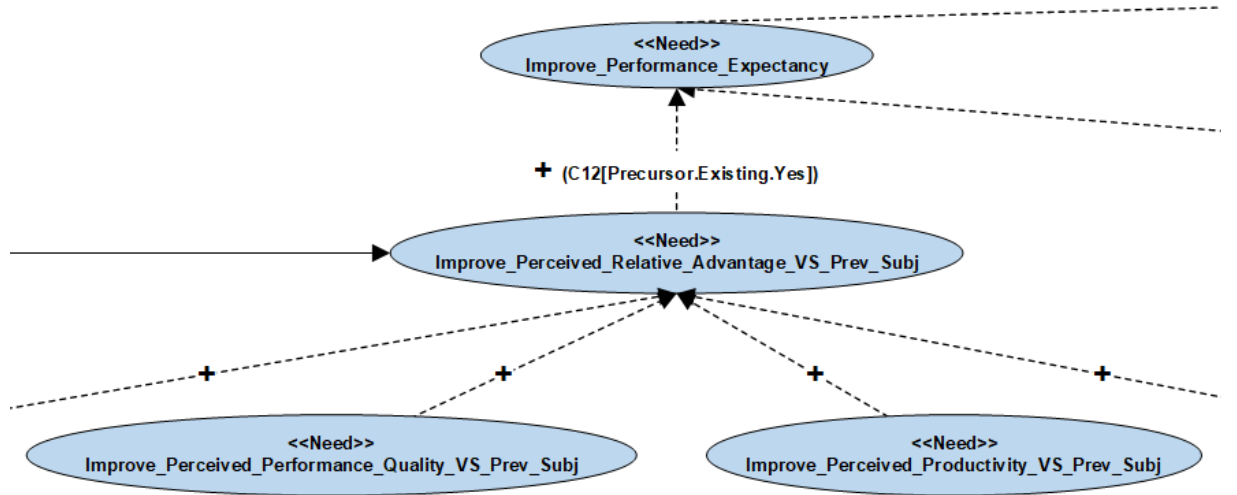


Figure 6.1: Example of elements suggested by Agon during “Phase 4: Context-Based Analysis of Acceptance Requirements” [Piras et al., a]

a] Improve Perceived Relative Advantage VS Prev Subject factor (because of the annotated rule C12[Precursor.Existing.Yes]).

Generally, Agon chooses acceptance factors on the basis of general guidelines from the literature, and then the analyst can make further decisions in relation to her specific

domain. For instance, decision makers do not have much free time, especially for steep learning activities. Accordingly, as shown in Figure 6.2, since they have used in the

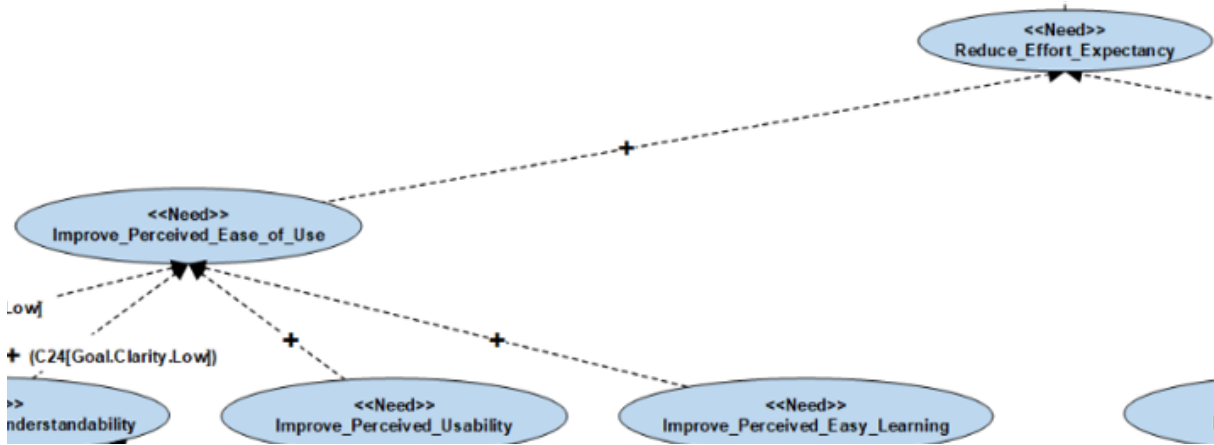


Figure 6.2: Example of analyst’s decisions on elements suggested by Agon during “Phase 4: Context-Based Analysis of Acceptance Requirements”, related to keeping the Improve Perceived Ease of Use need [Piras et al., a]

past platforms similar to PACAS, we kept just Improve Perceived Ease of Use as key factor for acceptance, and discarded Improve Ease of Use, as illustrated in Figure 6.3, because the latter may require steep learning activities.

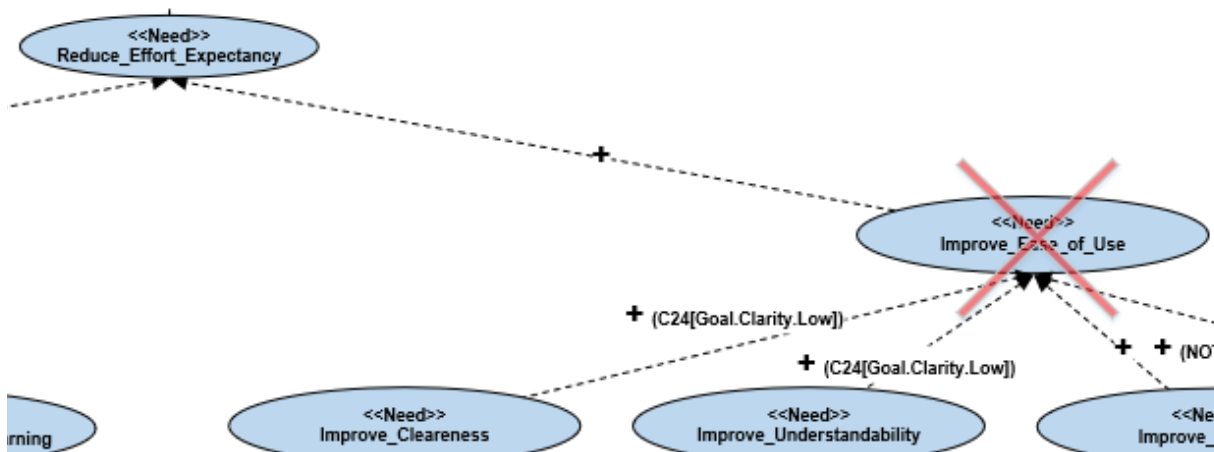


Figure 6.3: Example of analyst’s decisions (represented by red Xs) on elements suggested by Agon during “Phase 4: Context-Based Analysis of Acceptance Requirements”, related to discarding the Improve Ease of Use need [Piras et al., a]

In [Piras et al., a] it is available the Figure that presents the acceptance solution obtained at the conclusion of this phase, i.e. the result of Context-Based reasoning over

the Acceptance Model and analyst’s decisions. Elements discarded by the reasoning or by the analyst have been removed in the Figure [Piras et al., a] to have a clear view of the result [Piras et al., a].

### Phase 5: Acceptance Requirements Refinement

Agon individuates tactics, reported in Figure 6.4, that can refine the needs selected Piras et al. [a] (e.g., **Improve System Advantage Perception VS Competitor Systems via IT**, **Promote Collaboration**, etc.) and we decided to keep all of them except **Support Skill Improvement**, because it can lead to steep gamified learning activities that managers cannot afford because their commitments and related lack of time (Figure 6.4).

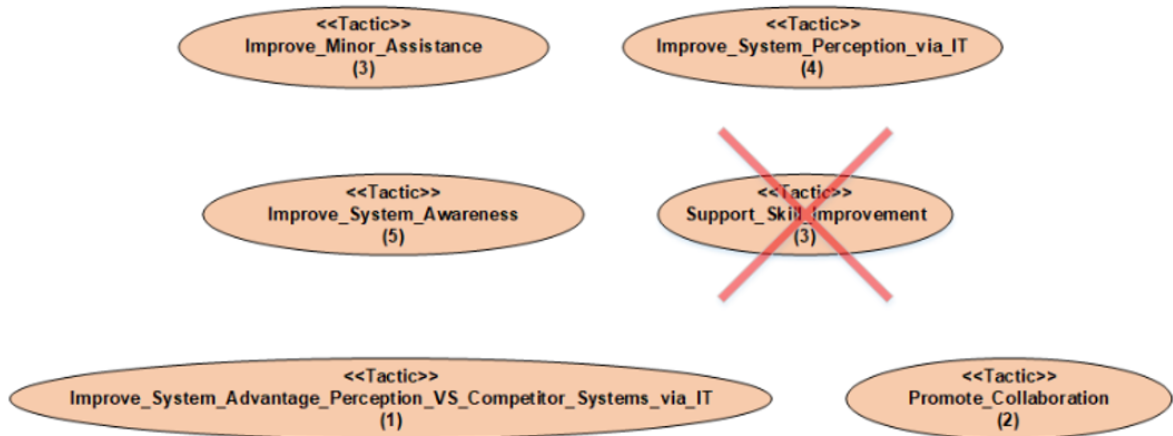


Figure 6.4: Elements proposed by Agon to the analyst during “Phase 5: Acceptance Requirements Refinement” and analyst’s decisions as red Xs [Piras et al., a]

Moreover, Agon suggests to the analyst high-level incentive mechanisms Piras et al. [a] that can operationalize those tactics such as **Design Gamification**, **Design Tangible Incentives** and **Design Serious Games** (Figure 6.5). Because this thesis focuses on gamification incentives, and Agon currently supports only gamification (even though, our framework has been designed to support also other incentive mechanisms, which are going to be considered by us in the next future), the analyst excludes the other options.

Then, Agon suggests other tactics (closer to the gamification world) that can have a positive side-effect to the users, but do not guarantee to fulfill acceptance (Figure 6.6). The analyst adds **Increase User Surprise**, **Improve Trust** and **High Design Quality** Piras et al. [a] (Figure 6.6). For instance, **Improve Trust** is useful in the context of PACAS



Figure 6.5: Operationalizations proposed by Agon to the analyst during “*Phase 5: Acceptance Requirements Refinement* (red Xs are the analyst’s decisions)” [Piras et al., a]

for leading to tactics to employ strategies for enhancing reputation and trust among collaborators.

The solution designed so far is updated with tactics selected in this phase, and the operationalization chosen (represented by its high-level goal to be fulfilled shown in Figure 6.5, i.e. **Design Gamification**). In [Piras et al., a] it is available the Figure that presents the updated solution obtained at the conclusion of this phase [Piras et al., a].

### Phase 6: Context-Based Operationalization via Gamification

In this phase, on the basis of the acceptance, tactical requirements selected and the context instance, Agon suggested gamification strategies to engage decision makers [Piras et al., a]. The result is available at [Piras et al., a]. For example, as illustrated in Figure 6.7, given that the goal clarity level is low (i.e., the goal is complex [Piras et al., 2017a]), Agon knows it is necessary to involve users in working in teams and suggested the **Set Team Roles** (Figure 6.7) and **Team Leader-boards** (Figure 6.8) gamification goals [Piras et al., 2017b]. Agon chooses **Set Team Roles** also because it operationalizes a tactic we selected: **Promote Collaboration** [Piras et al., 2017b] (Figure 6.7).

In general, Agon suggests gamification goals on the basis of general guidelines and best practices from the literature. The analyst can adopt or refine these for her specific scenario [Piras et al., a]. For instance, as illustrated in Figure 6.8, we discarded the **Time Dependent Leader-boards** gamification goal because users have to make important decisions over ATM procedures, by taking into account many heterogeneous variables, thus, we do not want to create competition by time pressure that could lead to poorly-thought out solutions.

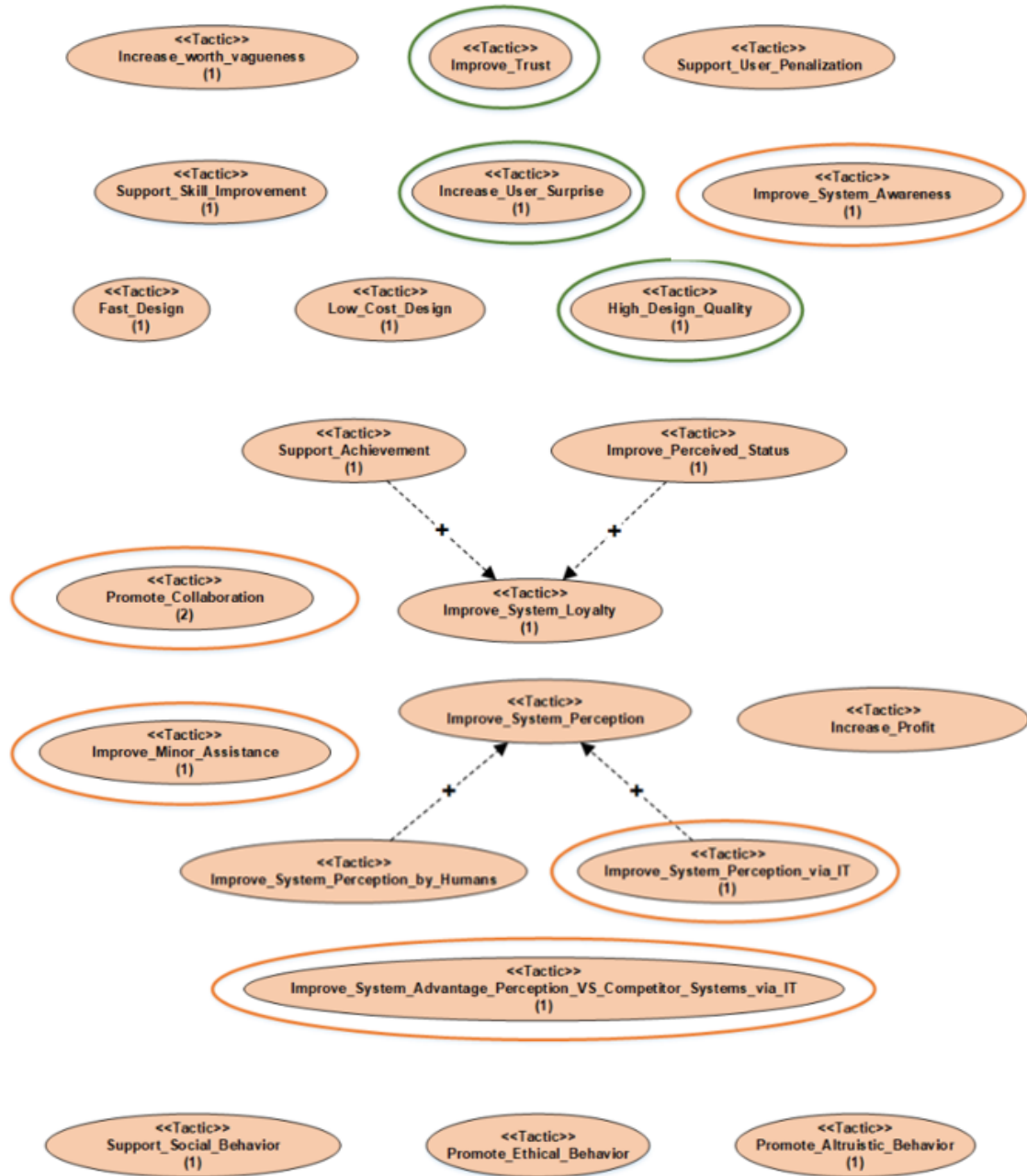


Figure 6.6: Additional elements proposed by Agon to the analyst during “Phase 5: Acceptance Requirements Refinement” (the elements circled in green are the additional ones selected now, and the elements circled in orange are the ones chosen previously) [Piras et al., a]

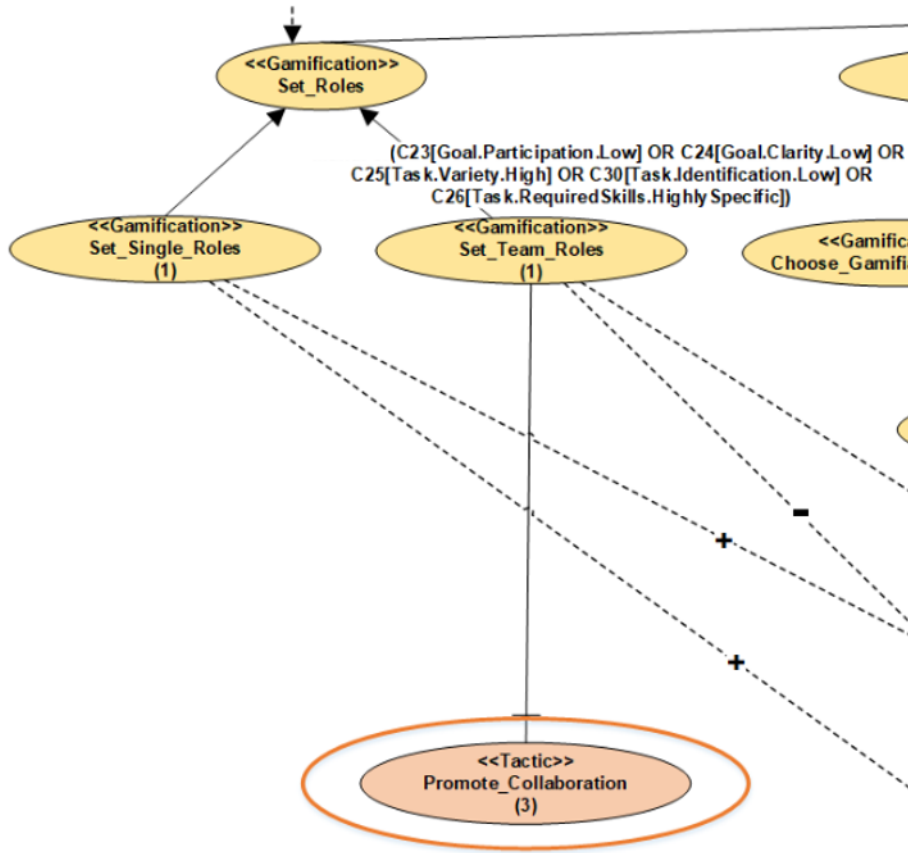


Figure 6.7: Solution proposed by Agon, after reasoning over the gamification model (“Phase 6: Context-Based Operationalization via Gamification”), in relation to the kinds of user roles to use in the gamification design [Piras et al., a, 2017b]

### Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms

Agon’s suggestions come from generic meta-models and do not necessarily address specific domain elements. Thus, the analyst has to instantiate those goals introducing goals and tasks Chung et al. [2012] at the PACAS level. The gamification solution designed after concluding this last phase, where the analyst instantiated and customized gamification suggestions of Agon, is available at [Piras et al., a]. For example, Agon suggested [Piras et al., a] to use paths (**Set Paths**) and levels (**Set Levels**) but cannot suggest what these paths might be. The analyst needs to determine these taking into account the ATM domain and the problem at-hand. We specified different progressions paths (Figure 6.9) for different roles [Piras et al., a, 2017b], for instance: (i) the **Challenge Proposer**, hereafter also called **Challenger**, who throws challenges to the other PACAS users for stimulating

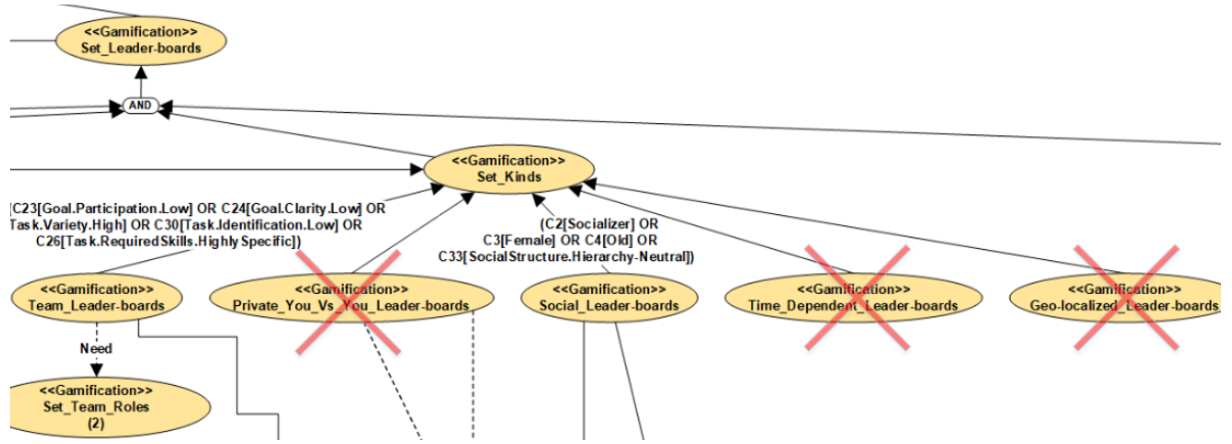


Figure 6.8: Example of decision taken by the analyst, regarding the Leader-boards gamification concept, over solutions proposed by Agon after reasoning over the gamification model (“Phase 6: Context-Based Operationalization via Gamification”) [Piras et al., a]

them to participate to the PACAS process, to individuate problems and to devise valuable solutions [Piras et al., 2017b]; (ii) the **Problem Solver**, who accepts such challenges and, thus, contributes more to individuate solutions for ATM problems [Piras et al., 2017b]. For the **Challenge Proposer** we designed the **Challenger Path** (Figure 6.9) with different levels [Piras et al., 2017b, Zichermann and Cunningham, 2011] (Figure 6.10) such as Novice, Intermediate, Expert, Master and Guru.

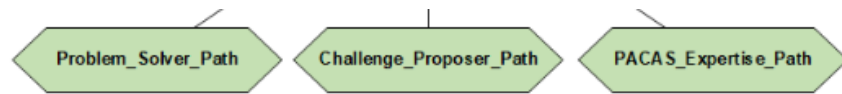


Figure 6.9: Example of customization and instantiation of gamification solutions proposed by Agon, performed in “Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”, regarding the Path gamification concept [Piras et al., a, 2017b]

Furthermore, the analyst can decide to modify/improve/cut gamification elements offered. For example, Agon suggested to define a particular metric (**Define Metric**) for assigning experience points to actions, instead we preferred to employ a simpler policy: assign 1 point to each action (**Assign 1 Point to Each Gamifiable Action**) [Piras et al., a].

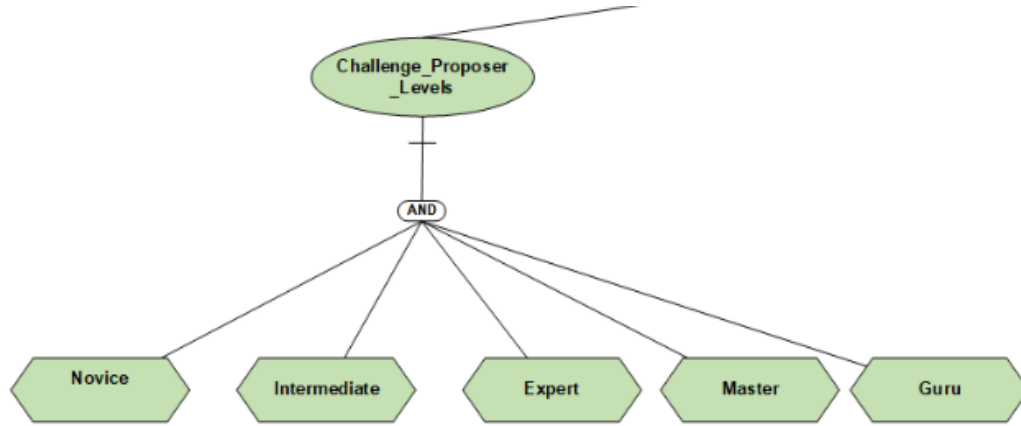


Figure 6.10: Example of customization and instantiation of gamification solutions proposed by Agon, performed in “*Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms*”, regarding Levels of the PACAS Challenge Proposer Path (also called Challenger Path) [Piras et al., a, 2017b]

### Gamification Solution

The gamification solution, designed by using Agon for the PACAS case, is composed of 5 goal models counting in total: 596 goals and tasks, and 825 relations of various kinds. Specifically, 52 goals and tasks are related to the problem domain (PACAS and ATM), 201 goals (i.e. needs, tactics and gamification goals) concern Agon suggestions as generic analyst’s decision support, and 343 goals and tasks are related to the game (e.g., game concepts and mechanisms applied to the pathway through the negotiation process, and for fostering the exploration of the problem space, the creation of new solutions, the learning of how to use the platform, the collaboration and participation to the process through challenges, etc.).

Most of the gamification concepts and strategies of this gamification solution - generated [Piras et al., a] by Agon, in a systematic, interactive way - have been implemented in the PACAS platform and, in the following, we summarize the most important elements of the solution [Piras et al., a]. Then, in Section 6.3, we provide further details of the gamification elements implemented in the PACAS platform.

In order to give to the decision makers a perception of ease of use of the PACAS platform and of the advantages versus previous similar systems they used, a simple gamified tour (**Provide Tour**) showing main system features and its advantages (**Advantage VS Competitor Systems**) is offered to the users when they start using the system (this fulfills **Improve System Perception via IT** and **Improve System Advantage Perception VS**

**Competitor Systems via IT**). Since PACAS is complex, users need at least simple training. Thus, at the beginning of each phase, a fast gamified tutorial (**Provide Tutorials**) is proposed (this satisfies **Improve System Awareness** and **High Design Quality**). Furthermore, an avatar (**Set Avatar Trainer** that fulfills **Increase User Surprise**) has been chosen for supplying suggestions (it fulfills **Improve Minor Assistance**) during each phase (**Train During Playing**). Concluding assistance elements, there is a gamified forum (this operationalizes **Improve Minor Assistance**) for promoting interactions among users.

Moreover, we designed different progression paths (**Set Paths**), Figure 6.9, and levels (**Set Levels**), Figure 6.10, concerning the different activities in PACAS: e.g., give more “As-Is” details, propose alternatives, propose a problem (like a threat), explore a solution, etc. Each path has some levels (e.g., as in Figure 6.10, **Novice**, **Intermediate**, **Expert**, **Master**, **Guru**). Paths subsist for both single users (**Set Single Roles**) and teams (**Set Team Roles**), Figure 6.7. Teams fulfill **Promote Collaboration** (Figure 6.7) as well as **Team Leader-boards** (Figure 6.8) that involve more internal collaboration in teams for competing with the other teams concerning the different activities in PACAS. Leader-boards are calculated per PACAS phase, action, regarding the single or the team and in relation to a single change management or all the change managements in PACAS.

Furthermore, there are also **Team Challenges** and **Personal Challenges**. For instance, a user can give a challenge to another expert concerning the evaluation of a particular problem. There is a reputation system, where after the completion of a phase or of a challenge each user rates the other. This reputation system is also useful to PACAS for expert selection when new change management projects are initiated.

## **Final Remarks**

The contribution of this Section, and above all of this entire Chapter, is to show how Agon and its method, described in the previous chapter, can help in real cases for performing a systematic acceptance requirements analysis based on gamification, supporting the analyst in gamifying a software system by designing a game that is suitable for motivating the user in fulfilling software objectives through game mechanisms. The research method followed, and the results of the evaluation are reported in the evaluation Chapter (i.e. Chapter 7, above all in Sections 7.4, 7.5 and 7.6). Specifically, this case study has been useful to evaluate Agon being used by analysts considered as experts (Section 7.4). While, non-expert analysts have been involved in other experiments as deeply described in the evaluation chapter. Thus, the PACAS case study evaluates mainly the feasibility and

usefulness of the Agon employment, in real cases, for the benefit of experts.

In summary, as described in the previous Subsections, Agon supported the experts in (i) analyzing the specific domain of the system, i.e. the PACAS domain, (ii) analyzing the objectives to be fulfilled by stimulating the users, (iii) selecting the candidate software features to be gamified, (iv) characterizing the user to motivate, and, on the basis of it, (v) selecting needs, tactics and, finally, game concepts and mechanisms to consider for gamifying the PACAS platform making it an engaging tool fulfilling, at the same time, the PACAS objectives.

Furthermore, contributions and decisions of analysts are fundamental in the Agon interactive method. In fact, Agon provides an interactive approach, and the analyst's knowledge, regarding the specific domain, is crucial for applying decisions over valuable elements suggested by Agon. The framework provides generic solutions, the most suitable for the intended users, but it is the analyst that, in the last phase, instantiates the generic solutions, supplied by Agon, in game solutions fitting the specific domain features. As a future work, we will try to make Agon to evolve for providing even more specific suggestions, closer to the software domain.

Finally, as also confirmed by real PACAS users (Sections 7.5 and 7.6), the Agon gamification solution can foster users in collaborating, and participating more to the PACAS process, for finding agreements and producing high-quality solutions.

## 6.3 Gamification of the PACAS Platform

In Section 6.2 we illustrate how we used Agon for the analysis and design of a gamification solution for the PACAS platform. Furthermore, in the last part of Section 6.2 we describe the gamification solution obtained. It is composed of many interesting gamification concepts and strategies, however, due to constraints within the PACAS EU project in relation to time and resources we have been able to implement (Figure 6.11 and Figure 6.12) a subset of the most important element of the solution that are described in the following Subsections.

Specifically, in Section 6.3.1, we provide further information concerning analysis, design and implementation of the gamification solution in the web PACAS platform. In Sections 6.3.2, 6.3.3, and 6.3.4 we start describing more in detail the gamification elements implemented in the platform. In particular, such Sections illustrate the *Gamified Paths* of the platform. While, in Sections 6.3.5 and 6.3.6, we outline respectively the *Gamified Tutorials* and the *Gamified Co-Pilot Avatar* implemented in the PACAS platform. Finally, in Section 6.3.7, we conclude with a summary of the gamification solution, by recapping

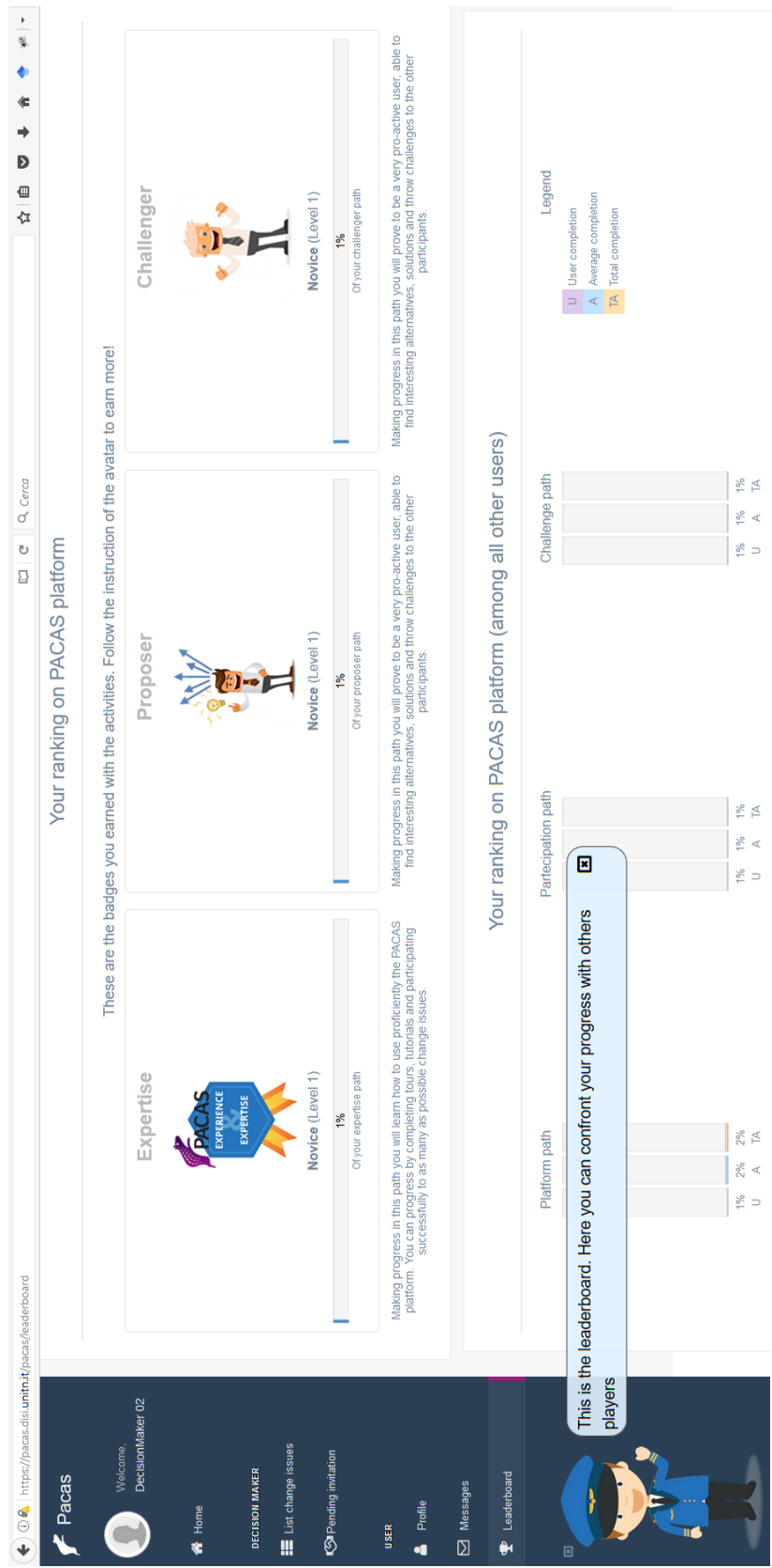


Figure 6.11: Some of the gamification elements implemented in the PACAS platform according to the Agon solution [Piras et al., 2017b]

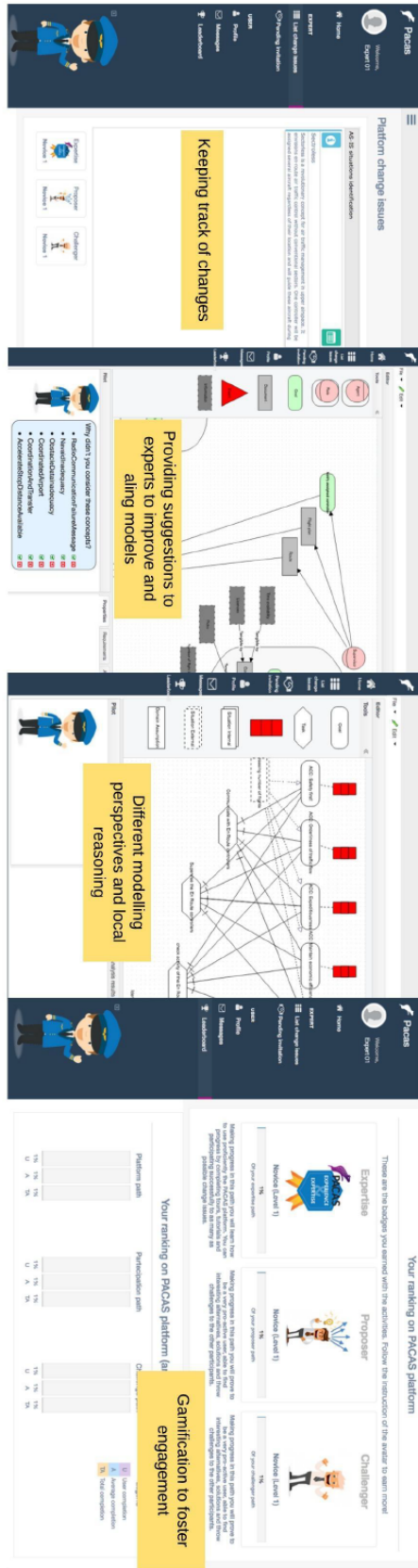


Figure 6.12: Pillars of the PACAS platform and some of the gamification elements implemented in the PACAS platform according to the Agon solution [Paja et al., 2018, Piras et al., 2017b]

most important concepts, and describing the related gamification experience through screenshots of the gamified PACAS platform.

### **6.3.1 Acceptance Analysis, Gamification Design and Implementation**

In order to gamify the PACAS platform, we conducted interviews and organized workshops with the Advisory Board (AB) members. On the basis of these interviews, and the use of two frameworks, namely the acceptance requirements framework called Agon [Piras et al., 2016, 2017a,b] for acceptance analysis and gamification design, and the Motivational Antecedents Framework [Cuel et al., 2011, Piras et al., 2017a, Simperl et al., 2013, Tokarchuk et al., 2012] (MAF), for characterizing deeply the context and domain of PACAS, we were able to:

- collect and define requirements (especially, acceptance and gamification requirements [Piras et al., 2016, 2017a,b]),
- characterize the target users [Piras et al., 2017b] and the context (the social structure where the platform will be used, the tasks to be carried out by the users, etc. [Cuel et al., 2011, Piras et al., 2017a, Simperl et al., 2013, Tokarchuk et al., 2012]), and
- execute a comprehensive systematic acceptance requirements analysis based on gamification [Piras et al., 2016, 2017a,b] that allowed us to design and implement the gamification of the PACAS web platform [Piras et al., 2017b].

The full requirements collected in this process concern wider aspects on the entire PACAS approach. While, the requirements mentioned in this Section (and the ones in the previous Sections) are focused on a more specific aspect: how to motivate the users of the PACAS platform to use such software and to participate actively and collaboratively on the change management process. Such requirements depend mainly on the characterization of the users [Piras et al., 2017a], their needs [Piras et al., 2016] and concern acceptance conditions (called acceptance requirements [Piras et al., 2016, 2017a,b]) which rely on psychological, cognitive, and motivational aspects [Piras et al., 2017a]. In particular, in PACAS we turn those requirements into gamification mechanics by employing the Agon Framework and its method [Piras et al., 2016, 2017a,b].

The full models of our study are available at [Piras et al., a] and have been illustrated and discussed in the previous Section. During this process, two high-level objectives (aka requirements) emerged that guided and constrained the gamification design and implementation we conducted. These requirements refer to the artifacts produced by

the PACAS process, i.e., the solutions for a given change issue. According to this, the resulting solution has to:

1. cover all the relevant perspectives such as security, safety, economics and organizational ones (*complete interdisciplinary coverage*);
2. be as much as possible precise, detailed, exhaustive, and cannot have gaps, threats or dangerous parts/components (*safe, complete solutions*).

Furthermore, the PACAS process shall strive to:

1. foster collaboration among decision-makers (*collaboration*);
2. motivate decision makers to participate in the decision-making process using the platform (*participation*);
3. push decision makers to identify the most suitable experts for each problem to solve (*expert identification*);
4. incentivize users to find potential gaps and threats in the identified solutions (*problem finding*);
5. stimulate user collaboration for solving an identified problem and select the most suitable expert for solving it (*expert identification*);
6. foster user communication while finding and solving problems (*communication*);
7. make users conduct all the activities prescribed above continuously, proficiently designing successful, brilliant solutions (*continuous, proficient, successful, brilliant solution design*).

Furthermore, we have identified a set of anti-requirements that should be avoided:

1. *competition*, for it could lead to potential conflicts among the participants, obstructing their collaborative work (a requirement above) and blocking the harmonious process that is required for designing high-quality solutions;
2. *time pressure*, for it could lead to poor solutions to satisfy the deadlines. In the air traffic management domain, it is particularly critical to ensure the quality of the solutions.

Moreover, these requirements are the desired ones to be fulfilled from the outcome expected from employing the PACAS platform in the context of Participatory Architectural Change Management in ATM Systems. Therefore, the outcome of playing the game is expected to favor the fulfillment of most of these requirements; we discuss in detail the related evaluation and results in Chapter 7 (Sections 7.5 and 7.6). Most of them have been collected during the preliminary phases of the PACAS project. Furthermore, when we used Agon for conducting acceptance requirements analysis and gamification design of the PACAS platform, we considered the requirements illustrated in this Section, being the ones closer to the PACAS domain, every time it was needed to take decisions over suggestions provided by Agon. The same for the final customization and instantiation of the gamification solution provided by Agon.

The gamification design we created for the PACAS platform consists of the following main gamification concepts [Piras et al., 2017b]: *Paths, Levels, Badges, Challenges, Avatar, Gamified Tours, and Gamified Tutorials*. In particular, our gamification design is organized around three paths (Figure 6.13), that, while orchestrating the other gamification elements,

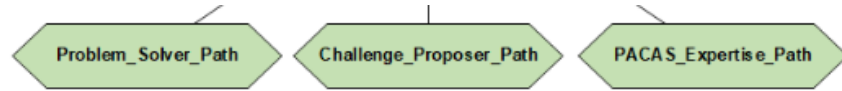


Figure 6.13: Customization and instantiation of gamification solutions proposed by Agon, performed in “*Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms*”, regarding the Path gamification concept [Piras et al., a, 2017b]

foster user progression while using the platform. The paths are as follows [Piras et al., 2017b]:

1. the **Challenger Path** (or **Challenge Proposer Path**);
2. the **Problem Solver Path**;
3. the **PACAS Platform Expertise Path**.

The general idea of a *Challenge* is represented in the sequence diagram in Figure 6.14. Player A (called *challenger*) creates a problem to be solved (a *challenge*) and throws it to Player B (*problem solver*). First, the problem solver evaluates the importance of the challenge that was received. Then, the problem solver can either accept or decline the challenge. If accepted, she is expected to resolve it by sending a solution. After a solution has been sent, the challenger evaluates the quality of the obtained solution. In case the

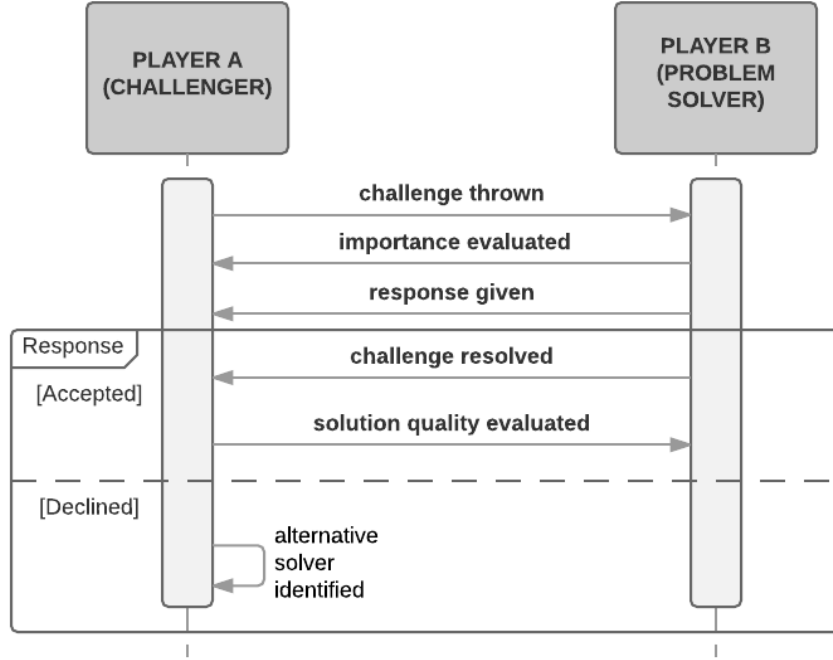


Figure 6.14: Sequence diagram showing the gamification mechanism of challenges implemented in the PACAS platform [Piras et al., 2017b]

problem solver declines to resolve the solution, the challenger identifies an alternative problem solver.

In the PACAS platform we implemented the challenge process as a prototype. It could be considered also as a simplification of the real process where negotiations and interactions could be not only dyadic, but also multi-party. However, this way of dealing with small tasks, aiming at involving two parties in improving a specific aspect of a solution, is realistic and useful for most of the cases as confirmed by real users (further details in Chapter 7, Sections 7.5 and 7.6).

In the following, we describe the most important gamification concepts and strategies, designed by using Agon, we implemented in the PACAS platform. In particular, we describe each path, their embedded gamification elements, the implementation in the PACAS platform, and we explain how these paths address also the needs described above.

### 6.3.2 The Challenger Path

A user can progress in the levels of the **Challenger Path** by identifying, given a decision point, **(i)** the most challenging activities, potential threats or problems that either affect the as-is ATM procedures or that should be improved by a proposed solution, and **(ii)** the most suitable users (single user or multiple users) that are able to solve a specific problem.

Table 6.1 shows the structure of this path by presenting the levels and corresponding

Main Level	Sublevels	Progression Trigger	Progressive Behaviour Change
Novice	1, 2, 3, ...	New challenge thrown AND Challenge importance $\geq$ Trivial	1. Problem finder; 2. Real problems finder
Intermediate	1, 2, 3, ...	New challenge thrown AND <b>Challenge importance <math>\geq</math> Normal</b>	1. Problem finder; 2. <b>Increasingly relevant problems finder</b>
Expert	1, 2, 3, ...	New challenge thrown AND Challenge importance $\geq$ <b>Important</b> AND <b>Challenge not declined</b>	1. Problem finder; 2. <b>Important</b> problems finder; 3. <b>Finder of most suitable problem solvers</b>
Master	1, 2, 3, ...	New challenge thrown AND Challenge importance $\geq$ <b>Critical</b> AND Challenge Success $\geq$ <b>According to standards</b>	1. Problem finder; 2. <b>Critical</b> problems finder; 3. Finder of most suitable <b>successful standard</b> problem solvers
Guru	1, 2, 3, ..., $\infty$	New challenge thrown AND Challenge importance $\geq$ <b>Very critical</b> AND Challenge Success $\geq$ <b>Above standards</b>	1. Problem finder; 2. <b>Very critical</b> problems finder; 3. Finder of most suitable <b>successful above standards</b> problem solvers

Table 6.1: Gamification design of the Challenger Path within the PACAS platform [Piras et al., 2017b]

badges, the progression triggers that make the user advance through the main levels and

sub-levels, and the desired behavior change (*progressive behavior change*) that the game mechanics stimulate. Such behavior change follows the directions of fulfilling some of the process requirements identified previously: *problem finding*, *collaboration for solving problems*, and *identification of most suitable problem solvers* [Piras et al., 2016, 2017a,b].

Concepts represented in Table 6.1 are the results of the gamification design obtained by instantiating and customizing the gamification solution provided by Agon, during “*Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms*” [Piras et al., 2017b]. This instantiation, within the full instantiation of the PACAS gamification solution is available at [Piras et al., a]. While, in Figure 6.15, Figure 6.16, Figure 6.17, Figure 6.18, Figure 6.19 and Figure 6.20 this instantiation is represented. Specifically, Figure 6.15 shows - the high-level part of - the instantiation of rules specifying conditions for progressing in the **Challenge Proposer Path** through the *Challenges* gamification concept. While, in the other Figures the progression for a specific level is illustrated (it is compatible with what is reported in Table 6.1). Furthermore, each of these Figures reports the rule for reaching the related main level or for progressing in its sub-levels. When it is specified **Left** and **Right**, we respectively refer to the left-hand side and right-hand side of the rule. In the left-hand side are reported conditions to progress in the next sub-level, and in the right-hand side rewards (i.e. reaching the next sub-level and winning the related badge).

The main *Levels* are (Table 6.1 and Figure 6.15): **Novice**, **Intermediate**, **Expert**, **Master** and **Guru** [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011]. Each of these main levels is composed of *Sub-Levels* (Table 6.1). For instance, there are the **Expert level 1**, **Expert level 2**, etc. For each sub-level, a *Badge* is assigned to the user who has achieved skills, competences, or is acting in the way that is expected by that path at that level. The column *Progression Trigger* expresses the minimum required conditions, called triggers, for progressing in next sub-levels of a main level (and then towards another main level). The **Guru** is the only main level (the same holds also for the other paths described in the next sections) that goes to infinite. It is important to employ this gamification design strategy [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011] to avoid that the user leaves the game just after reaching the last level. In fact, we can keep motivating the user and her interest in participating in the game at high levels, by not having a last level, but having infinite ones, and showing her that it is still possible to progress in the path [Schell, 2014, Zichermann and Cunningham, 2011].

The badge of the **Novice Level 1** (Table 6.1 and Figure 6.16) has an implicit trigger (not shown in the Table, it is shown in Figure 6.16): the user earns it when she starts using the PACAS platform [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham,

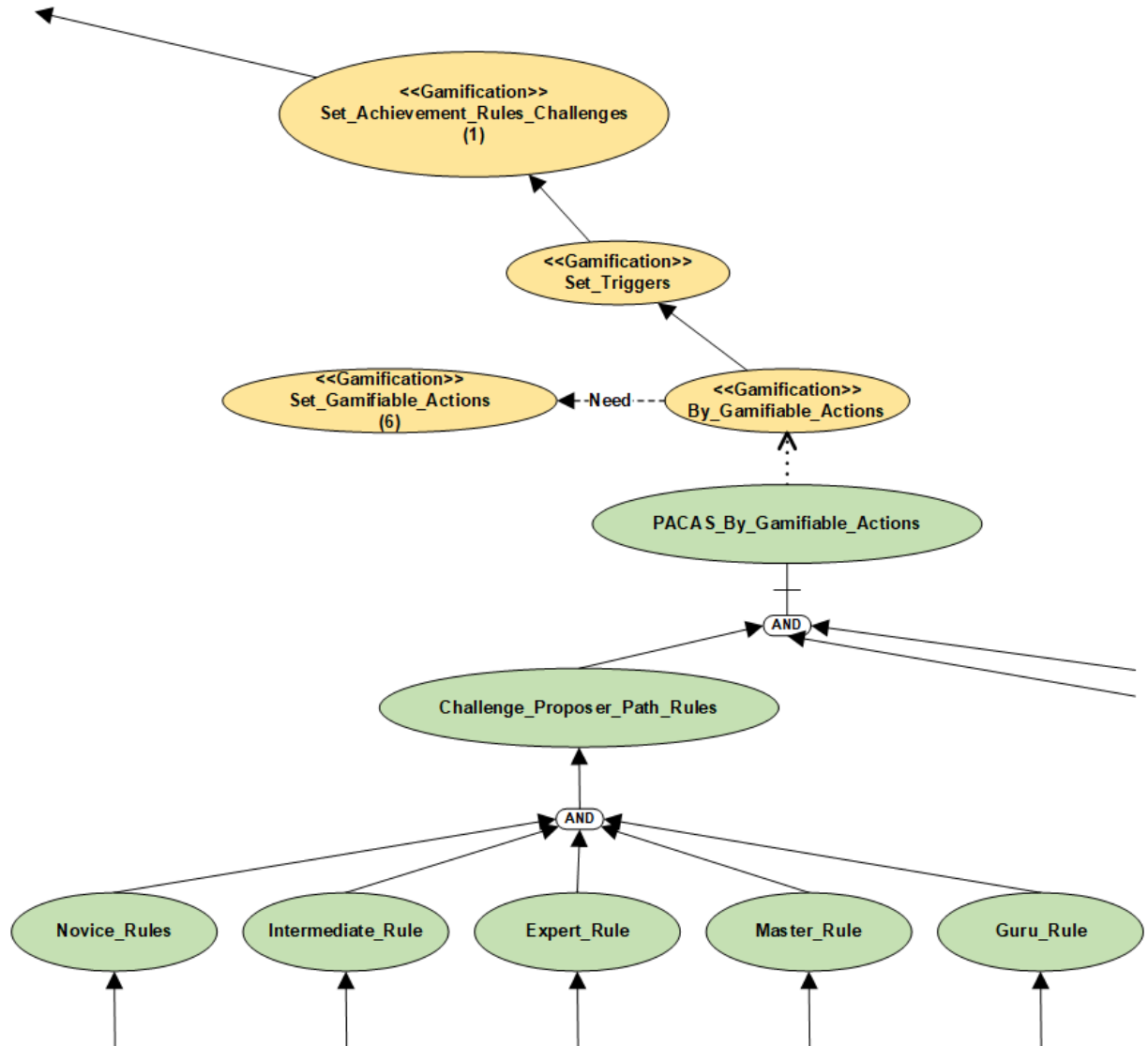


Figure 6.15: The high-level part of the instantiation of rules specifying conditions for progressing in the **Challenge Proposer Path** through the *Challenges* gamification concept (“Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”) [Piras et al., a, 2017b]

2011]. This is useful for making the user aware (through an unexpected reward that supports **Increase User Surprise**, a tactic selected by us during “Phase 5: Acceptance Requirements Refinement” and illustrated in Figure 6.6, i.e. a tactical strategy of the Agon we used, that represents an emotion that can further engage the user [Piras et al., 2016, 2017a,b]) that there is that path in the platform where she can progress being rewarded with gamification elements such as the novice badges, levels and paths [Piras

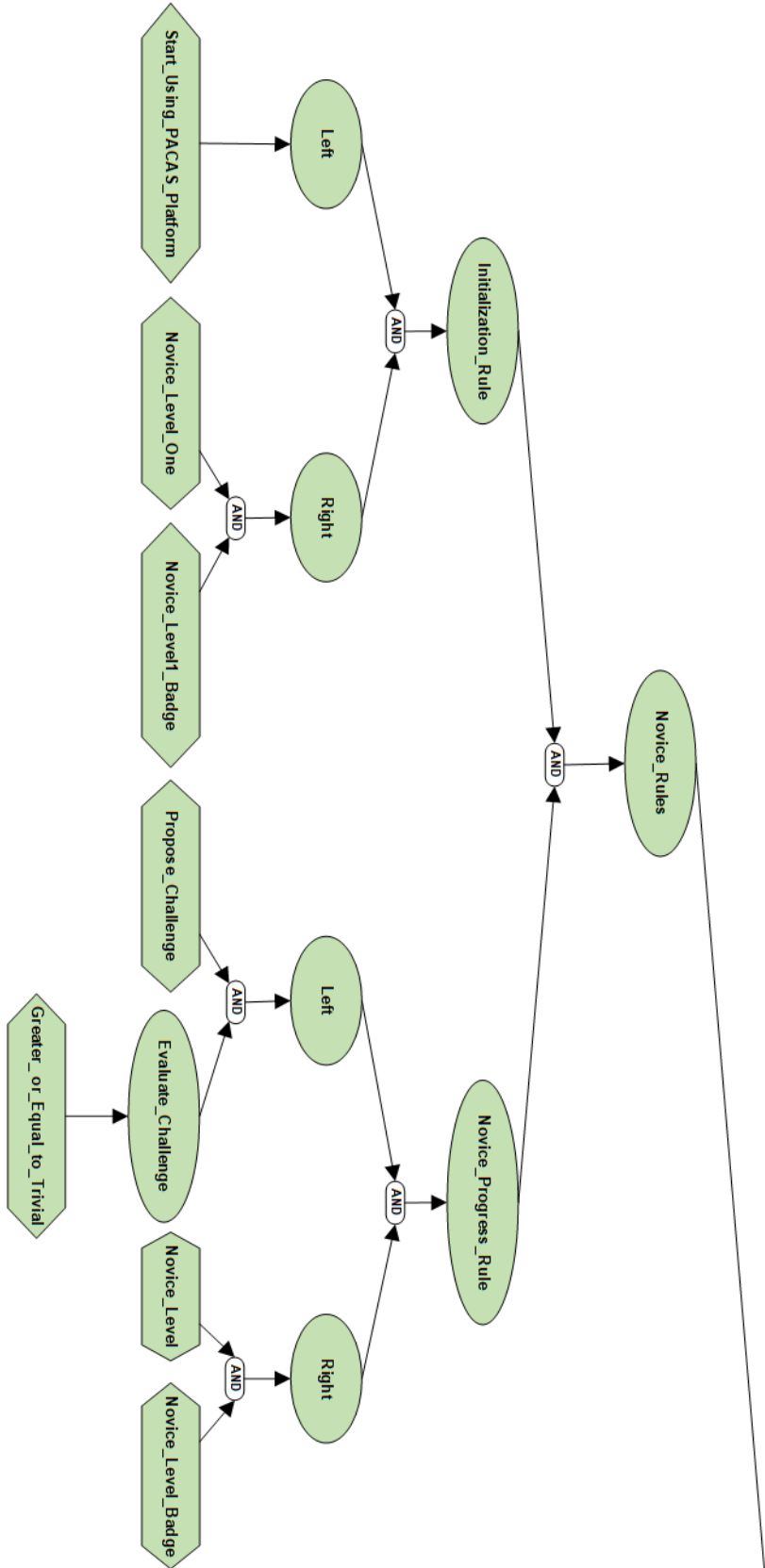


Figure 6.16: The high-level part of the instantiation of rules specifying conditions for progressing in the Challenge Proposer Path through the *Challenges* gamification concept (“*Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms*”); specifically, this instantiate the rules for the *Novice Levels* [Piras et al., a, 2017b]

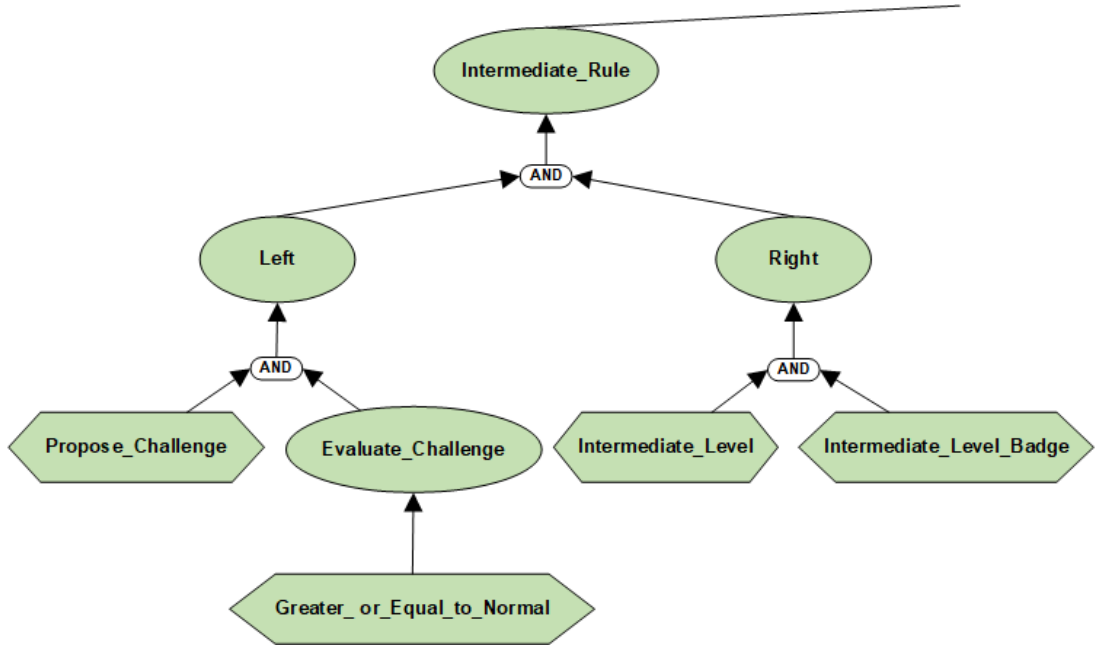


Figure 6.17: The high-level part of the instantiation of rules specifying conditions for progressing in the **Challenge Proposer Path** through the *Challenges* gamification concept (“Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”); specifically, this instantiate the rules for the *Intermediate Levels* [Piras et al., a, 2017b]

et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011].

The column *Progressive Change Behavior* (Table 6.1) shows how the path is expected to influence user behavior. It starts from the novice level by making the user able to find problems (*problem finding* requirement). The trigger specifies two conditions: “*New challenge thrown AND Challenge importance  $\geq$  Trivial*”:

- the first condition (“*New challenge thrown*”) (Table 6.1) refers to the fact that the user has to find a problem (e.g., a potential threat in a solution, an incomplete part to be analyzed further, etc.) and throws a challenge to another user for dealing with it<sup>3</sup>. Challenges are delivered via the co-pilot (the avatar gamification concept) hiding the real challenge thrower. It is hidden because we want to minimize the influence of individuals, e.g. to avoid that a user classifies a challenge as important just because her Team Leader threw it to her;

<sup>3</sup>Note that the progression through this path (by throwing challenges) is tightly related to the progression in another path, i.e., the problem solver path (Section 6.3.3) in which another user progresses by solving the received challenges

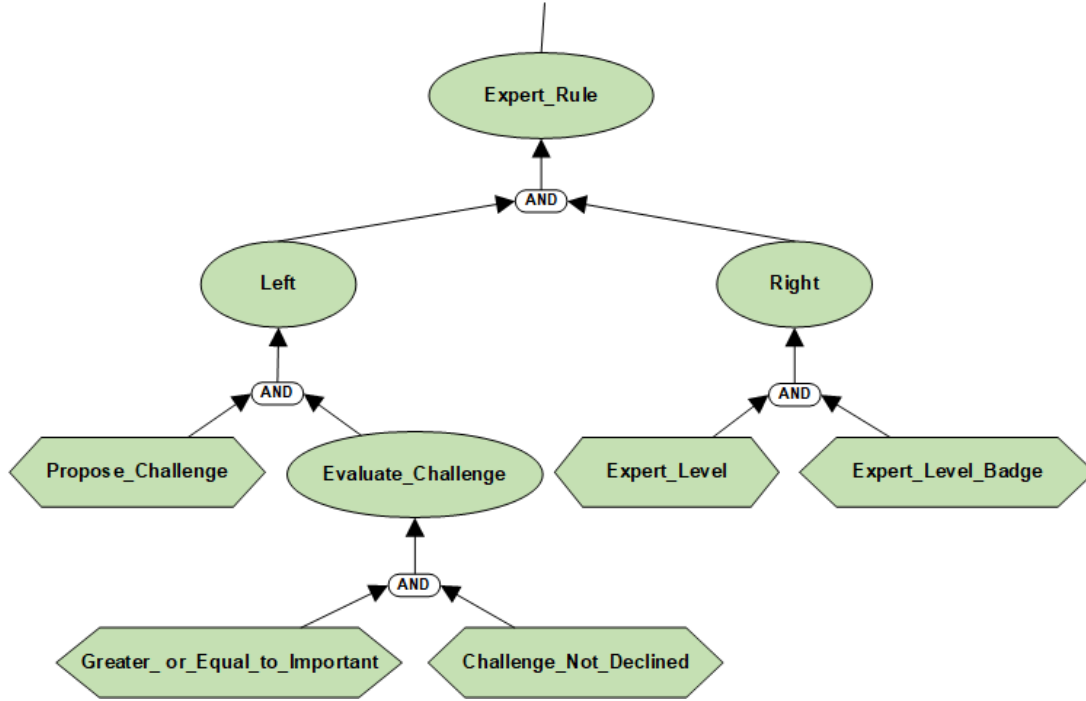


Figure 6.18: The high-level part of the instantiation of rules specifying conditions for progressing in the **Challenge Proposer Path** through the *Challenges* gamification concept (“Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”); specifically, this instantiate the rules for the *Expert Levels* [Piras et al., a, 2017b]

- the second condition (“*Challenge importance*  $\geq$  *Trivial*”) (Table 6.1) concerns the actual evaluation of a challenge according to the scale: **Useless**; **Trivial**; **Normal**; **Important**; **Critical**; **Very Critical**.

As mentioned above, challenges are delivered via the *Co-Pilot* (the *Avatar* gamification concept outlined in Section 6.3.6). We already introduced the *Avatar* concept in the Subsection named “Gamification Solution” in Section 6.2.1. Specifically, Agon suggested it to us in “Phase 6: Context-Based Operationalization via Gamification” (Section 6.2.1), among its supported concepts, because the *Avatar* concept operationalizes 2 tactics we have chosen in the “Phase 5: Acceptance Requirements Refinement” (Section 6.2.1), i.e. **Increase User Surprise** and **High Design Quality** (Figure 6.6). Actually, there could be other solutions that can operationalizes such tactics, for example speech guides, cartoon characters, visualization of alternatives, hidden surprises, autonomous surprise agents, etc., however Agon at the moment does not support them. Thus, here we are not claiming that the *Avatar* is the only element that can operationalize such tactics. In the future, we will try to make the framework to evolve in order to offer to the analyst

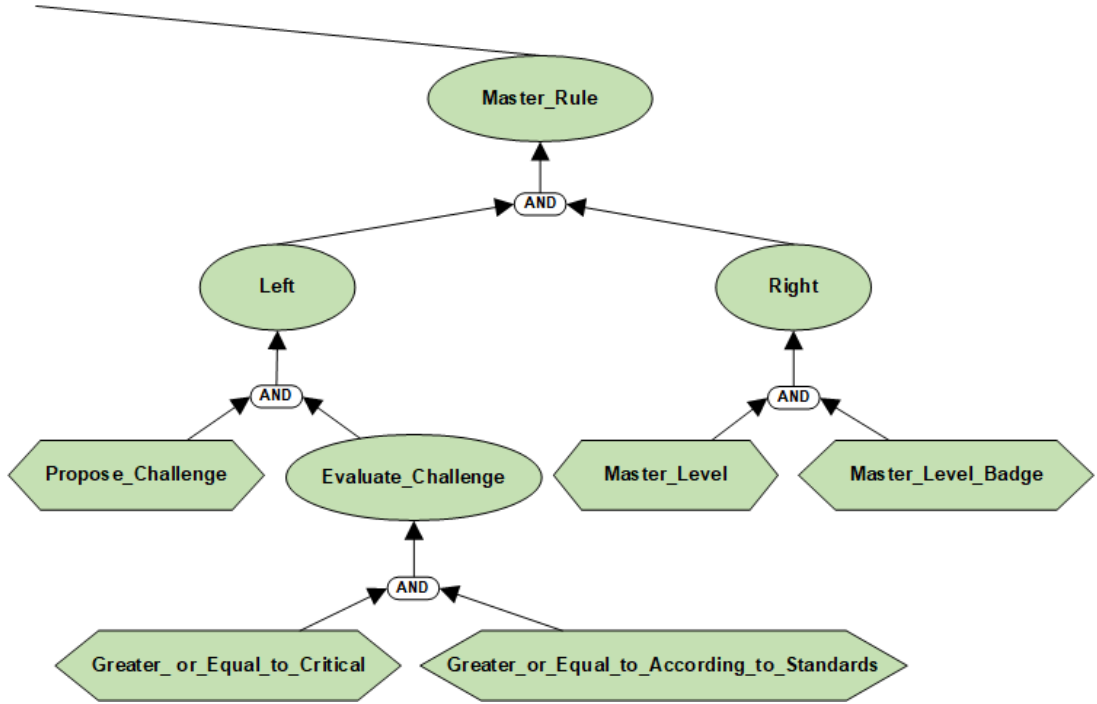


Figure 6.19: The high-level part of the instantiation of rules specifying conditions for progressing in the **Challenge Proposer Path** through the *Challenges* gamification concept (“Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”); specifically, this instantiate the rules for the *Master Levels* [Piras et al., a, 2017b]

different alternatives also in relation to this aspect.

By avoiding the possibility to progress just by throwing “useless” challenges (i.e., the first step of the challenge importance scale), the gamification mechanic fulfills the **real problems finder** behavior in the last column of the Table 6.1, and the user starts being engaged in this mechanism of producing challenges. However, this is not enough for satisfying the PACAS platform objectives discussed in the intro of Section 6.3.1, and therefore while progressing in the main levels of the path there are triggers with conditions made progressively more difficult that make the user to progress by changing behavior. This behavior change is expressed in the last column (Table 6.1) evidencing the achievement of the other objectives. Those changes, in these two columns (Table 6.1), are highlighted in bold (the use of bold is to show what are the conditions that change, from a level to the next one, for enabling the user to progress). In fact, at the **Intermediate Level**, it is possible to progress if the importance of the challenge is at least **Normal**. Accordingly, the progressing user will become an **Increasingly Relevant Problem Finder** (Table 6.1), namely a proposer that increases the importance of the challenge proposed, by identifying

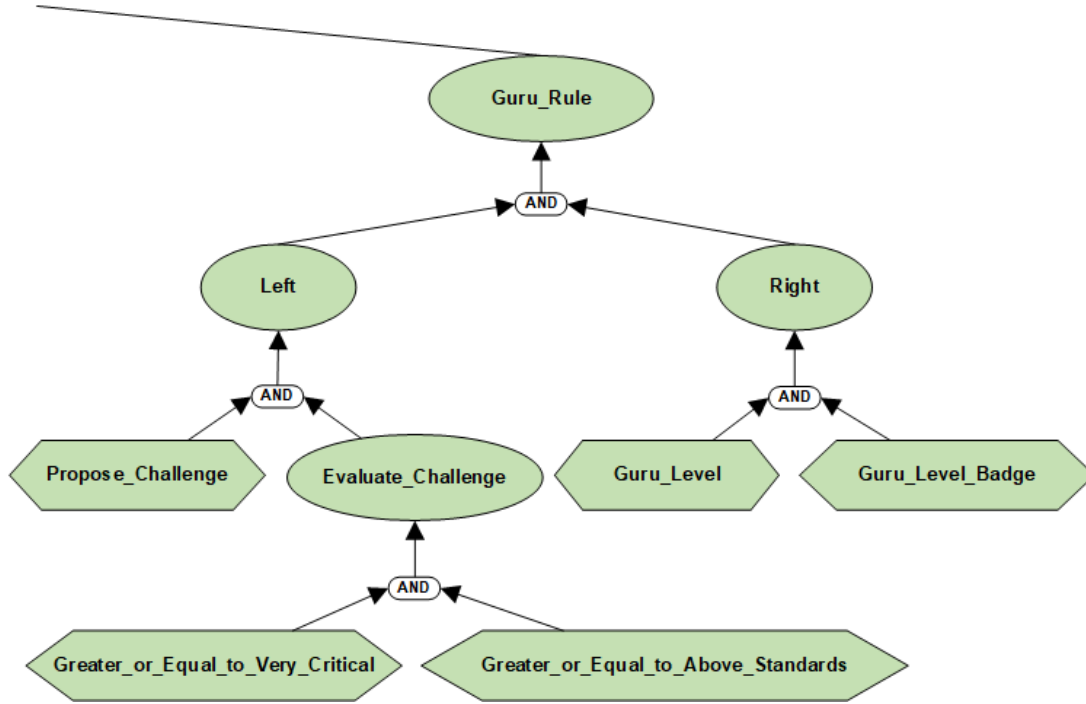


Figure 6.20: The high-level part of the instantiation of rules specifying conditions for progressing in the **Challenge Proposer Path** through the *Challenges* gamification concept (“Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms”); specifically, this instantiate the rules for the *Guru Levels* [Piras et al., a, 2017b]

more important problems to be solved by other users, and being even more helpful for the decision-making process.

At the **Expert Level** (Table 6.1 and Figure 6.18), the user becomes an **Important problems finder** due to the fact that it is needed to propose at least important challenges. Moreover, it is necessary to start making the user to select most suitable users to solve the challenges proposed (not random selected users just to progress in the path), for fulfilling the *Identification of most suitable problem solvers* objective. In fact, a challenge has not to be declined by the problem solver, making her a **Finder of Most Suitable Problem Solvers**.

At the **Master Level** (Table 6.1 and Figure 6.19), the user becomes a **Critical Problems Finder** due to the fact that it is needed to propose at least critical challenges. Furthermore, it is enforced also the *Individuation of most suitable problem solvers* objective that now is stricter due to the fact that it now needs that the problem solver individuated, not only does not decline the challenge, but also solves the challenge proposed at least according to standards. This makes her a **Finder of Most Suitable Successful**

**Standard Problem Solvers.** The challenger evaluates the solution that the problem solver player has provided using the following scale: **Unsuccessful**; **below standards**; **according to standards**; **above Standards**; **well above standards**.

At the **Guru Level** (Table 6.1 and Figure 6.20), two important aspects are enforced: **(i)** The user should be able to find very critical problems and throw them as challenges; **(ii)** The user should identify problem solvers that propose solution at least above standards. In this way, the user will become a **Very Critical Problems Finder** and **Finder of Most Suitable Successful Above Standards Problem Solvers**.

Additionally, when a user reaches a certain level, she cannot lose it. She can only progress in the path. Progression is possible by fulfilling constraints (represented in Table 6.1 and Figure 6.16, Figure 6.17, Figure 6.18, Figure 6.19, Figure 6.20) required for the current level. This is valid for all the kinds of paths of this gamification solution.

Furthermore, when the user enters in the system for the first time, **(i)** the player is introduced by the *Co-Pilot* (the *Gamified Avatar* concept outlined in Section 6.3.6) regarding all the game mechanisms and rules associated to the path (it is a good practice to provide the user with *Clear Rules* for creating in her *Game Awareness* [Schell, 2014, Zichermann and Cunningham, 2011]), and **(ii)** the player starts from the *Novice Level* in each path, receiving a *Novice Badge* for each of them (this creates also the *Surprise Emotion* in the user, and this is another good practice [Schell, 2014, Zichermann and Cunningham, 2011]). Therefore, it is not the game designer that defines at the design time the experience and skills of a user, by locating her at a specific level for each path. Rather, it is the user that, starting from the *Novice Level* and by playing and demonstrating to have good skills, can success soon and progress easily and rapidly. This is allowed also by a mechanism of hidden points, behind the challenges, technically called *Experience Points* [Zichermann and Cunningham, 2011], for tracking successes of the user, and to make her to skip levels reaching high levels early (respecting at least the minimum requirements specified in Table 6.1). For instance, according to the Table 6.1, if a novice challenger identifies and proposes to a problem solver a challenging problem, recognized as **Important** by the solver, and the solver do not decline it and successes, the challenger can reach levels higher than expected, for example the **Expert** level in Table 6.1 (further details and examples are available at [Giorgini et al., 2017]).

The organization and gamification design of the other two paths is similar to that of this Section. Thus, in the following, we illustrate the other 2 paths without repeating common elements (e.g., the structure of levels and sub-levels, in fact, what changes is mainly related to the progress conditions, user roles involved and related actions).

### 6.3.3 The Problem Solver Path

The aim of this path is to fulfill progressively the following staircase of needs: *acceptance to tackle a problem (not declined), continuous acceptance, problems are solved, problem are solved continuously, problems are solved in a successful way, and complex problems are continuously solved in a successful way*. All these needs are related to accepting and carrying out continuously and successfully progressively complex challenges received [Piras et al., 2016, 2017a,b].

In Table 6.2, we show the structure of this path, related levels and badges, and the progression triggers that allow the user to advance through the main levels and sub-levels. Furthermore, the table shows the progressive behavior change, as explained in the previous Section.

The badge **Novice Level 1** (Table 6.2) has been designed and implemented (fulfilling the same needs and tactics, e.g., the **Increase User Surprise** tactic we selected, see Figure 6.6) the same way as that in the previous path. Therefore, the user earns it when she starts using the PACAS platform.

In the following, we describe the design of the path at each level by explaining the *triggers* and the *progressive behavior change*.

At the **Novice Level** (Table 6.2), the objective is to make the user start to accept challenges, and to receive an evaluation of the solution from the challenger that is at least **Basic Solution** (avoiding **No Success**, meaning that the problem solver failed to achieve the challenge).

The **Intermediate Level** (in the Table 6.2, boldface text shows the stricter conditions compared to the previous level) aims at improving the solution quality reaching at least **Normal Solution** and, above all, requests the user to accept the challenges continuously by requiring that she has not declined the last 3 challenges.

The objective of the **Expert Level** (Table 6.2) is to reach an evaluation of at least **Good Solution** and to require a stricter condition of continuously accepting challenges by adding the constraint that the importance of the last accepted challenge is at least **Good**. From this level on, the problem solver cannot progress by solving challenges evaluated by herself below good. This could appear as a problem, because the problem solver is the one that evaluates the importance of the challenge proposed. However, the problem solver herself is not aware of this condition, and therefore we expect her to continue evaluating in a fair way the challenges received (this is the only assumption we make in the gamification design).

At the **Master Level** (Table 6.2), both the requirements of the previous levels are

Main Level	Sublevels	Progression Trigger	Progressive Behaviour Change
Novice	1, 2, 3, ...	New challenge thrown AND Challenge importance $\geq$ Trivial	1. Problem finder; 2. Real problems finder
Intermediate	1, 2, 3, ...	New challenge thrown AND <b>Challenge importance <math>\geq</math> Normal</b>	1. Problem finder; 2. <b>Increasingly relevant problems finder</b>
Expert	1, 2, 3, ...	New challenge thrown AND Challenge importance $\geq$ <b>Important</b> AND <b>Challenge not declined</b>	1. Problem finder; 2. <b>Important</b> problems finder; 3. <b>Finder of most suitable problem solvers</b>
Master	1, 2, 3, ...	New challenge thrown AND Challenge importance $\geq$ <b>Critical</b> AND Challenge Success $\geq$ <b>According to standards</b>	1. Problem finder; 2. <b>Critical</b> problems finder; 3. Finder of most suitable <b>successful standard</b> problem solvers
Guru	1, 2, 3, ..., $\infty$	New challenge thrown AND Challenge importance $\geq$ <b>Very critical</b> AND Challenge Success $\geq$ <b>Above standards</b>	1. Problem finder; 2. <b>Very critical</b> problems finder; 3. Finder of most suitable <b>successful above standards</b> problem solvers

Table 6.2: Gamification design of the Problem Solver Path within the PACAS platform [Piras et al., 2017b]

enforced respectively requiring a solution that is at least **Brilliant**, and a quality of the last solved challenge at least **Brilliant**.

At the **Guru Level** (Table 6.2), the latter requirement is reinforced by requiring that the last 3 challenges solved have at least **Brilliant Quality**. In this way, a proficient **Guru** will be the one that keeps accepting **Brilliant** challenges and solves them with **Brilliant** solutions.

### 6.3.4 The PACAS Platform Expertise Path

The aim of this path is to make the user aware of all the functionalities provided by the PACAS platform [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011], how to use them in a proficient way, and, above all, to make her to use continuously and in a collaborative participatory way the platform, being pro-active in all the phases of the decision-making. This fulfills progressively the needs: *perceived awareness*, *awareness*, *concrete skills*, *continuous collaborative*, *participatory behavior* and *advanced skills* [Piras et al., 2016, 2017a,b].

The progression throughout this path is illustrated in Table 6.3.

Main Level	Sublevels	Progression Trigger	Progressive Behaviour Change
Novice	1, 2, 3, ...	A video of a tour watched OR questionnaire completed	Basic Skilled User (perceived awareness of the platform)
Intermediate	1, 2, 3, ...	A tutorial activity completed	Intermediate interactive Skilled User (uses the platform through exercises, not only perceived awareness of the platform)
Expert	1, 2, 3, ...	A phase of a change issue is completed	Expert interactive Skilled User (uses the platform concretely: concrete platform experience)
Master	1, 2, 3, ...	A change issue is completed	Master interactive Skilled User (uses the platform concretely and participate continuously: concrete continuous platform experience)
Guru	1, 2, 3, ..., $\infty$	Completed 2 consecutive change issues	Guru interactive Skilled User (uses the platform concretely and participate continuously: stable concrete continuous platform experience)

Table 6.3: Gamification design of the PACAS Platform Expertise Path within the PACAS platform [Piras et al., 2017b]

At the **Novice Level** (Table 6.3) the objective is to make the user to perceive to be aware of being able to use the platform (**Perceived Awareness** of at least **Basic Skills**). This can be obtained by watching a video as part of a gamified tour or by compiling a questionnaire related to a video [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011].

The **Intermediate Level** (Table 6.3) makes the user aware of her ability to use the platform thanks to the received training (**Awareness of at least Basic Skills**) through gamified tutorials. Therefore, the user progresses each time she has completed an activity of a gamified tutorial [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011].

In summary, at the **Novice Level** (Table 6.3), it is very easy to progress: the user watches a video and progresses; then, the user compiles a questionnaire and progresses. Afterwards, at the **Intermediate Level** (Table 6.3), progression conditions are stricter, in fact, in order to progress, it is necessary to complete both.

The objective of the **Expert Level** (Table 6.3) is to make the user able to use the platform concerning real usage of the platform (**Concrete Skills**) on the basis of real tasks. This can be achieved by participating in the completion of the activities of a change issue. Therefore, all the users that conclude those activities, if they are at the **Expert Level**, make progress in this path.

The objective of the **Master Level** (Table 6.3) is to make the user able to use the platform continuously and in a collaborative and participatory way (fulfilling objectives such as **Concrete Skills, with Continuous, Collaborative and Participatory Behavior, Advanced Skills**). This can be achieved by participating in the completion of a change issue.

The objective of the **Guru Level** (Table 6.3) is to make the user able to use the platform continuously and in a collaborative and participatory way (fulfilling objectives such as **Concrete skills, with Continuous, Collaborative and Participatory Behavior, Advanced Skills**). This can be achieved by participating in the completion of multiple consecutive change issues continuously [Piras et al., 2016, 2017a,b].

### 6.3.5 Gamified Tutorials

As mentioned in the Section 6.3.4, the PACAS platform includes gamified tutorials [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011] that fulfill the requirement **Improve System Awareness** [Piras et al., 2016, 2017a,b] (see Figure 6.6) of the Agon Framework. In fact, during the analysis phases, the need to make the user more confident concerning the usage of the PACAS platform regarding the entire change management process emerged [Piras et al., 2016, 2017a,b]. Tutorials have been designed and implemented as short videos related to a specific task to carry out by using the platform, and a questionnaire is proposed after watching it for making sure that the user has been correctly trained. Furthermore, achievements related to tutorial and questionnaire completion allow

the user to progress in the PACAS Platform Expertise Path.

### 6.3.6 The Co-Pilot Avatar

In order to make the gamified user experience more attractive and engaging, we introduced a the co-pilot, which instantiates the game element of an *Avatar* [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011]. For the last release of the platform, we defined precise *Event-Condition-Action* rules that explain in which cases the co-pilot has to motivate the user with messages, rewards, etc.:

- *Events* concern either gamification concepts (e.g., the user reaches a new level or the achievement a new badge) or states in the platform (e.g., the user adds a comment to a decision point);
- *Conditions* are further restrictions that need to hold for the event to trigger the rule (e.g., it is the first time that the user accesses a page);
- *Actions* are messages provided by the co-pilot to the user for motivating her to continue using the platform, to participate more in the process, and to notify her concerning new achievements [Piras et al., 2016, 2017a,b, Schell, 2014, Zichermann and Cunningham, 2011].

It is important that the user is motivated through messages to make her aware of the achievement of some gamification results or rewards [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011]. For example, one such rule notifies the user when she achieves a new badge, and another one notifies her when a new level is reached. Other rules guide the user to make her aware concerning how to use a specific platform page [Piras et al., 2017b, Schell, 2014, Zichermann and Cunningham, 2011]. For example, one such rule provides the user with further clarifications on how to approach and use specific elements of a page.

### 6.3.7 The Gamification Experience in the PACAS Platform

In Section 6.2.1 we describe in detail how we used Agon, and its method, for analyzing and designing a gamification solution for the PACAS platform. Furthermore, in the Subsection named “Gamification Solution” (Section 6.2.1) we illustrate the gamification solution of the PACAS platform, and in the previous Subsections (of this Section 6.3), we provide more details regarding the most important gamification concepts and mechanisms we designed and implemented. In the following, we conclude with a summary of the

gamification solution, by recapping most important concepts, and describing the related gamification experience through screenshots of the gamified PACAS platform. Further details are available in [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

In PACAS, we experimented a wide range of gamification elements and game mechanics [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Our goal has been to engage the participants in the change process so to foster dialogue across different areas of expertise. Therefore, the PACAS Collaborative Platform had to encourage stakeholder engagement during the change management process [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. A gamified experience has been therefore designed to increase participation in this process, so that the required data are captured in the PACAS web platform. Specifically, we constructed sustained engagement through an experience of serving deeper human “needs” [Piras et al., 2016, 2017a,b], such as those of exploration and social interaction. Accordingly, we integrated in the PACAS Collaborative Platform effective game elements and mechanisms into the change management processes [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

Some gamification elements serve better to attract attention, some are better for stimulating engagement and interaction [Piras et al., 2016, 2017a,b], while others will mainly serve to extend each user session, after it has ended; i.e., how to get the user “back” to the product again [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

The overall experience that the PACAS platform delivers draws an analogy between a participant in the ATM decision making process and a passenger in a flight. Just like passengers are guided to their destination by the pilot(s), the participant using the PACAS platform is guided in the tasks concerning decision making by a virtual avatar that resembles a pilot [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] (Figure 6.21 and Figure 6.22).

Overseen by the pilot’s interaction with the user, multiple other game elements and mechanics are featured aiming at reinforcing the user’s motivation, at creating and strengthening team dynamics, and at ensuring that the user is made aware of the possibilities that the web platform offers [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

Furthermore, we designed the gamified experience on the basis of the kinds of intended users to be involved and motivated [Piras et al., 2017b], i.e. ATM decision makers and experts [Dalpiaz et al., 2017, Giorgini et al., 2017]. Indeed, different typologies of users are positively affected by different gamification strategies [Piras et al., 2017b]. For instance, a social strategy that encourages people interaction can affect positively socializers (players that use software systems for creating new social relationships), but

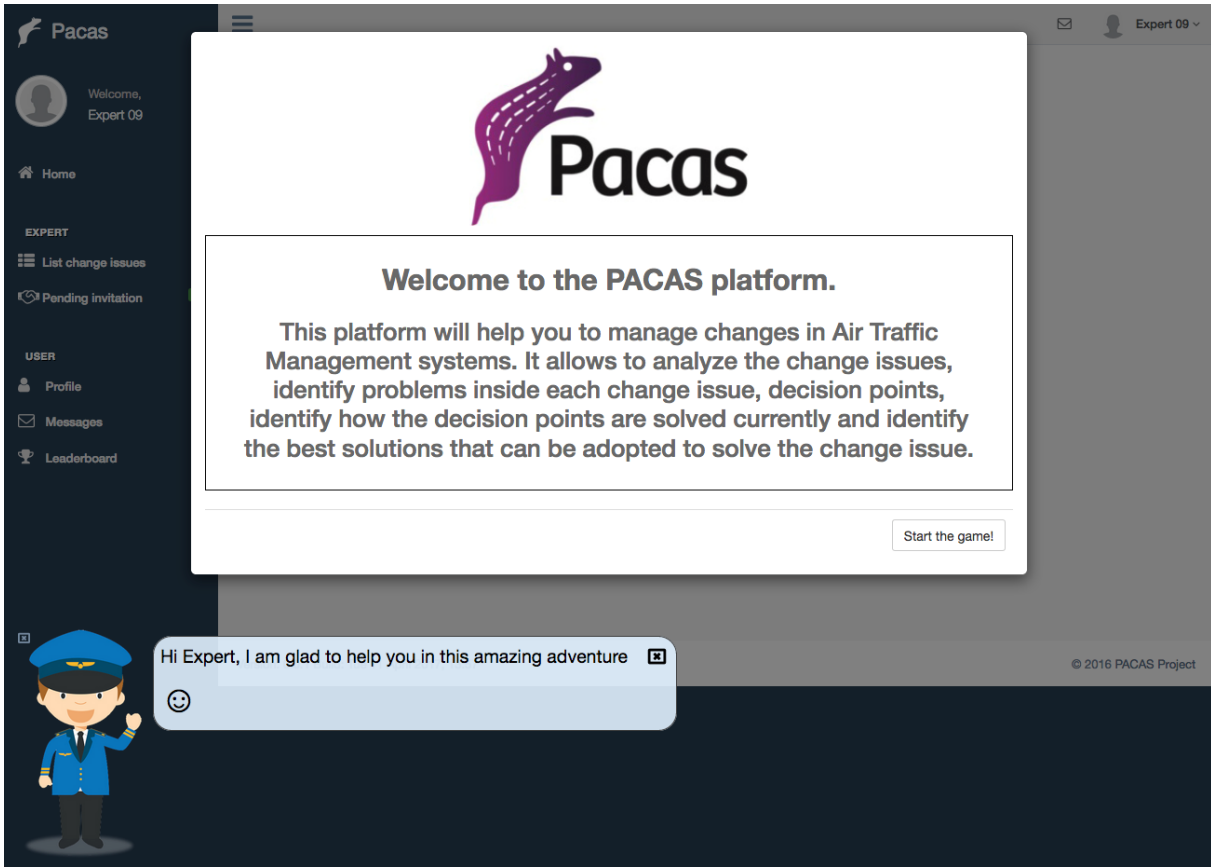


Figure 6.21: The screen that is shown after the first time login in the gamified PACAS platform, and the PACAS *Co-Pilot* (the *Avatar* gamification concept) [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

can have either a negative or no effect on achievers (players that want to achieve as many as possible successes or collect as many rewards as possible). Such characterization of users is necessary to conduct a systematic analysis that is used [Piras et al., 2016, 2017a,b]: (i) to select psychological factors and strategies that can positively affect the target users, and (ii) to choose which incentive mechanisms can make those strategies concrete and effective. Accordingly, in order to analyze and design a gamification solution able to engage intended users, we interviewed Advisory Board (AB) members, of the PACAS project, to categorize the type of users that will use the PACAS web platform and, based on this data, we employed two frameworks to design the PACAS gamified experience: Agon [Piras et al., 2016, 2017a,b] (an Acceptance Requirements Framework based on Gamification) and MAF [Cuel et al., 2011, Piras et al., 2017a, Simperl et al., 2013, Tokarchuk et al., 2012] (the Motivational Antecedents Framework). Both frameworks helped us in selecting

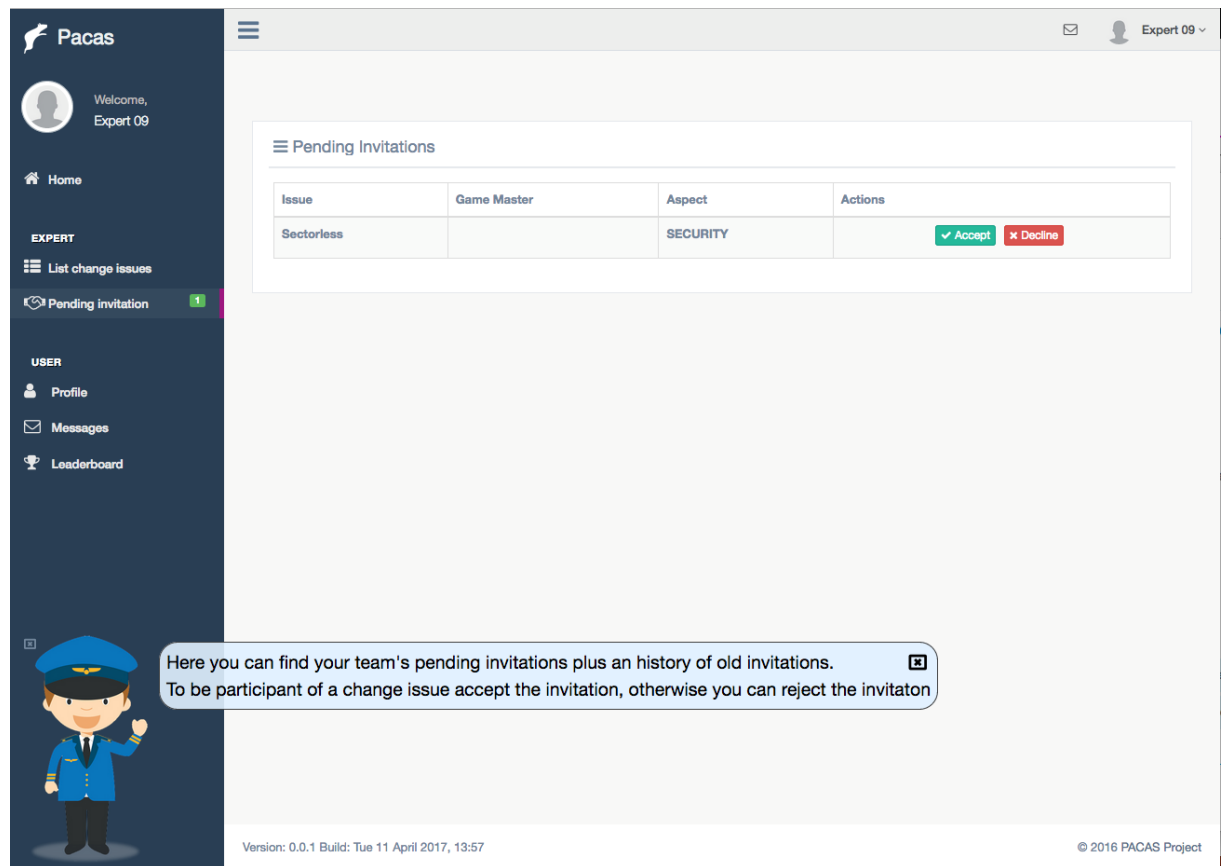


Figure 6.22: The *Co-Pilot* (the **Avatar** gamification concept) of the gamified PACAS platform guiding the user in managing invitations [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

and designing a gamification solution with the most suitable concepts and strategies for the PACAS users [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. In the following, we describe the PACAS gamification experience concepts and mechanisms, by showing also screenshots of the PACAS platform.

The pilot-resembling avatar (called co-pilot from now on) serves the function of coordinating the gamification experience for the participants in the PACAS web platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. The co-pilot, which is situated in a corner of the window (Figure 6.21 and Figure 6.22) and can be enabled/disabled by the user, interacts first by providing hints about the capabilities of the platform (in the early stages, as in Figure 6.21, when the user is in the learning phase) and later by delivering more in-depth insights on the actions (Figure 6.22) that the user can/should do to make progress on the current change issues. Figure 6.22 shows the avatar assisting the user in

the learning phase by explaining how the page concerning team invitations works.

Furthermore, the avatar's behavior, besides fostering learning activities (by exposing the user to the main functionalities of the web platform), supports also other important aspects, for instance [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]: **(i)** supplying hints to the modelers when significant changes are made by modelers from other teams or perspectives (Figure 6.23), **(ii)** stimulating the user as a player in carrying out gamified platform activities, and, accordingly, showing her game results and guiding her concerning how to progress in the game by fulfilling, at the same time, PACAS objectives (Figure 6.24), **(iii)** showing achieved results and rewarding the user for them (Figure 6.25).

We selected a virtual character, an avatar, as a personal assistant of the user, in order to give to the users a *Perception of Ease of Use* [Piras et al., 2017b] of the PACAS platform (according to the **Improve Perceived Ease of Use** need selected by using Agon [Piras et al., 2017b], see Figure 6.2 and related explanations in “*Phase 4: Context-Based Analysis of Acceptance Requirements*”, Section 6.2.1). Furthermore, in order to deliver such perception of usability of the platform, we combined the co-pilot with other gamification concepts and strategies we describe in the following [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Thus, the co-pilot is the character that guides and motivates the user in her gamified experience by proposing activities to improve her knowledge concerning the usage of the system (e.g., gamified tours as in Figure 6.27, gamified tutorials as in Figure 6.26 and Figure 6.25) or challenges to fulfill PACAS platform purposes [Piras et al., 2017b] (challenges are illustrated later in this Section). The interaction of the users with the co-pilot is pleasant and engages the user in carrying out PACAS platform activities by rewarding her with, for example, points and badges [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] (Figure 6.25).

In order to motivate the users in learning how to use the PACAS platform, it is necessary to encourage them to explore the platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Therefore, we employed gamified tours [Schell, 2014, Zichermann and Cunningham, 2011] (Figure 6.27) and gamified tutorials [Schell, 2014, Zichermann and Cunningham, 2011] (Figure 6.26 and Figure 6.25). Tours show how to use main system features and highlights related usage advantages. In order to maximize the possibility that the user will use them, we made them more attractive by applying gamification [Piras et al., 2016, Zichermann and Cunningham, 2011]. In fact, during the usage of those elements, the user is rewarded at the beginning, in the end and, especially, at certain times in an unpredictable way for increasing the “User Surprise” [Zichermann and Cunningham, 2011] and related involvement. Accordingly, we designed the co-pilot for increasing the “User

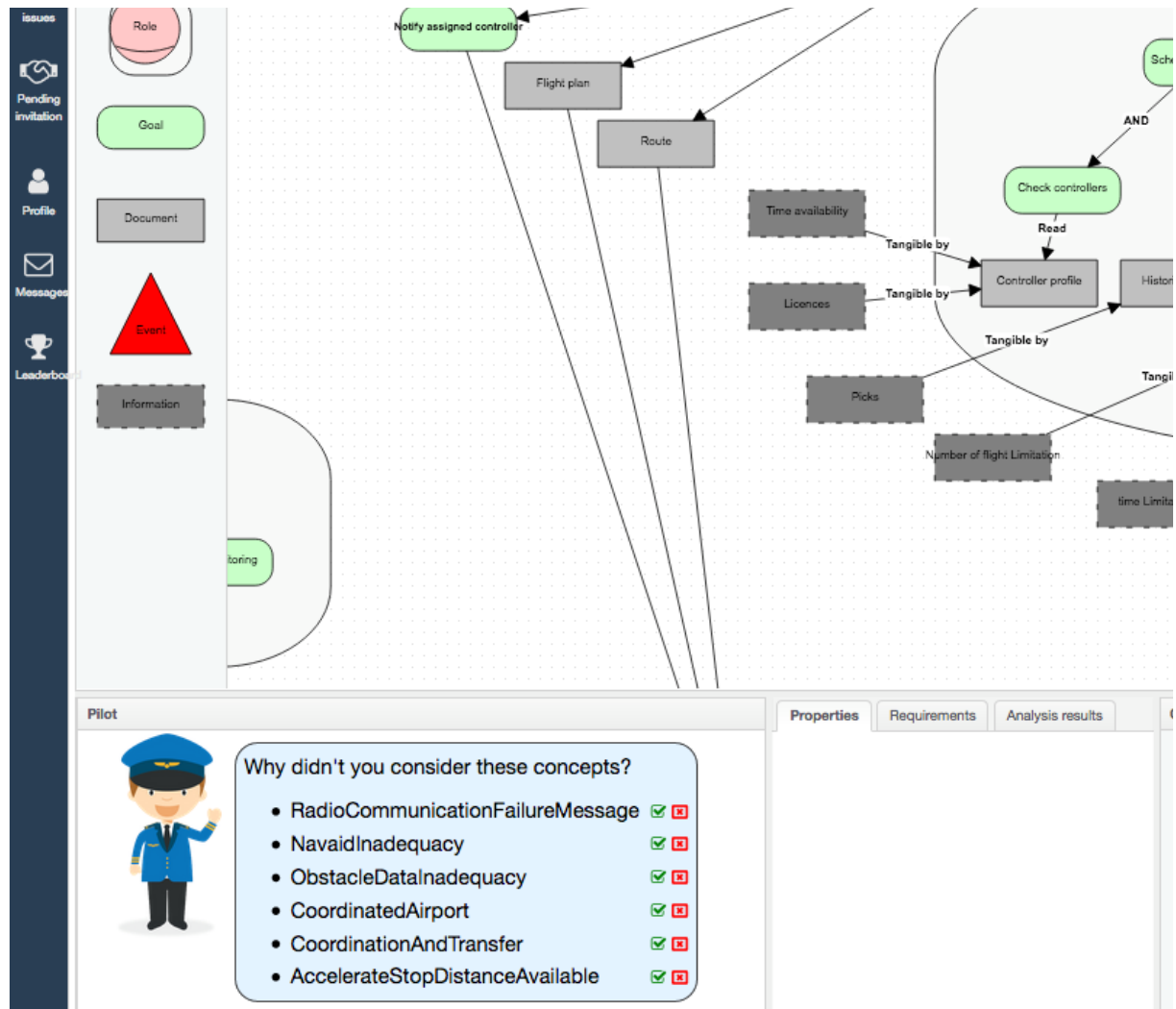


Figure 6.23: The *Co-Pilot* (the **Avatar** gamification concept) of the gamified PACAS platform and the STS-ML Editor (one of the modeling editors of PACAS) [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

Surprise” [Piras et al., 2017b] (this is in line with the **Increase User Surprise** tactic selected by using Agon [Piras et al., 2017b], see Figure 6.6 and related explanations in “Phase 5: Acceptance Requirements Refinement”, Section 6.2.1) and keeping the attention of the user at high levels [Piras et al., 2017b]. In fact, suggestions are provided when the user does not expect them, making on the one hand the system more attractive and less boring, and on the other hand offering a guided and supported user experience [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

We selected gamified tutorials also because we identified the requirement of improving

### 6.3. GAMIFICATION OF THE PACAS PLATFORM

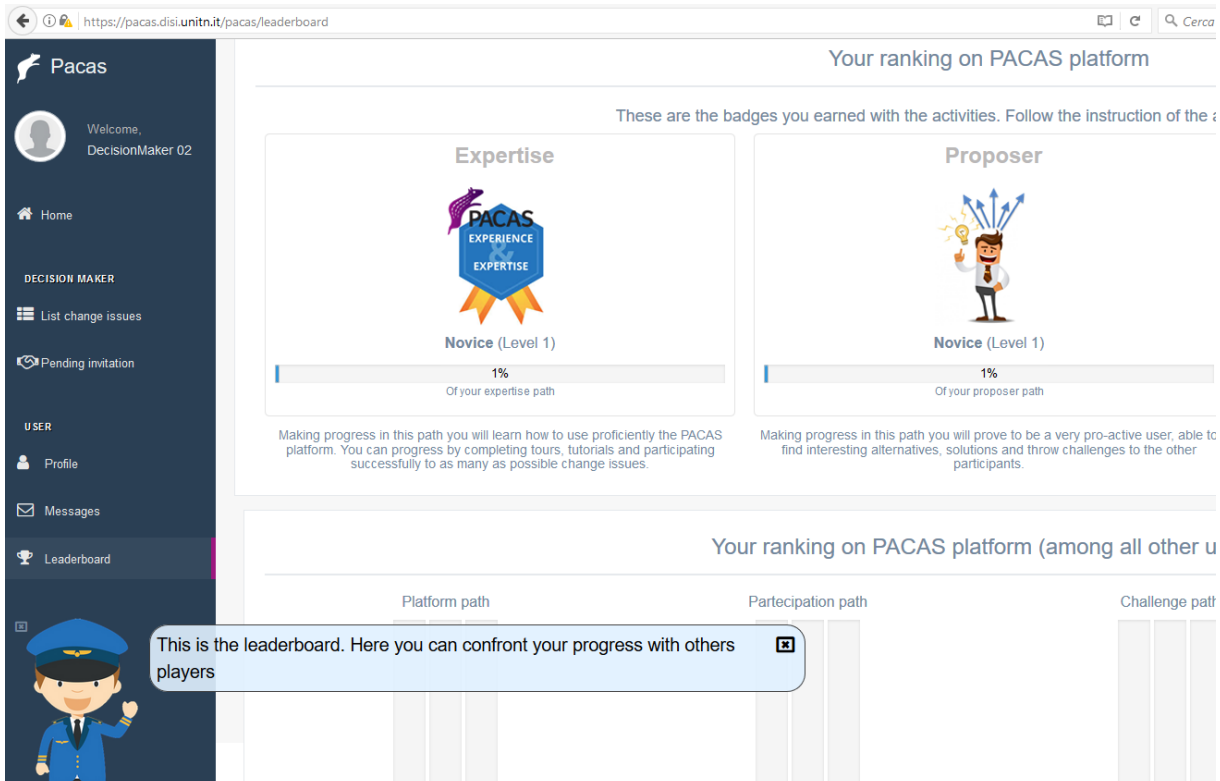


Figure 6.24: The *Co-Pilot* (the **Avatar** gamification concept) of the gamified PACAS platform showing to the user her game results, and guiding her concerning how to progress in the game [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

the system awareness of the users [Piras et al., 2017b] (according to the Agon suggestion related to the **Improve System Awareness** tactic [Piras et al., 2017b], see Figure 6.4 and related explanations in “*Phase 5: Acceptance Requirements Refinement*”, Section 6.2.1). Gamified tutorials improve users’ usage experience and knowledge of the platform, increasing the possibility of interaction with other users and the possibility of designing high-quality effective solutions by using the PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

Moreover, the PACAS platform allows stakeholders to interact in order to achieve a shared goal. While experts traditionally analyze problems from their own point of view, PACAS allow them to easily explore how other experts analyze the same problem and therefore it encourages them to consider other point of views [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. The exploration is an important factor to consider: exploring the world is a core human need, that is very similar to the mechanisms that many computer games use by allowing players to explore their fictional world. By

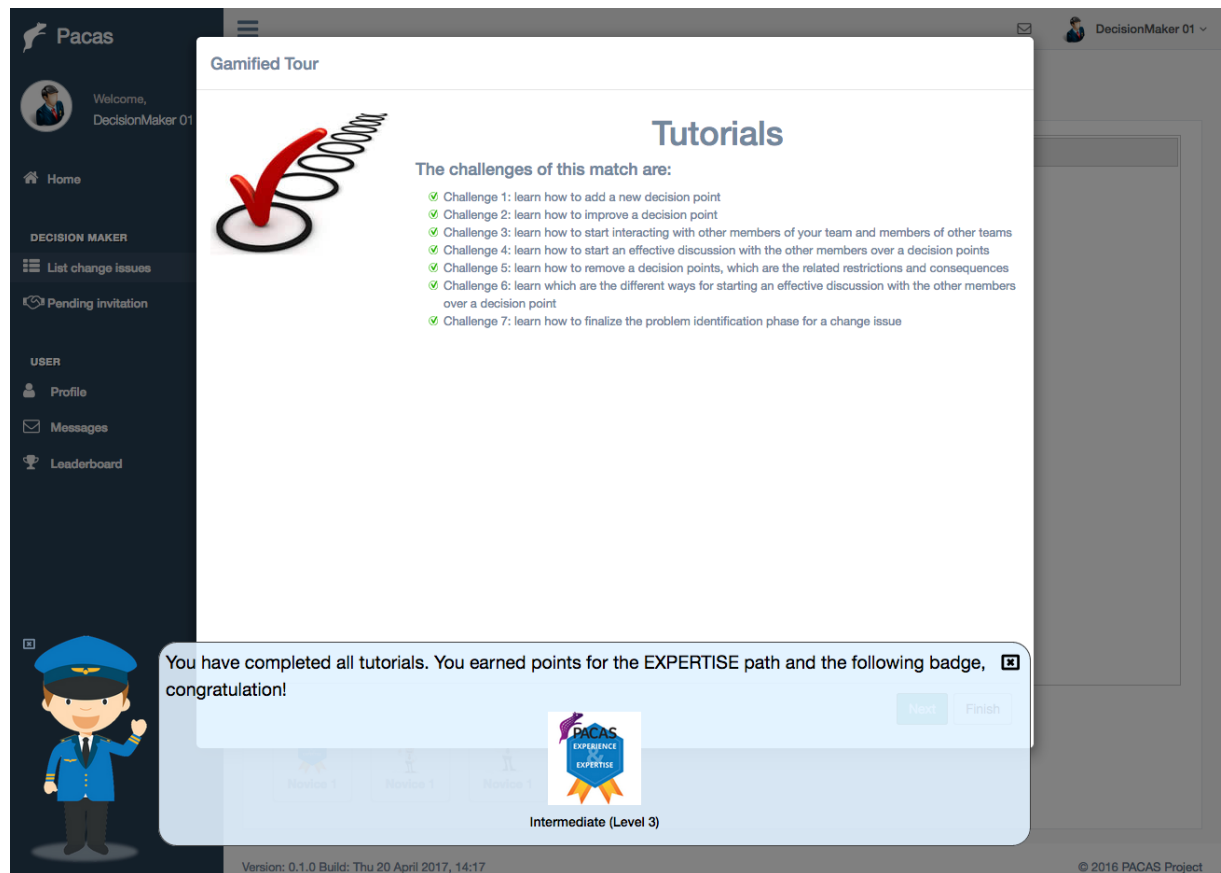


Figure 6.25: The *Co-Pilot* (the **Avatar** gamification concept) of the gamified PACAS platform showing achieved results, and rewarding the user [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

	Name	Description	Status	Actions
	Tutorial 1	Learn how to add a new decision point	Completed	<a href="#">Start the tutorial</a>
	Tutorial 2	Learn how to improve a decision point	Video Watched	<a href="#">Watch the video</a> <a href="#">Fill the questionnaire</a>
	Tutorial 3	Learn how to finalize the problem identification phase	Not Completed	<a href="#">Watch the video</a> <a href="#">Questionnaire</a>

Figure 6.26: **Gamified Tutorials** of the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

facilitating this exploration in a carefully crafted tool, experts become more open minded towards adjusting their own contributions to meet others' inputs as well [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. However, an expert will often require sound arguments to be convinced that they should do this. This is the reason why PACAS allows

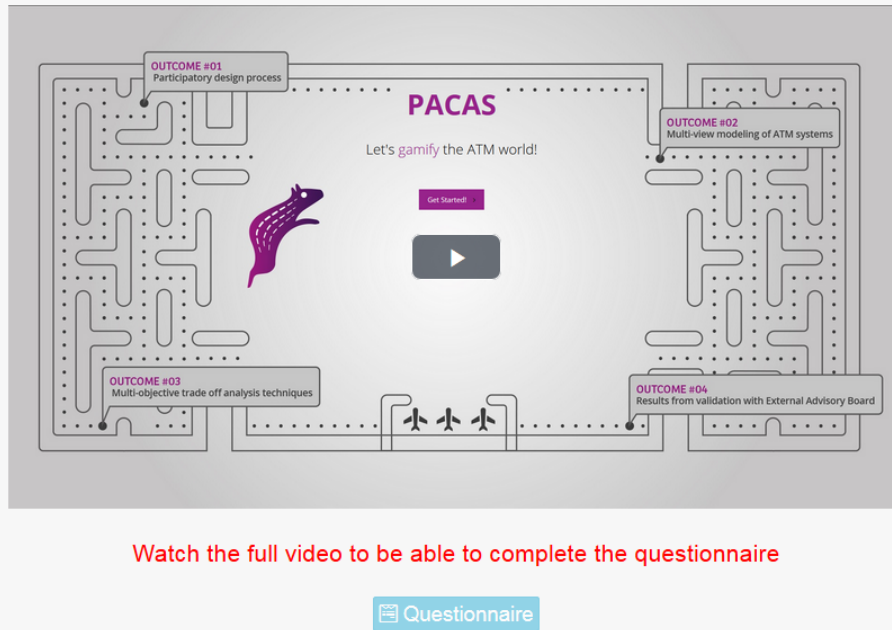


Figure 6.27: A Gamified Tour in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

anyone involved in the change issue to see the results of an experts analysis, and to allow the users to “drill down” on information they find interesting. In addition, the PACAS platform allows users to give spontaneous feedback. Altogether, this give participants a feeling of both autonomy and contributing to a higher meaning [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

In the PACAS platform we encourage the exploration by turning it in a gamified experience through the design of specific progression paths, levels and badges [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] (Figure 6.28). We designed different progression paths and levels which measure how much users explored the PACAS platform, and improved/used their skills concerning the different activities of PACAS [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] (Figure 6.28):

- the **Challenger Path** measures how much a user challenges the others in a positive and productive way, and also how much she is able to identify the most suitable users to involve in challenges;
- the **Problem Solver Path** measures how much a user is active and effective in fulfilling challenges received by other participants; for instance, how good she is in finding alternatives, solutions, etc.;

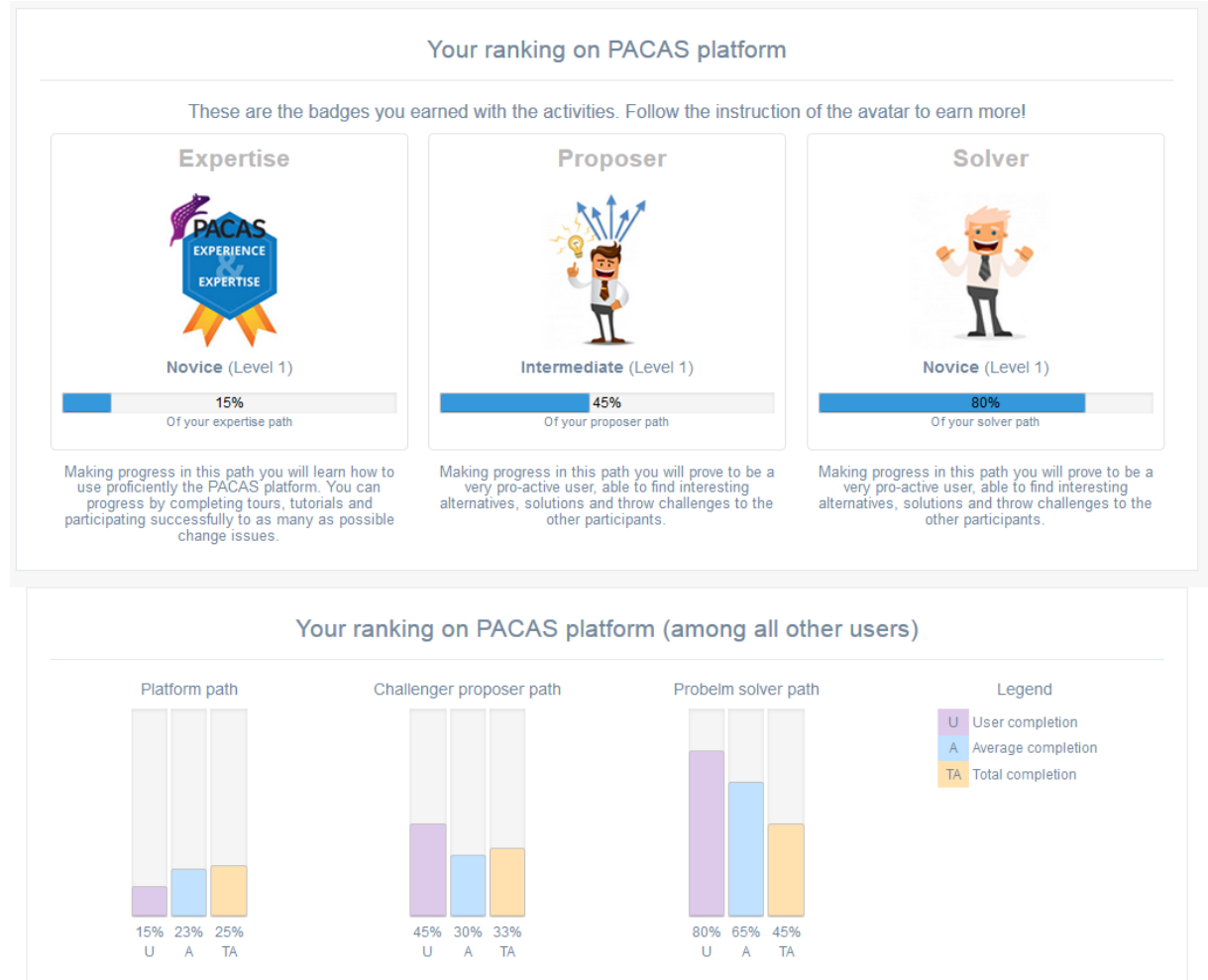


Figure 6.28: Gamified Paths, Levels, Badges and Leader-boards of the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

- the PACAS Platform Expertise Path measures how much a user knows how to use the PACAS platform; a user can progress by completing tours, tutorials and participating successfully to as many as possible change issues.

Each progression path is organized in different levels and sub-levels [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b] (e.g., regarding the Expertise path: “Expertise - Novice” and its sub-levels, “Expertise - Intermediate” and its sub-levels, “Expertise Expert” and its sub-levels, etc.). During each progression path, badges are given to confirm that the user achieved a particular skill (Figure 6.25), or contributed in a particular positive way concerning the PACAS activities [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. We selected badges because they are effective for improving the “Social Status”

of users, especially, in our specific case the aim was to create trust among collaborators (thanks to the badges that can certify acquired competences in the PACAS context) and, therefore, more collaboration [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Accordingly, in “*Phase 6: Context-Based Operationalization via Gamification*”, Agon suggested to use **Publishable Badges** [Piras et al., 2017b] (i.e. badges that are not private, but public and visible to the other users, e.g., publishable in a community) that can operationalize the **Improve Perceived Status** and **Support Social Behavior** tactics [Piras et al., 2017b], supporting also collaboration and trust among collaborators.

Moreover, in the PACAS gamified experience we included also challenges [Piras et al., 2017b]. The idea is to stimulate the user with missions, which are rewarded (with badges, progression into the levels of paths, etc.) if successfully completed. For instance, we employed this mechanism for pushing challengers (according to the *Challenger Path*) towards the identification of problem solvers (according to the *Problem Solver Path*) that are most suitable for carrying out specific activities, and involving them more by throwing a gamified challenge maximizing the possibility that those tasks will be successfully accomplished [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Specifically, we designed this mechanism with the possibility for a challenger, to indicate another player (problem solver) that best fits the needs of a task to be completed, and to propose her the task through a gamified challenge. In this way, we can stimulate more interest in concluding successfully activities by involving the most suitable users [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Challenges can be used also to receive support from other users. This mechanism increases also the trust on the PACAS platform and makes users aware that are adequately supported also in solving very difficult ATM problems. Moreover, we push them to be proactive and to collaborate/participate more in/to the process [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

Specifically, challenges in the PACAS platform are integrated in most of the activities of the change management process [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Usually, it is possible to throw a challenge either for an item of the process from listing pages, or from modeling editor pages. For example, as shown in Figure 6.29, in the top right corner of the screenshot there is a button named **Launch Challenge**. If a user clicks on it, it is shown the form in Figure 6.30. There, it is possible to indicate the user that will receive the challenge, to name the challenge, and to explain the challenge with a detailed description of tasks expected to be carried out and goals to be fulfilled. For instance, a challenger can ask a problem solver to design a model, by using one of the PACAS modeling editors (e.g., the one in Figure 6.23), for proposing a solution to a critical problem. When the user clicks on the **Submit** button, the challenge is created and

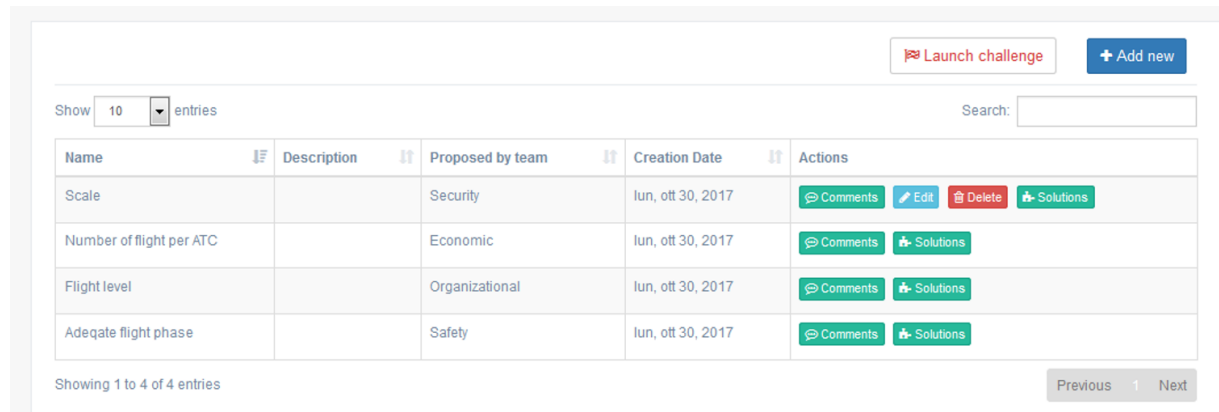


Figure 6.29: Button for throwing **Gamified Challenges**, in the top right corner of the screen, in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

The screenshot shows the form for throwing a Gamified Challenge in the gamified PACAS platform. The form has the following fields:

- Member \***: A dropdown menu with the text '-- none --'.
- Name \***: A text input field with the placeholder text 'Challenge name'.
- Description**: A text area with the placeholder text 'Type the challenge objectives description'.

At the bottom of the form, there are two buttons: 'Cancel' and 'Submit'.

Figure 6.30: Form for throwing a **Gamified Challenge** in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

a notification sent to the problem solver [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b].

Then, both the challenger and the problem solver can see the challenge created in their challenges page, shown in Figure 6.31. There, **Active Challenges** in the top part, and **Closed Challenges** in the bottom part, are shown. In turn, both the active and closed groups are organized in **Thrown Challenges** and **Received Challenges**. It is possible to work with active challenges, while closed challenges are reported there just to have a challenges history. With active challenges it is possible, by clicking on the buttons in the same line of the specific challenge (Figure 6.31), to revoke, accept/reject, or complete the

ACTIVE CHALLENGES						
Thrown						
To	Name	Description	Created	Status	Actions	
Expert 01	Create a solution for Scale decision point		30/10/2017	THROWN	<a href="#">Details</a>	<a href="#">✖ Revoke</a>
Builder 01	Focus analysis on the Scale solution		30/10/2017	ACCEPTED	<a href="#">Details</a>	
Received						
From	Name	Description	Created	Status	Actions	
Builder 01	Create another decision point		21/11/2017	THROWN	<a href="#">Details</a>	<a href="#">✔ Accept</a> <a href="#">✖ Reject</a>

CLOSED CHALLENGES						
Thrown						
To	Name	Description	Created	Status	Challenge vote	Solution vote
Builder 01	asdsadas	dasdsadd	31/10/2017	ENDED	Critical	Good
Received						
From	Name	Description	Created	Status	Challenge vote	Solution vote
Builder 01	Create decision ponint		21/11/2017	ENDED	Important	Normal

Figure 6.31: Page of the **Gamified Challenges** in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

challenge [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. For example, the challenger can revoke a challenge she has thrown, and the problem solver can accept/reject a challenge received. While, concerning the completion button (Figure 6.31), on one side, the problem solver can use it for notifying the challenger to have finished the work and, thus, the challenger can check it; while, on the other side, the challenger can click on it for evaluating the work of the problem solver, and to close the challenge [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. Regarding the evaluation that the challenger has to express in relation to the quality of the result, and the problem solver on the importance of the challenge received, in both the cases a dialog like the one in Figure 6.32 is shown [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]. After these evaluations activities (Figure 6.32), both the challenger and the problem solver will be notified by the co-pilot regarding the new achievements and progressions in their respective gamified paths: the *Challenger Path* and the *Problem Solver Path*. Related results, updated progressions and leader-boards will be visible in the page of the screenshot

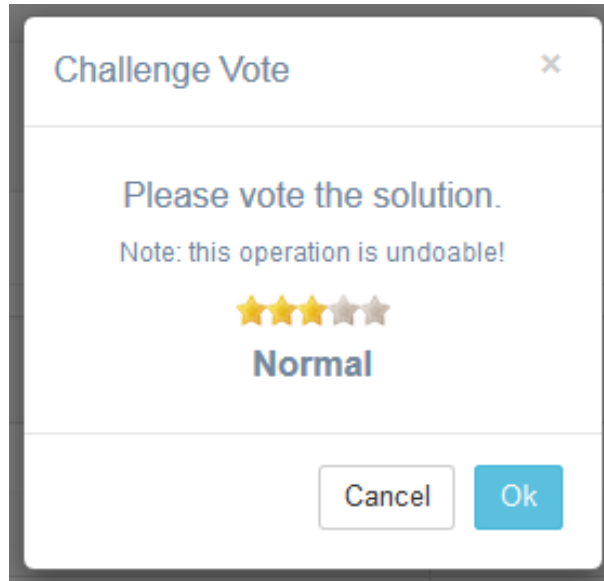


Figure 6.32: Dialog for voting a **Gamified Challenges** in the gamified PACAS platform [Dalpiaz et al., 2017, Giorgini et al., 2017, Piras et al., 2017b]

reported in Figure 6.28.

## 6.4 Chapter Summary

This Chapter introduces the *Participatory Architectural Change Management in ATM Systems* (PACAS) European project, its context and the PACAS platform (Section 6.1). Moreover, the Chapter describes the case study where we gamified the PACAS platform by using Agon, and the gamification solution we designed and implemented (Section 6.2). Specifically, we analyzed the complex context of PACAS and delivered an engaging platform for motivating decision makers to collaborate in a participatory way by using such platform. We explain how we employed Agon for the analysis and design of this engaging platform, in this real case study carried out in the context of the PACAS European project. This is the main case study of this thesis. We conclude this Chapter by describing in detail the gamification mechanisms implemented in the PACAS platform (Section 6.3), and by providing further details concerning the analysis, design and implementation of the gamification solution in the PACAS platform (Section 6.3). Results and details concerning the evaluation of this real case study are discussed in Chapter 7.



# Chapter 7

## Evaluation

This Chapter presents the activities we carried out for the evaluation of the Agon framework, and discusses the results obtained. Specifically, we performed experiments and case studies in real and realistic settings for gamifying software systems and evaluating the usefulness of Agon for the requirements analyst, obtaining positive results. Such settings concerned the gamification of software systems in the context of European projects and master courses (Chapter 5, 6, 7, 8), involving experts and students.

In Section 7.1, we outline our approach and the phases performed within our evaluation plan. Then, in Section 7.2, 7.3, 7.4 and 7.5, we describe in detail such phases and related experiments and case studies of the evaluation plan. Finally, in Section 7.6, we discuss results, findings, lessons learned and threats to validity, in relation to all the evaluation phases, experiments and case studies performed.

### 7.1 Evaluation Approach

We carried out different qualitative and quantitative evaluations of the Agon framework and its method, by organizing them in different phases with different objectives (as outlined in the next Subsection), trying to fulfill our high-level research objective and answering to our Research Questions (RQs). Our high-level research objective can be recapped as follows.

**Research Objective:** *to support the requirements analyst in a Systematic Requirements Analysis for designing Engaging Software Systems.*

According to our research objective, we designed our evaluation considering also the 2 following hypotheses:

- H1.** Agon and its method can support *non-experts* (Table 7.1);
- H2.** Agon and its method can support *experts* (Table 7.1).

Table 7.1: Experts and non-experts involved in the evaluations

	Requirements Engineering expertise	Gamification expertise
<b>Non-experts</b>	Good	Good <sup>1</sup>
<b>Experts</b>	High	High

The “support” mentioned in our hypotheses refers to what we deeply explain in the previous Chapters, and in the introduction Chapter when we describe our RQs and related challenges. Specifically, our aim is to investigate concerning the possibility that, from the perspective of the requirements analyst, our framework Agon can support her, through its method, in a systematic acceptance requirements analysis based on gamification for designing engaging software systems. The dependent variables we want to test are related to the fact that Agon is recognized, by the analyst, as *guiding, systematic, semi-automatic*, but also sufficiently *interactive* (**RQ3, RQ4**) by offering the possibility to take decisions during all the phases of the analysis (**RQ3**), helping the analyst, by offering ready-to-use structures of elements, at different level of abstractions, designed on the basis of the literature and best practices (**RQ2, RQ1, RQ4**), and, on the other hand, offering a wide set of alternatives, even more that an analyst can consider herself (**RQ2, RQ1**). Most of the elements above, are strictly dependent on the Agon meta-model, thus, other dependent variables to evaluate are related to the possibility that Agon offers *interdisciplinarity, interoperability, context-dependency, extensibility* and *generality*, through its *Agon Multi-Layer Meta-Model* (**RQ2, RQ1**). Therefore, we are also interested in evaluating the possibility that Agon suggests solutions in line with the context (**RQ2, RQ3**), and that can be applied to as many as possible heterogeneous realistic and real domains (**RQ4**).

In the next Subsection, we provide an overview of how we organized our evaluation plan and which have been the objectives of each phase. Then, in the following Sections, we describe such phases in detail. Finally, in Section 7.6, we discuss results, findings, lessons learned and threats to validity.

### 7.1.1 Evaluation Phases Overview

Our evaluation plan followed the organization and research methods [Wohlin et al., 2012] illustrated in Table 1.1 and discussed in Section 1.3. In the next, we describe phase by

<sup>1</sup>After our training, before the training gamification expertise was classified as “Basic”

phase our plan, and in the following Sections, we describe such phases in detail.

In *Phase 1: Evaluation with Non-Experts in Realistic Cases*, we performed 2 evaluations: the first one (a case study) has been preliminary and we carried out exploratory qualitative research [Wohlin et al., 2012] (Table 1.1), while in the second one (a Human-Oriented Experiment [Wohlin et al., 2012]) explanatory qualitative and quantitative research [Wohlin et al., 2012] (Table 1.1). Specifically, in both the evaluations, we worked with *non-experts* (Table 7.1), master students, individually and in a master class, with the aim of investigating the usefulness of Agon employed for the gamification of software systems related to realistic cases. We evaluated and compared the two different experiences of gamifying the same software system, performed respectively (i) without the employment of a requirements engineering framework for supporting the analyst, and (ii) with a supporting framework, i.e. Agon.

Moreover, in this phase we confirmed that our proposed solution, Agon, addresses positively our RQs in relation to non-experts. However, concerning the *generality* (**RQ2**) of Agon, i.e. the possibility to employ Agon in heterogeneous domains obtaining useful support, in this phase, we had just preliminary evidences, due to having tested Agon in a reduced number of settings:

1. gamification of a *Meeting Scheduler System* for motivating users to participate to the organization of meetings;
2. gamification of a *Food Service System* related to a *Smart Canteen*.

Thus, in order to confirm also the *generality* (**RQ2**) of Agon, we had to apply Agon to a higher number of heterogeneous domains. This has been the objective of the next phase.

In *Phase 2: Evaluation with Non-Experts in Heterogeneous Cases*, we performed exploratory qualitative research [Wohlin et al., 2012] (Table 1.1), and evaluated the *generality* (**RQ2**) of Agon, i.e. the possibility to employ Agon in heterogeneous cases receiving a fruitful support. For achieving this, we conducted other case studies, in realistic and real cases, where we employed Agon, concerning the gamification of the software systems shown in Table 7.2.

Specifically, in Table 7.2 it is shown the full list of case studies and experiments of this thesis (see also Table 1.1). In detail, the first two in 7.2 (respectively one case study

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<sup>2</sup><http://www.streetlife-project.eu/>

<sup>3</sup><http://www.streetlife-project.eu/>

<sup>4</sup><http://www.visioneuproject.eu/>

<sup>5</sup><https://www.supersede.eu/>

<sup>6</sup><http://www.pacasproject.eu/>

<sup>7</sup><http://www.pacasproject.eu/>

Table 7.2: Case studies and experiments of this thesis

Study	Phase	Eval	Participants	System Gamified by using Agon	Scenario	Project
1	1	1	Non-Experts	Meeting Scheduler System	Realistic	X
2	1	2	Non-Experts	Food Service System (The Smart Canteen)	Realistic	X
3	2	3	Non-Experts	Sustainable Urban Mobility (SUM) System	Real	STREETLIFE <sup>2</sup> EU project
4	2	3	Non-Experts	Mobility Assistance for Children (MA4C) System	Realistic	STREETLIFE <sup>3</sup> EU project
5	2	3	Non-Experts	Project Management System	Realistic	X
6	2	3	Non-Experts	Privacy Platform	Real	VisiOn <sup>4</sup> EU project
7	2	3	Non-Experts	Collaborative Requirements Prioritization System	Real	SUPERSEDE <sup>5</sup> EU project
8	3	4	Experts	Platform for Participatory Architectural Change Management in ATM Systems	Real	PACAS <sup>6</sup> EU project
9	4	5	Users	Platform for Participatory Architectural Change Management in ATM Systems	Real	PACAS <sup>7</sup> EU project

and one experiment, as reported in Table 1.1) are the evaluations of the previous phase, the case study 8 is the subject of the next phase, and the case study 9 is the subject of the last phase. While, the ones from 3 to 7 are the subjects of this phase, and respectively regards the gamification of:

- a system for incentivizing citizens to choose *Sustainable Urban Mobility* (SUM) solutions (the scenario is taken from our experiment in Chapter 3 and comes from the STREETLIFE European project<sup>8</sup>);
- a system for favoring *Mobility Assistance for Children* (MA4C) (the scenario is taken from Chapter 3 and comes from the STREETLIFE European project<sup>9</sup>);
- a system for motivating users in participating collaboratively and actively to *Project Management* activities;
- a *Privacy Platform* in the context of the *VisiOn* European project<sup>10</sup>;
- a system for motivating stakeholders in participating collaboratively and actively to *Collaborative Requirements Prioritization* activities in the context of the *SUPERSEDE* European project<sup>11</sup>;

<sup>8</sup><http://www.streetlife-project.eu/>

<sup>9</sup><http://www.streetlife-project.eu/>

<sup>10</sup><http://www.visionproject.eu/>

<sup>11</sup><https://www.supersede.eu/>

These case studies have been conducted by master students concerning their master theses, under our supervision, by using the Agon framework for gamifying the related software systems. Some of them are realistic cases and other ones are real cases. In fact, some of them have been conducted in the context of European projects. Thus, in this phase, we established also the *generality* (**RQ2**) of Agon. Moreover, we were able to further confirm, also in those case studies, to have addressed the other RQs, and this time with *non-experts* also concerning *real cases* (in the previous phase the cases were realistic).

Then, in *Phase 3: Evaluation with Experts in a Real Case*, we performed exploratory qualitative research [Wohlin et al., 2012] (Table 1.1), and we focused on addressing our RQs also with *experts* (Table 7.1). Thus, we carried out a complete real case study in the context of the *Participatory Architectural Change Management in ATM Systems* (PACAS) European project<sup>12</sup> (case study 8 in Table 7.2). It is the main case study of this thesis, we describe it in Chapter 6. In such case study, Agon has been employed for the analysis and design of an engaging platform for supporting decision-making activities in the complex context of PACAS, which is related to change management in ATM systems. Specifically, the case study delivered an engaging platform, the PACAS platform, for motivating decision makers to collaborate in a participatory way by using such software system. Experts (Table 7.1) have been involved in the process of gamifying the PACAS platform, and solutions obtained in the different phases have been shared, discussed and, finally, implemented. The gamification solution implemented is the subject of the next phase.

In *Phase 4: Evaluation with Users in a Real Case*, we performed exploratory qualitative research [Wohlin et al., 2012] (Table 1.1), and we evaluated if *real users* were engaged by the gamification solution produced through the employment of Agon. This phase has been conducted in the context of the PACAS European project. In fact, we made use concretely the gamified PACAS platform, we implemented, to intended users (case study 9 in Table 7.2). Such users were Advisory Board (AB) members and ATM experts external to the PACAS project, which really use similar software in their job.

Furthermore, in the first 3 phases (Table 7.2), we collected also comments on advantages and disadvantages related to each phase of the Agon method, and new ideas and suggestions for improving Agon (discussed in Section 7.6). In the last phase (Table 7.2), we collected comments, from real users, on the usage experience of the gamification solution obtained by employing Agon. We collected from them feedback on the engagement produced by such gamified platform, and also useful comments regarding how to improve it (discussed

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<sup>12</sup><http://www.pacasproject.eu/>

in Section 7.6).

In the next Sections, we describe such phases (Table 7.2) in detail. Then, in Section 7.6, we discuss results, findings, lessons learned and threats to validity of all the evaluations.

## 7.2 Phase 1: Evaluation with Non-Experts in Realistic Cases

We started evaluating **H1** and answering to our RQs, working with *non-experts* (Table 7.1), computer science master students of the University of Trento (Italy), with the aim of investigating the usefulness of Agon employed for the gamification of software systems related to examples and realistic cases. We evaluated and compared the two different experiences of gamifying the same software system, performed respectively **(i)** without the employment of a framework for supporting the requirements analyst, and **(ii)** with a supporting framework, i.e. Agon.

We performed 2 evaluations (Table 1.1). The first one (Subsection 7.2.1) has been an exploratory, preliminary case study with 5 students concerning the gamification of our exemplar, the Doodle-Like Meeting Scheduler Exemplar (DLMSE). In this case, we conducted exploratory qualitative research [Wohlin et al., 2012] (Table 1.1). Then, on the basis of the preliminary positive results obtained, we executed a second evaluation (Subsection 7.2.2), an experiment, in a master student class with a higher number of participants, with the aim of confirming and establishing such positive results. This experiment concerned the gamification of a software system in the context of a University Food Service (the Smart Canteen). The experiment was specifically a human-oriented experiment [Wohlin et al., 2012] and we carried out explanatory qualitative and quantitative research [Wohlin et al., 2012] (Table 1.1).

In both cases, the students had limited expertise concerning gamification and acceptance, no expertise regarding Agon and its method, but good expertise in relation to requirements engineering. Thus, we trained them for guaranteeing they had good knowledge of the topics (Table 7.1). Furthermore, after the evaluations, we collected elements concerning the usage experience of Agon, compared to the experience of not using Agon. Specifically, in the first evaluation we interviewed the participants with semi-structured interviews, while in the second evaluation, we asked participants to compile a semi-structured questionnaire. Moreover, we collected advantages/disadvantages related to each phase of the Agon method, and also new ideas and suggestions for improving Agon.

Furthermore, with these activities, we investigated concerning the possibility that, from the perspective of the requirements analyst, the *Agon Method* proves to be *supporting*, *guiding*, *systematic*, *semi-automatic* but also enough *interactive* by offering the possibility

to take decisions (**RQ3**, **RQ4**). Moreover, we have been able to evaluate also the *interdisciplinarity*, *interoperability*, *context-dependency*, *extensibility* and *generality* of the *Agon Multi-Layer Meta-Model* (**RQ2**), as explained in the following.

Regarding *interdisciplinarity*, we investigated if the participants perceived that, on the basis of how we designed Agon, the Agon meta-model is able to capture correctly acceptance and gamification knowledge for supporting the design of engaging systems.

In relation to *Interoperability*, which is tied to the previous aspect, we wanted to test if, from the requirements analyst perspective, the different acceptance and gamification knowledge have been designed in a interoperable, homogeneous, effective way in the meta-model.

Concerning *context-dependency*, we examined, from the requirements analyst perspective, the adequacy of the Agon context model to represent the user context, and if context annotations in the meta-model help in filtering appropriate solutions, fitting the context at the different levels.

Regarding *extensibility*, we evaluated the feeling of participants concerning the possibility to extend the meta-model (then, we investigated this more deeply in the study of Chapter 8, providing also guidelines for extending Agon, and showing possibilities for integrating Agon with other frameworks/methodologies).

Finally, *generality* concerns the capability of Agon to be employed in heterogeneous cases giving a fruitful support to the requirements analyst. In this phase, we had preliminary evidence, of the *generality* aspect, by employing Agon in two different domains, i.e. the subjects of the two evaluations of this phase: DLMSE and the Smart Canteen. However, establishing this, has been the objective of the *Phase 2: Evaluation with Non-Experts in Heterogeneous Cases*, where a higher number of heterogeneous, realistic and real, cases have been investigated.

In the following, we describe in detail the two evaluations conducted in this phase. Then, in Section 7.6, we discuss results, findings, lessons learned and threats to validity, related to this phase and to the other ones.

### 7.2.1 Gamification for Meeting Scheduling

In order to evaluate **H1** and to address RQs, we set a preliminary evaluation by involving 5 *non-experts* (Table 7.1) composed of computer science master students at the University of Trento (Italy). In the following, we refer to this case study as **Eval1** (case study 1 in Table 7.2). Within this case study we conducted exploratory qualitative research [Wohlin et al., 2012] (Table 1.1). The non-experts involved had good background in requirements

engineering and modeling but not regarding gamification and acceptance. Therefore, we trained them concerning acceptance and gamification and proposed to analyze and design a gamification solution for the Doodle-Like Meeting Scheduler Exemplar [Piras et al., 2016, 2017a] (scenario presented in Chapter 5). We invited them to gamify it in 2 different ways: (i) without using Agon; (ii) by using Agon. Finally, we interviewed them, with semi-structured interviews [Wohlin et al., 2012], aiming at comparing the 2 different experiences for evaluating **H1**, and to check if, with the Agon solution, we answered to RQs. We carried out with them the activities in Table 7.3.

Table 7.3: Evaluation activities of **Eval1** (Table 1.1 and Table 7.2) with non-experts

Activity	Description	Modality
1	2 hours of Gamification introduction	Individual
2	2 hours of introduction on Acceptance	Individual
3	Gamification exercise without using Agon	Individual
4	2 hours of Agon introduction	Individual
5	Gamification exercise by using Agon	Individual
6	Evaluation of Agon and comparison of the 2 experiences with a semi-structured interview	Individual

The entire case study has been conducted individually with each student.

We started (activity 1 in Table 7.3) the training with an introduction of gamification in general, as an individual lecture, giving notions on: (i) game taxonomies, to clarify the differences among gamification, serious games, game-inspired-design, virtual simulation and video-games; (ii) gamification definitions and concepts; (iii) gamification design strategies and best practices; (iv) success cases from the literature and the market. They had 1 week to study gamification on books and papers we suggested.

Afterwards (activity 2 in Table 7.3), we gave a lecture introducing acceptance from technology acceptance and psychology points of views. They had 1 week to study acceptance through papers we suggested.

Then (activity 3 in Table 7.3), we proposed an exercise where they had to gamify an exemplar by using their background (on acceptance and gamification) acquired thanks to the study they did and our training. For this, we introduced the Doodle-Like Meeting Scheduler as the exemplar to gamify. They had 1 week to carry out the exercise at home.

Afterwards (activity 4 in Table 7.3), we discussed their exercise and gave a lecture related to Agon, its meta-models, its method and usage examples.

Moreover (activity 5 in Table 7.3), we proposed to repeat the same exercise, but this

time it was by using Agon. They had 1 week to carry out the exercise at home.

Finally (activity 6 in Table 7.3), we discussed their exercise and, above all, we interviewed them, with semi-structured interviews, aiming at evaluating Agon and to compare the 2 different experiences in executing the same exercise, 1 time without using Agon and 1 time by using Agon.

We discuss results related to this case study, and to the other evaluations, in Section 7.6.

### 7.2.2 Gamification for Food Services (the Smart Canteen)

Then, on the basis of the preliminary positive results obtained in the previous evaluation (**Eval1**), we executed a second similar evaluation, but this time an experiment [Wohlin et al., 2012] (Table 1.1 and Table 7.2), in a master student class with a higher number of participants, 21 *non-experts* (Table 7.1), with the aim of confirming and establishing such positive results. This experiment, we name **Eval2**, concerned the gamification of a software system in the context of a *University Food Service* (the *Smart Canteen*, study 2 in Table 7.2). The experiment was specifically a human-oriented experiment [Wohlin et al., 2012] and we carried out explanatory qualitative and quantitative research [Wohlin et al., 2012] (Table 1.1). In the following 2 Subsections we respectively give (i) the description of the realistic scenario of the *Smart Canteen*, and (ii) the characterization of the users to motivate. We proposed both these elements, to the participants, at the beginning of the experiment. After these descriptive Subsections, we provide another Subsection with further information concerning the experiment.

#### The Smart Canteen

With the recent increase of the University of Trento and its internationalization, the Software Engineering Group had the great idea of creating a system for the management of the university canteen. Initially, the canteen was suffering with big problems of high demand during lunchtime, including big queues and reduced number of seats, food waste and lack of food diversity, including lack of health and delicious types of food.

In face of such demands, the Software Engineering group addressed such problems with the creation of the *Smart Canteen*, a software system to manage the whole lifecycle of the canteen, starting with online lunch bookings, queue management, management of after-lunch like food trashing and/or recycling as well elaboration of statistics of canteen usage. The overall objective of such system was to increase productivity and happiness of students by reducing the waiting time for lunch and providing healthier and more varied food options.

In a survey with students and administrative staff of the university, the Software Engineering Group came up with groups of functionalities for the system that are provided before, during and after the lunch takes place. In a nutshell, before lunch, users must be able to online book their lunch and decide whether the lunch will be consumed or not in the canteen facilities. They should be able also to decide the type of food, together with the size of portions and choose the method of payment. With such demands, the system should provide recommendations for users concerning the three aforementioned functionalities, i.e., regarding the consumption of food, the system should show free seats and where the user's friends are seated (together with their food options); regarding the selection of food, the system should give healthy food suggestions, show prices and calories as well as provide other types of suggestions like best food of the day/month, economic food options, dietary problems, food suggestions based on previous user's lunches; and regarding payment, the system should allow the user to pay in advance as well as recharge the canteen card. During lunch, if the user has booked his/her lunch online, Smart Canteen has to enable the user to skip the queue by doing check-in with your canteen card, take the food booked previously and pay this food. For the food bought at the canteen, the systems needs to show the prices, calories and other info like the healthiest options and give the possibility to the user to pay by your card or cash. Furthermore, the system needs to show the less crowded places of the canteen, so that the user can decide in advance the place to sets and also show where the user's friends are. Finally, after lunch, users need to be able to rate the food together with the canteen assistants and the system needs to generate statistics on the basis of that.

Unfortunately, after the deployment of Smart Canteen at University of Trento canteen, user's adherence to the system was low, i.e., users were not motivated to participate and not willing to use all the system's features. In face of that, the activity of such experiment is to gamify the system in order to achieve more users' participation and involvement. Furthermore, the gamification solution should also incentivize people to choose the healthiest daily diet.

### **Characterization of the Smart Canteen Users (Students)**

Most of the students are female, young, socializer, not employed. Moreover, most of the students are not expert of the functions provided by the new software system of the Smart Canteen (in relation to online functions and software functions inside the canteen such as automatic food machines or smart monitors with information) because the low user's adherence to the system. However, they have tried a previous system not so advanced.

Finally, they are not obliged to adhere to the smart canteen system, they can also use the traditional way.

### The Smart Canteen Experiment

In order to further establish **H1** and to address RQs, we set an evaluation, a human-oriented experiment [Wohlin et al., 2012], by involving 21 *non-experts* (Table 7.1), students of a computer science master class at the University of Trento (Italy). They had good background in requirements engineering and modeling but not regarding gamification and acceptance. Therefore, we trained them concerning acceptance and gamification in two separated lectures. Then, in another lecture we involved them in the *Smart Canteen* experiment (**Eval2**, i.e. study 2 in Table 7.2). We proposed them to analyze and design a gamification solution for the Smart Canteen. We invited them to gamify it in 2 different ways: (i) without using Agon; (ii) by using Agon. Finally, we asked them to fill a semi-structured questionnaire with the aim of comparing the 2 different experiences for evaluating **H1**, and to verify if, with the Agon solution, we answered to RQs. We carried out with them the activities in Table 7.4:

Table 7.4: Experiment activities of **Eval2** (Table 1.1 and Table 7.2) with non-experts

Activity	Description	Modality
1	3 hours of Gamification introduction	Group (master class lecture)
2	3 hours of Acceptance and Agon introduction	Group (master class lecture)
3	3 hours of experiment	Group (master class lecture)
3a	Introduction of the Smart Canteen scenario and of the intended users characterization	Group (master class lecture)
3b	Gamification without using Agon	Individual
3c	Gamification by using Agon	Individual
3d	Evaluation of Agon and comparison of the 2 experiences with a semi-structured questionnaire	Individual

The lectures and the entire experiment have been conducted within the master class. The experiment has been carried out individually by each student in the class (activity 3 in Table 7.4).

We started (activity 1 in Table 7.4) the training with an introduction of gamification in general, as a master class lecture, giving notions on: (i) game taxonomies, to clarify the differences among gamification, serious games, game-inspired-design, virtual simulation and video-games; (ii) gamification definitions and concepts; (iii) gamification design

### 7.3. PHASE 2: EVALUATION WITH NON-EXPERTS IN HETEROGENEOUS CASES

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strategies and best practices; (iv) success cases from the literature and the market. They had 1 week to study gamification on books and papers we suggested.

Afterwards (activity 2 in Table 7.4), we gave a lecture introducing acceptance from technology acceptance and psychology points of views, Agon, its meta-model, the Agon method, usage examples and gave a complete demo/tutorial with practice exercises by using Agon. They had 2 weeks to study acceptance and Agon (through papers we suggested), and to practice with the Agon method.

Afterwards (activity 3 in Table 7.4), we involved them in the *Smart Canteen* experiment (**Eval2**), in a lecture, with the activities outlined in the following. During activity 3a in Table 7.4, we introduced the organization of the experiment and started giving them the information for gamifying the Smart Canteen. We described the Smart Canteen scenario and provided them with also the characterization of the users to be motivated (both described in the previous Subsections). These are the common starting elements for gamifying the Smart Canteen with or without Agon. In fact, after giving this information, we invited them to gamify it in 2 different ways: (i) without using Agon; (ii) by using Agon. In the first part, activity 3b in Table 7.4, they had to gamify the Smart Canteen by using their background (on acceptance and gamification) acquired thanks to the study they did and our training provided during the master course. After this, they had to gamify the Smart Canteen by using Agon (activity 3c in Table 7.4).

Finally (activity 3d in Table 7.4), we asked them to fill in a semi-structured questionnaire with the aim to evaluate Agon and to compare the 2 different experiences in executing the same exercise, 1 time without using Agon and 1 time by using Agon.

We discuss results of this experiment, and of the other evaluations, in Section 7.6.

## 7.3 Phase 2: Evaluation with Non-Experts in Heterogeneous Cases

After having established the usefulness of Agon for non-experts (**H1**), and having confirmed that our proposed solution, Agon, addresses positively our RQs in relation to non-experts, the only thing that, so far, has been evaluated in a preliminary way, was the *generality* contemplated in **RQ2**. Thus, the main aim of this phase was to establish the *generality* (**RQ2**) of Agon, i.e. the possibility to employ Agon in heterogeneous domains obtaining useful support. In fact, in the previous phase, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, we had just preliminary evidences on the *generality* aspect (**RQ2**), due to having tested Agon in a reduced number of settings: (i) gamification of a *Meeting Scheduler System* for motivating users to participate to the organization of meetings (case

study 1 in Table 7.2); **(ii)** gamification of a *Food Service System* related to a *Smart Canteen* (case study 2 in Table 7.2).

Thus, in order to confirm also the *generality* (**RQ2**) of Agon, we carried out the broad study of this phase (**Eval3**) consisting of the application and evaluation of Agon to a higher number of heterogeneous domains (Table 7.2). In fact, for achieving this, we conducted other case studies (Table 7.2), in realistic and real cases, where we employed Agon, respectively concerning the gamification of **(i)** a system for incentivizing citizens to choose *Sustainable Urban Mobility* (SUM) solutions (case study 3 in Table 7.2), **(ii)** a system for favoring *Mobility Assistance for Children* (MA4C) (case study 4 in Table 7.2), **(iii)** a system for motivating users in participating collaboratively and actively to *Project Management* activities (case study 5 in Table 7.2), **(iv)** a *Privacy Platform* in the context of the *VisiOn* European project<sup>13</sup> (case study 6 in Table 7.2), **(v)** a system for motivating stakeholders in participating collaboratively and actively to *Collaborative Requirements Prioritization* activities in the context of the *SUPERSEDE* European project<sup>14</sup> (case study 7 in Table 7.2). Specifically, such studies are sub-studies [Wohlin et al., 2012] of the broad study of this phase (**Eval3**). The sub-studies are the ones from 3 to 7 (Table 7.2). Within all the case studies, we performed exploratory qualitative research [Wohlin et al., 2012] (Table 1.1). These case studies have been conducted by master students concerning their master theses, under our supervision, by using the Agon framework for gamifying the related software systems. Some of them are realistic cases and other ones are real cases. In fact, some of them have been conducted in the context of European projects (Table 7.2). Thus, in this phase: **(i)** we established the *generality* (**RQ2**) of Agon and, **(ii)** we were able to further confirm, also in those case studies, to have addressed the other RQs, and this time with *non-experts* also concerning *real cases* (in the previous phase the cases were realistic).

The common high-level pattern of each of the studies of this phase (**Eval3**) has been the one in Table 7.5.

Activity 1 (Table 7.5) concerns introducing to the student the scenario of the case assigned to her. This includes introducing the main functions, objectives of the system to gamify and the context and domain aspects where the system will be used. This has been exposed to the student either by us (individual situation), or by involving also other researchers, project partners, experts, stakeholders or affiliated in general (group situation in Table 7.5).

Activity 2 (Table 7.5) regards providing the student with the characterization of

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<sup>13</sup><http://www.visioneuproject.eu/>

<sup>14</sup><https://www.supersede.eu/>

### 7.3. PHASE 2: EVALUATION WITH NON-EXPERTS IN HETEROGENEOUS CASES

Table 7.5: High-level pattern of evaluation activities for **Eval3** (Table 1.1 and Table 7.2) with non-experts

Activity	Description	Modality
1	Introduction of the scenario of the realistic/real case	Individual/Group
2	Introduction/acquisition of the intended users characterization	Individual/Group
3	Gamification by using Agon	Individual
4	Evaluation report of Agon and semi-structured interview	Individual

the intended users to motivate, i.e. the users of the system to be gamified. This is an important input for Agon and for gamifying a software system in general. In some of these studies (e.g., real cases from European Projects) we have been able to supply the students directly with available users' characterization (introduction situation). In this situation, the characterization has been illustrated to the student either by us (individual situation), or by involving also other researchers, project partners, experts, stakeholders or affiliated in general (group situation). While, in the acquisition situation, needed when the characterization is not available, we asked the student to acquire it directly or indirectly. Preferable directly, namely through questionnaires given to real users, if this was possible, otherwise, indirectly by analyzing the related literature and/or official data.

Afterwards (activity 3 in Table 7.5), the student gamified individually, supported by Agon, the software system of the case assigned.

Finally (activity 4 in Table 7.5), we asked each student to write a complete report for evaluating Agon, its method and her experience in gamifying a system by employing Agon. Specifically, we requested the student to explain in detail if Agon, for that specific domain, resulted useful and supporting regarding the analysis and gamification design of the related system. Furthermore, we asked the student also to provide complete considerations concerning each step of the Agon method by specifying pros/cons, suggestions and ideas for improvements. Moreover, during our supervision, we observed the student, in order to further confirm elements of their evaluation report. In the end of each study, we also interviewed them, in a semi-structured way [Wohlin et al., 2012].

In the next Subsections, we briefly provide specific details for each case study, and in Section 7.6, we discuss results related to this phase, and to the other ones. Full models of these case studies, and the related gamification solutions, are available at [Piras et al., a].

### 7.3.1 Gamification for Sustainable Urban Mobility (SUM)

This case study concerns the gamification of a system for incentivizing citizens to choose *Sustainable Urban Mobility* (SUM) solutions (case study 3 in Table 7.2).

The scenario (activity 1, Table 7.5, of **Eval3**) is taken from our gamification experience described in Chapter 3. It is a real scenario from an experiment [Kazhamiakin et al., 2015] (Chapter 3) we carried out in the context of the STREETLIFE European project<sup>15</sup>. In a nutshell, citizens of the Rovereto city (Italy) should be stimulated in choosing SUM solutions, being guided and motivated by a mobile application called *Viaggia Rovereto*<sup>16</sup> [Kazhamiakin et al., 2015]. Such application is the gamification subject of this study. This app provides the user with different functions such as travel planning with different multi-modal solutions (e.g. bus, train, bike sharing, car sharing, personal bike, personal car, walking, etc.), reporting traffic jam and delays, visualizing timetables etc. The scenario has been introduced directly by us to the student (individual situation) without involving external people.

The characterization of intended users (activity 2, Table 7.5, of **Eval3**), was not exhaustive, therefore we asked the student to acquire the missing characterization data (acquisition situation). He collected relevant context variables from the literature and, above all, from official data on citizens of Rovereto (Italy).

### 7.3.2 Gamification for Mobility Assistance for Children (MA4C)

This case study concerns the gamification of a system for favoring *Mobility Assistance for Children* (MA4C). It is the case study 4 in Table 7.2.

The scenario (activity 1, Table 7.5, of **Eval3**) is taken from our gamification experience [Piras et al., 2015] described in Chapter 3. It is a realistic scenario [Piras et al., 2015]. *Mobility Assistance for Children* (MA4C) (also known in the literature as *CIM* [Piras et al., 2015], standing for *Children's Independent Mobility*) is important for the mental, physical and cognitive development of the child [Beunderman, 2010, Piras et al., 2015]. In fact, it has been proven that, if a child is pushed and supported to make grow progressively her independent mobility, more likely she will be an adult with less probability of manifesting different kinds of problems [Beunderman, 2010, Piras et al., 2015] (e.g., psychological, social problems). We consider the case of a Smart Community [Piras et al., 2015] (Definition 3.3), in a neighborhood, where children have to go to school. Usually,

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<sup>15</sup><http://www.streetlife-project.eu/>

<sup>16</sup>available on Google Play at <https://play.google.com/store/apps/details?id=eu.trentorise.smartcampus.viaggiarovereto&hl=en>

### 7.3. PHASE 2: EVALUATION WITH NON-EXPERTS IN HETEROGENEOUS CASES

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parents tend to chauffeur by car to the school their children [Beunderman, 2010, Piras et al., 2015]. This, on the one hand, affects negatively their independent mobility, and on the other hand increases the traffic level near the school creating traffic jams, increasing carbon emissions and safety problems such as car accidents [Piras et al., 2015]. In our scenario, the smart community has a MA4C system composed of different devices, sensors, software systems for helping citizens to support children in their independent mobility growth. Children can go to school by using services such as walking buses, bike trains, and others [Piras et al., 2015] described in Chapter 3. The point is that, those services in order to work need volunteers (e.g., parents, grandparents, neighbors, teachers, etc.). Therefore, the aim of this study has been to gamify the MA4C system, for involving and motivating people of the smart community, to participate actively and collaboratively to make working those services, by using MA4C functions, and, thus, favoring progressively the independence of children. The scenario has been introduced directly by us to the student (individual situation) without involving external people.

The characterization of intended users (activity 2, Table 7.5, of **Eval3**), was not exhaustive, therefore we asked the student to acquire the missing characterization data (acquisition situation). He collected relevant context variables from the literature and official available data on real communities with these kinds of problems. He focused mainly on motivating grandparents to participate as volunteers.

#### 7.3.3 Gamification for Project Management

This case study concerns the gamification of a system for motivating users in participating collaboratively and actively to *Project Management* activities (case study 5 in Table 7.2).

This case study started from analyzing, in the literature and in the industry, the Project Management in general focusing on cases: **(i)** where it has been investigated how to motivate users in participating to project management; **(ii)** where gamification has been employed for engaging users in project management activities. The student involved in this process, after individuating effective and non-effective strategies, current gaps and problems, on motivating project managers to participate actively to project management, gamified a software platform for Project Management by using Agon, being guided in a systematic acceptance analysis based on gamification, and taking decisions as an analyst, by considering what learned in the previous analysis.

The scenario (activity 1, Table 7.5, of **Eval3**) has been introduced directly by us to the student (individual situation) without involving external people. We proposed a realistic scenario in the context of project management in a company. We summarize the scenario

as follows. The aim is to motivate users of a project management software system, i.e. managers of the company, to use some important system functions more frequently for taking decisions. The system functions support managers in: **(i)** identifying critical tasks in their projects, **(ii)** optionally notifying them to other colleagues, **(iii)** proposing solutions (either by themselves or in a collaborative way) for making sure that such tasks will be successful, **(iv)** identifying risks related to the application of the solution, **(v)** prioritizing the countermeasure activities needed to implement the solution and **(vi)** guaranteeing that countermeasure activities will be performed by the resources involved, etc. The company, by analyzing the behavior of the managers, realizes that most of them neither notify to other colleagues critical task identified, nor interact with the other managers for proposing collaborative solutions, nor identify adequately risks of the solution to be applied. All of them are considered critical for the success of the company. Therefore, the analyst has to gamify the system trying to make those functions more engaging, interesting and appealing, for motivating managers to accept and use them.

Regarding activity 2 (Table 7.5) of **Eval3**, we introduced to the student (introduction situation) also the characterization of intended users, without involving external people (individual situation). We proposed the characterization of decision makers used in the PACAS project.

### 7.3.4 Gamification for Privacy Requirements (VisiOn EU Project)

This case study concerns the gamification of a *Privacy Platform* in the context of the *VisiOn* European project<sup>17</sup> (case study 6 in Table 7.2).

The scenario (activity 1, Table 7.5, of **Eval3**) is the real setting of the *VisiOn* European project<sup>18</sup> and its privacy platform. In order to introduce the scenario, to the student assigned to this case, we involved external experts of such privacy platform (group situation). The VisiOn platform is a complex system for the Public Administration (PA) with the aim of supporting: **(i)** the citizen to be aware of the current level of privacy related to any of her personal data managed by the PA, and also to have the possibility to create personal privacy levels to apply to her data; **(ii)** the PA officials in the analysis, design, delivery and management of privacy policies, and personal privacy levels, and, at the same time, guaranteeing both efficiency and security concerning software systems involved. The VisiOn platform is composed of different software systems, we selected one of them for this case study, it is the STS-Tool<sup>19</sup>. This tool allows the requirements analyst

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<sup>17</sup><http://www.visioneuproject.eu/>

<sup>18</sup><http://www.visioneuproject.eu/>

<sup>19</sup><http://www.sts-tool.eu/>

to model security and privacy requirements, by considering different relevant aspects (e.g., social, information and authorization views), and supporting her with automated analysis for model checking. Therefore, according to the VisiOn scenario, the aim of this study has been to gamify the STS-Tool for motivating the requirement analyst, a PA official, to use such tool (within the VisiOn platform activities) for modeling effective privacy and security requirements able to fulfill the VisiOn objectives (points (i), (ii) above).

The characterization of intended users (activity 2, Table 7.5, of **Eval3**), was not available, therefore we acquired it (acquisition situation) through a structured questionnaire proposed to the representatives of the VisiOn project (group situation). They represent public and private institutions working on privacy in the PA context, collaborating with requirement analysts, as PA officials. Thus, they were able to provide us with a precise characterization of the users to be motivated.

### 7.3.5 Gamification for Collaborative Requirements Prioritization (SUPERSEDE EU Project)

This case study concerns the gamification of a system for motivating stakeholders in participating collaboratively and actively to *Collaborative Requirements Prioritization* activities in the context of the *SUPERSEDE* European project<sup>20</sup> (case study 7 in Table 7.2).

The scenario (activity 1, Table 7.5, of **Eval3**) is the real setting of the *SUPERSEDE* European project<sup>21</sup> and its software for collaborative requirements prioritization, i.e. the *DMGame* tool [Busetta et al., 2017]. As discussed previously in this thesis, the approach of applying available gamification guidelines directly to a software system is not enough to create engaging software, and this has been confirmed also in the case of the *DMGame* tool [Busetta et al., 2017]. In fact, in order to succeed, it is needed an approach like the one of Agon, i.e. performing a systematic acceptance requirements analysis based on gamification [Piras et al., 2016, 2017a,b]. For this reason, we have been involved in improving the gamification of the *DMGame* by employing Agon. Thus, we collaborated with the Fondazione Bruno Kessler (FBK<sup>22</sup>) research institute, and with other partners of the *SUPERSEDE* project, and co-supervised the student assigned to this case study for improving the gamification of *DMGame*. Therefore, for providing the student with this real scenario, we involved *SUPERSEDE* experts (group situation). *DMGame* is a gamified collaborative requirements prioritization tool, which has been developed within the *SUPERSEDE* EU project [Busetta et al., 2017]. The tool has been validated in the

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<sup>20</sup><https://www.supersede.eu/>

<sup>21</sup><https://www.supersede.eu/>

<sup>22</sup><https://www.fbk.eu>

context of three industrial use cases. Moreover, the effectiveness of specific game elements was further investigated through an experiment [Kifetew et al., 2017] that confirmed a lack of acceptance by intended users. Therefore, the aim of this case study has been to execute a systematic acceptance requirements analysis, by employing Agon, for re-gamifying the DMGame, to engage requirements analysts in using the DMGame tool for performing collaborative requirements prioritization.

The characterization of intended users (activity 2, Table 7.5, of **Eval3**) was not available. Thus, we acquired it (acquisition situation) through a structured questionnaire proposed to requirements analysts involved in SUPERSEDE (group situation). We obtained a precise characterization of the users to engage, because those analysts were real users that, as explained above, have been involved also in the industrial use cases of the SUPERSEDE project.

## 7.4 Phase 3: Evaluation with Experts in a Real Case

In this phase, in order to evaluate **H2**, we focused on addressing our RQs also in relation to *experts* (Table 7.1). We carried out a complete real case study (case study 8 in Table 7.2) in the context of the *Participatory Architectural Change Management in ATM Systems* (PACAS) European project<sup>23</sup>. It is the main case study of this thesis, we describe it in Chapter 6. Specifically, we performed exploratory qualitative research [Wohlin et al., 2012] (Table 1.1). In such study, Agon has been employed for the analysis and design of an engaging platform for supporting decision-making activities in the complex context of PACAS, which is related to change management in ATM systems. We name the case study of this phase as **Eval4**.

Specifically, this case study delivered an engaging platform, the PACAS platform, for motivating decision makers to collaborate in a participatory way by using such software system. Experts (Table 7.1) have been involved in the process of gamifying the PACAS platform, and solutions obtained in the different phases have been shared, discussed and, finally, implemented. The *experts* that participated in this evaluation were 10 members of the PACAS project. We involved them in the analysis and design of a gamification solution for the PACAS platform by using Agon. The gamification solution provided by Agon has been implemented in the PACAS platform. During the entire process, we interviewed, in a semi-structured way [Wohlin et al., 2012], the experts regarding the solutions proposed by Agon, their appropriateness for engaging the intended users, and involved them in taking decisions inline with the requirements of the PACAS platform

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<sup>23</sup><http://www.pacasproject.eu/>

and context. We executed the activities in Table 7.6:

Table 7.6: Evaluation activities of **Eval4** (Table 1.1 and Table 7.2) with experts

Activity	Description	Modality
1	Elicitation and analysis of requirements for the PACAS platform	Group
2	Analysis for characterizing the decision makers	Group
3	Acceptance requirements and gamification analysis	Group
4	Gamification design and instantiation of the meta-model solution	Group
5	Implementation of the gamified PACAS platform	Group

Concerning activity 1 (Table 7.6), for designing the core functions of the PACAS platform, we elicited and analyzed requirements during different workshops by interviewing the participants, ATM Advisory Board (AB) members and ATM experts external to the PACAS project.

In parallel, we carried out analysis of acceptance requirements and gamification and, according to the Agon method, we started characterizing the decision makers (activity 2 in Table 7.6). We were able to characterize decision makers thanks to the expertise of some PACAS members, psychologists and economists, that during the workshops analyzed the participants in relation to their behavior and concerning other relevant aspects [Piras et al., 2017a, Simperl et al., 2013, Tokarchuk et al., 2012]. On the basis of these results and characterization elements for the decision makers from the literature, we were able to instantiate the User Context Model of Agon.

On the basis of the characterization, we were able to conduct acceptance requirements and gamification analysis by employing Agon models and its method (activity 3 in Table 7.6) as described in the case study of Chapter 6.

Agon supplied us with a generic meta-model gamification solution suitable for our target users, the decision makers. We shared this solution with the *experts* (Table 7.1), involved in this case study (**Eval4**), for receiving feedback, comments and an evaluation of the solution and of the related experience. Finally, on the basis of these interactions and decisions, we instantiated the meta-model and completed the gamification design of PACAS (activity 4 in Table 7.6) by considering gamification elements suggested by Agon and requirements elicited in relation to the point 1 above.

Eventually, we implemented the PACAS platform inserting the gamification solution obtained by using Agon (activity 5 in Table 7.6). The gamification solution implemented is the subject of the next phase.

During the execution of the different activities of this phase, we involved the experts in

taking decisions, over the solutions proposed by Agon, by considering the requirements of the PACAS platform and context (collected in activity 1 and 2 of Table 7.6). Furthermore, during the entire phase, we interviewed, in a semi-structured way [Wohlin et al., 2012], the experts regarding the solutions proposed by Agon (activity 3 and 4 of Table 7.6), and their appropriateness for engaging the intended users (according to the outcome of activity 2 in Table 7.6).

We discuss results related to this case study, and to the other evaluations, in Section 7.6.

## 7.5 Phase 4: Evaluation with Users in a Real Case

In the context of the PACAS European project we analyzed, designed, implemented and evaluated the gamified PACAS platform. The gamification solution implemented in the previous phase is the evaluation subject of this phase. Specifically, in this phase, in order to evaluate the gamified PACAS platform, we involved *real users* in using concretely the gamified platform (case study 9 in Table 7.2). Such users were Advisory Board (AB) members and ATM experts external to the PACAS project, which really use similar software in their job. Thus, in this case study, we name **Eval5**, we conducted exploratory qualitative research [Wohlin et al., 2012] (Table 1.1), and we have been able to collect comments, from real users, on the usage experience of the gamification solution designed by employing Agon. We analyzed, designed and implemented the platform during *Phase 3: Evaluation with Experts in a Real Case*, the related evaluation is outlined in Section 7.4, and further details of the relative case study (case study 8 in Table 7.2) are provided in Chapter 6.

Therefore, in this phase, in order to collect feedback on the engagement produced by such gamified platform, and also useful comments regarding advantages, disadvantages and ideas for improving it, from *real users*, we conducted **Eval5** within the last PACAS workshop and involved 4 real users in the activities of Table 7.7.

We started this 1 day workshop by introducing (activity 1 in Table 7.7) to the participants (group situation) the PACAS project context, concepts, objectives, approach and tasks we carried out. Furthermore, we introduced the PACAS platform by describing its main functionalities, the change management process and the different roles involved in it.

Then (activity 2 in Table 7.7), the participants used the gamified PACAS platform playing in turn with the different roles (individual), and collaborating with the other players (group) for fulfilling the objectives of the change management process. We prepared different scenarios with individual and collaborative tasks to be carried out, which helped

Table 7.7: Evaluation activities of **Eval5** (Table 1.1 and Table 7.2) with real users

Activity	Description	Modality
1	Introduction of PACAS and its PACAS platform	Group
2	Usage of the PACAS platform	Individual and group
3	Discussion, with semi-structured interviews, on the PACAS platform and related usage experience	Group
4	Compilation of a semi-structured questionnaire on the PACAS platform and related usage experience	Individual
5	Writing of a final evaluation report	Individual

them to have a complete usage experience of the gamified PACAS platform.

Afterwards (activity 3 in Table 7.7), we discussed (semi-structured interviews [Wohlin et al., 2012]) with the users their usage experience, the functions of the system, and the engagement level felt through the gamification experience.

We also asked them to fill a semi-structured questionnaire (activity 4 in Table 7.7) organized in 2 parts. The first one for confirming requirements (e.g., promote collaboration among PACAS users) and anti-requirements (e.g., do not impose time constraints to the PACAS users, to avoid producing poor quality solutions, where quality is critical for ATM solutions) considered when we took decisions by using the Agon framework, and the second one for evaluating the gamification solution implemented in the PACAS platform.

Finally, we asked them to write also a final evaluation report (activity 5 in Table 7.7) for providing us with a complete evaluation of the PACAS project, the solutions proposed, the gamified PACAS platform and their usage experience.

In summary, thanks to all these activities within the PACAS project, we evaluated the gamification solution analyzed and designed by using Agon, and implemented in the PACAS platform, by involving *real users* in a *real experience* of platform usage. Furthermore, we obtained feedback on the engagement produced by such gamified platform, and also useful comments regarding advantages, disadvantages and ideas for improving it.

We discuss results related to this case study, and to the other evaluations, in Section 7.6.

## 7.6 Discussion

In Subsection 7.6.1, we discuss results, findings and lessons learned related to phases, case studies and experiments described in the previous Sections. Then, in Subsection 7.6.2, we provide ideas for improvements, and further considerations, collected in the process. Finally, in Subsection 7.6.3, we conclude with threats to validity related to the evaluations

performed and related results.

### 7.6.1 Results of the Case Studies and Experiments

In *Phase 1: Evaluation with Non-Experts in Realistic Cases*, we evaluated **H1** and our answers to RQs by involving *non-experts* (Table 7.1) respectively **(i)** in a preliminary case study, **Eval1**, with a reduced number of participants (5), and **(ii)** in a human-oriented experiment [Wohlin et al., 2012], **Eval2**, with a higher number of participants (21).

In those evaluations, we asked the participants to compare their experiences in applying gamification, to the same software system, one time on the basis of their acceptance and gamification knowledge (we trained them before, individually in **Eval1**, and with master class lectures in **Eval2**), and the second time by employing Agon. In both the evaluations, they expressed their preference for using Agon and evaluated it, in the following we discuss this and highlight the RQs addressed.

Concerning **Eval1**, we performed exploratory qualitative research [Wohlin et al., 2012] (Table 1.1), and in the semi-structured interviews all of them reported that during the first exercise, of not using Agon, they had many problems in selecting gamification concepts and, above all, in how to organize them in a homogeneous gamified structure. Instead, when they used Agon for the same exercise, they reported to have received clear guidance (**RQ3**, **RQ4**) on a worthwhile gamification structure (**RQ2**). In particular, non-experts stated to appreciate the method due to the accurate guidance (**RQ3**, **RQ4**) in considering all the most important aspects (**RQ2**) when this kind of analysis and design is carried on. They reported to have received, during all the phases, relevant suggestions as psychological factors and gamification concepts (**RQ2**) that fit the characterization of the users and their context (**RQ3**, **RQ4**). Moreover, non-experts reported that by using Agon the total effort needed for analyzing and designing a gamification solution was reduced (**RQ3**, **RQ4**). Furthermore, they found that Agon can give a user a broader set of psychological strategies, gamification concepts and best practices to consider than the ones an analyst can have in mind (**RQ2**, **RQ3**, **RQ4**).

Within **Eval2** we conducted explanatory qualitative and quantitative research [Wohlin et al., 2012] (Table 1.1). Specifically, in the human-oriented experiment [Wohlin et al., 2012] we executed, **Eval2**, we confirmed the results of **Eval1** with a higher number of *non-experts* (21). In the following, we show figures confirming those results, and, hereafter, when we refer to answers provided in semi-structured questionnaires of the experiments/case studies, the answers follow the scale shown in Figure 7.1.

Concerning the first part of **Eval2**, i.e. gamifying without using supporting tools (e.g.,

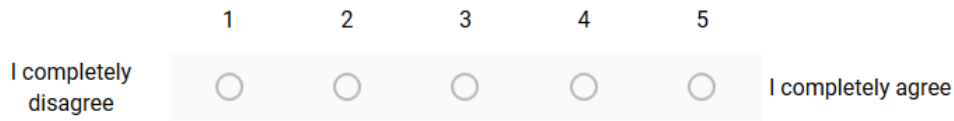


Figure 7.1: Answers scale of the semi-structured questionnaires related to the experiments/case studies (Table 1.1 and Table 7.2) of this thesis

Agon), majority of non-experts declared to have difficulties in organizing homogeneously game elements together, by assigning a value (Figure 7.1) to the next statement (results in Table 7.8).

“In the experience without using Agon, it has been difficult to decide how to put gamification elements together (e.g., rules, correlations, connections, achievement conditions, etc.)”

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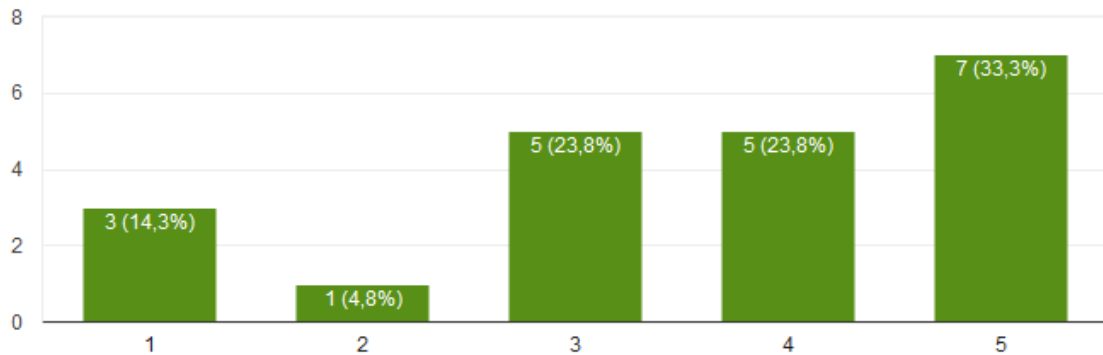


Table 7.8: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that participants, without using Agon, had difficulties in organizing game concepts together in a harmonious structure

Furthermore, participants found difficulties also in individuating the most appropriate elements, factors and strategies for the specific context. In fact, participants realized that they were selecting concepts that, actually, were not the most suitable ones for (i) the user context (Table 7.9), and for (ii) fulfilling the psychological factors and strategies fitting the intended users (Table 7.10). We registered the 2 evidences above, respectively by collecting, from the participants, responses (Figure 7.1) for the 2 next statements (results respectively in Table 7.9 and Table 7.10).

“In the experience without using Agon, you feel you were selecting concepts that actually are not the most suitable ones for intended users of the scenario”

“In the experience without using Agon, you feel you were selecting concepts that actually are not the most suitable ones for fulfilling psychological factors and strategies that fit intended users of the scenario”

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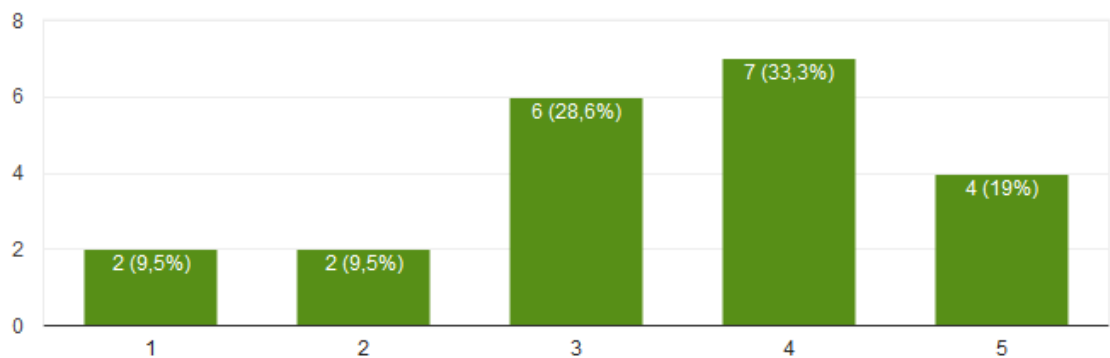


Table 7.9: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that participants, without using Agon, realized that they were selecting concepts that, actually, were not the most suitable ones for the intended users

While, in relation to the second part of **Eval2**, i.e. gamifying by using Agon, they highlighted (by assigning a value to the next statement; results in Table 7.11) that Agon inspired them by suggesting more elements than the ones they can have in mind (**RQ2**, **RQ3**, **RQ4**), as in Table 7.11.

“By using Agon and its method, gamification suggestions provided by Agon inspired you by giving you new elements that you had not in mind”

This means that Agon offers, thanks to its broad meta-model, a space of alternatives (automatically reduced to the elements fitting the specific context through Agon reasoning) that is even broader than the set of elements that an analyst can consider without a supporting tool (**RQ2**, **RQ3**, **RQ4**), like Agon. Therefore, this can help, inspire the analyst, in finding further not considered elements, suitable for her specific context, that could be included in the gamification solution (**RQ2**, **RQ3**, **RQ4**). This can also open the mind of the analyst towards other not expected, considered alternatives and new solutions.

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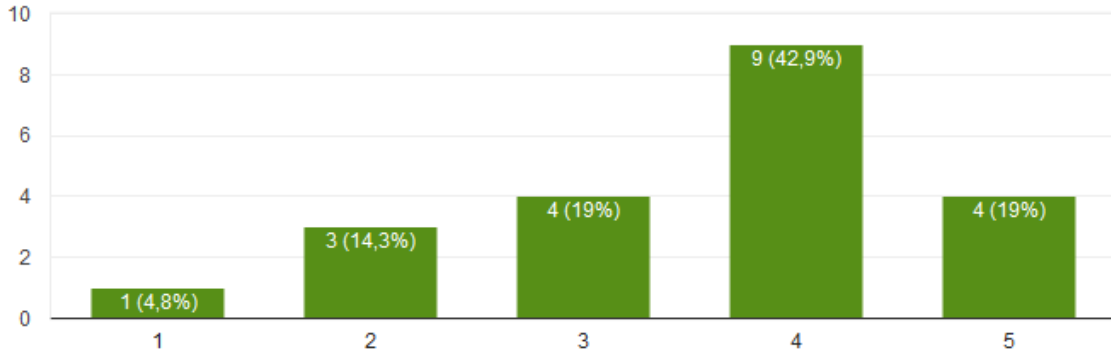


Table 7.10: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that participants, without using Agon, realized that they were selecting concepts that, actually, were not the most suitable ones for fulfilling psychological factors and strategies fitting the intended users

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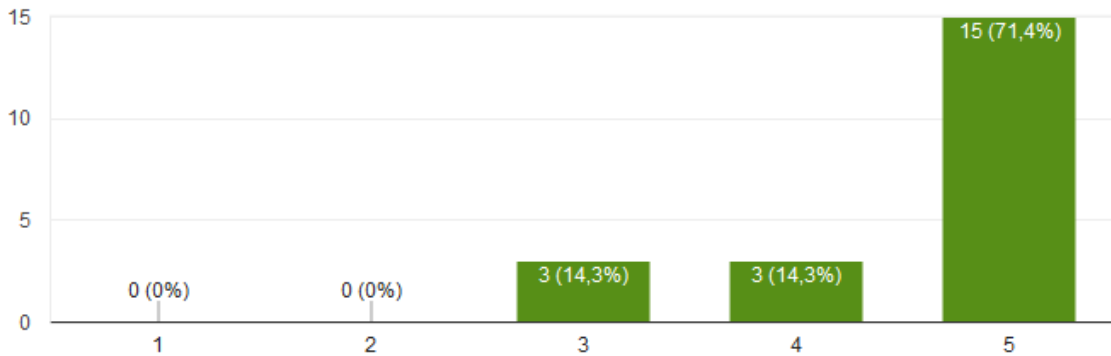


Table 7.11: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that Agon gamification suggestions inspire the analyst, by giving more elements to consider than the ones an analyst can have in mind

They stated (by assigning a value to the next statement; results in Table 7.12) that Agon provides the analyst with more details and guidelines, for configuring the gamification concepts involved in the design of a gamification solution (**RQ3**, **RQ4**), as shown in Table 7.12).

“By using Agon and its method, gamification suggestions provided by Agon gave you more details, and useful guidelines, concerning characteristics of

gamification concepts to consider when you design a gamification solution”

This helps in designing more exhaustive and effective gamification concepts, due to the availability of more variables and guidelines for each game element to design (**RQ2**). Moreover, they prefer a systematic approach, e.g. the one of Agon, for gamifying a system,

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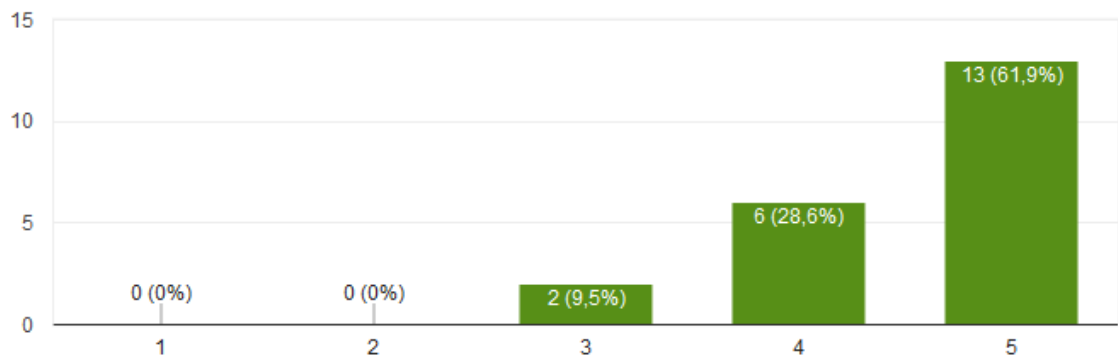


Table 7.12: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that Agon gamification suggestions provide the analyst with more details, and useful guidelines, concerning characteristics of gamification concepts to consider during the design of a gamification solution

because it allows the analyst to design more exhaustive, complete and effective solutions for motivating the intended users (see next statement and results in Table 7.13).

“Gamifying a system with a systematic approach is better, more helpful and can support the analyst in designing a more exhaustive, complete and effective solution for motivating the intended users”

They expressed that Agon supports such a systematic approach, in particular, by allowing the requirements analyst in performing a systematic acceptance requirements analysis for gamifying a system (**RQ3**), as illustrated in Table 7.14 (results from the next statement).

“By using Agon and its method, an analyst can execute a systematic acceptance requirements analysis for gamifying a system”

Furthermore, they affirm (results from the next statement in Table 7.15) that the systematic approach of Agon offers the analyst the possibility to take into account most of the psychological factors and strategies, which can positively affect the user to engage (**RQ3**, **RQ4**).

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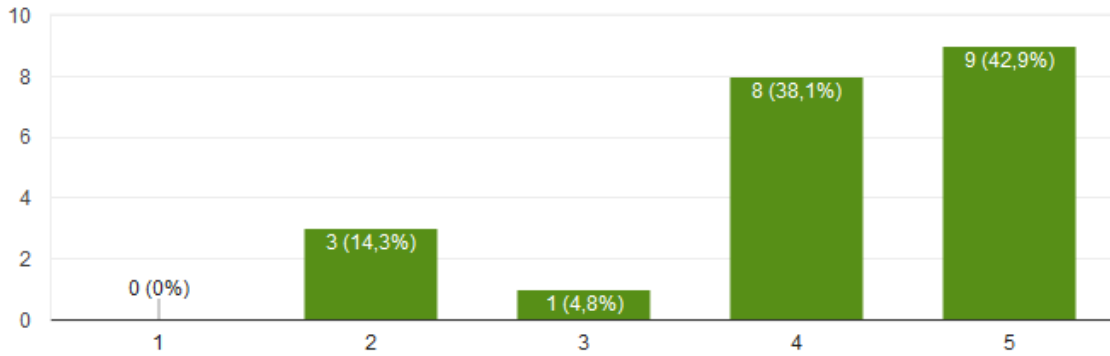


Table 7.13: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that employing a systematic approach, e.g. the one of Agon, for gamifying a system is better, because allows the analyst to design more exhaustive, complete and effective solutions for motivating the intended users

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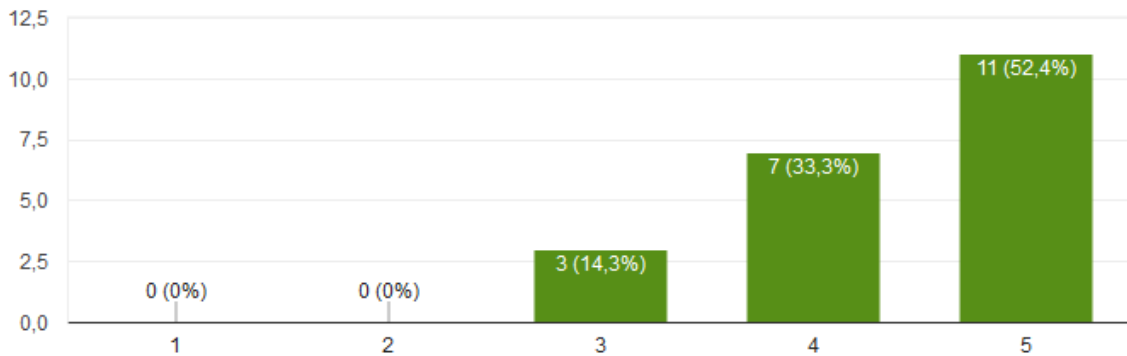


Table 7.14: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that by using Agon, an analyst can execute a systematic acceptance requirements analysis for gamifying a system

“By using Agon and its method, most of the psychological factors and strategies, which can affect positively the user to engage, can be considered by an analyst”

Participants confirmed (results from the next statement in Table 7.16) that the systematic method of Agon guides effectively the analyst in turning abstract psychological strategies with gamification design concepts (**RQ3**, **RQ4**).

“By using Agon and its method, the analyst is effectively guided in finding how

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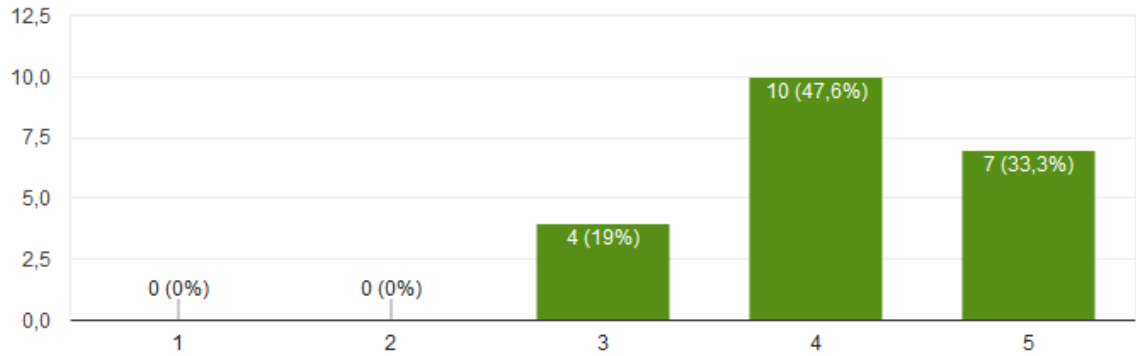


Table 7.15: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that the systematic method of Agon supports the analyst in considering most of the psychological factors and strategies, which can affect positively intended users

to make psychological strategies concrete by designing gamification solutions”

Therefore, the Agon meta-model is able also to cover these elements, thanks to the tactical model linking the acceptance and gamification models (**RQ2**). Moreover, due to these answers and the previous ones, we can say also that the Agon meta-model is able to cover acceptance factors and strategies (acceptance model), as well as, gamification concepts and guidelines (gamification model), addressing **RQ2**.

Moreover, in the semi-structured questionnaire of **Eval2**, we asked the participants also to evaluate more deeply the phases of the Agon method. In the following, we summarize their evaluation.

Concerning the “*Base System Requirements*” phase, they expressed that modeling the system to be gamified with goal models: **(i)** helps in having a clearer overview of the system to gamify; **(ii)** helps in individuating more easily functions that need human contributions; **(iii)** helps in individuating more easily crucial functions of the system to be fulfilled by gamifying the system; **(iv)** is useful also for this kind of analysis (acceptance requirements analysis based on gamification). These elements contribute to addressing **RQ3** and **RQ4**.

In relation to the “*Acceptance Requirements Elicitation and Analysis*” phase, they affirmed that using a goal model of the system for identifying functions to gamify (the ones that contribute positively to the achievement of critical purposes of the system and depend on human contributions to be fulfilled): **(i)** helps the analyst in finding more rapidly

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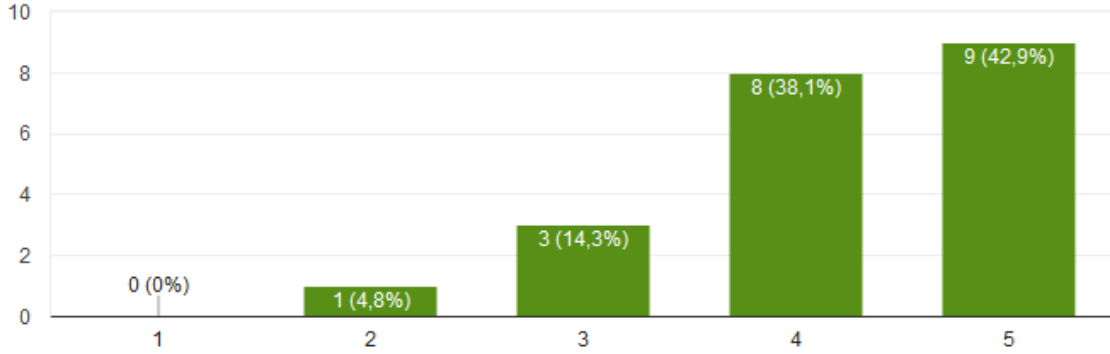


Table 7.16: Answers to a question of the **Eval2** questionnaire, *Phase 1: Evaluation with Non-Experts in Realistic Cases*, confirming that the systematic method of Agon guides effectively the analyst in finding how to make concrete the abstract psychological strategies selected, by designing gamification solutions

the functions; **(ii)** helps the analyst in finding more precisely the functions; **(iii)** helps the analyst in finding more functions; **(iv)** simplifies this activity supporting better the analyst. These elements contribute to addressing **RQ3** and **RQ4**.

Regarding the “*Context-Based Analysis of Acceptance Requirements*” phase, participants highlighted that: **(i)** suggestions obtained (as a goal model) by Agon, in this phase, helps the analyst in finding the most appropriate psychological strategies for the users (characterized) to motivate; **(ii)** analyst’s decisions (discarding some psychological strategies suggested by Agon) helps to have a set of psychological strategies that are, not only the most suitable ones for the users, but thanks to the interaction of the analyst, also more suitable concerning the needs of the system to be gamified; **(iii)** it is useful that part of this phase is interactive by providing the analyst with the possibility to take decisions. These elements contribute to addressing **RQ2**, **RQ3** and **RQ4**.

Relatively to the “*Acceptance Requirements Refinement*” phase, they confirmed that: **(i)** suggestions obtained (as tactics goals), by Agon in this phase, help the analyst in finding tactics, which can refine psychological factors selected in the previous phase; **(ii)** analyst’s decisions (discarding some tactics suggested by Agon) help to have a set of tactics that are, not only the most suitable ones for the users, but thanks to the interaction of the analyst, also more suitable concerning the needs of the system to be gamified; **(iii)** it is useful that this part is interactive by providing the analyst with the possibility to take decisions over tactics suggested by Agon; **(iv)** the additional tactics proposed by Agon can

help the analyst in discovering tactics that could have a positive side-effect; this guides the analyst in considering further factors important for gamification, and in finding ways for fulfilling other needs not considered regarding intended users and the specific system. These elements contribute to addressing **RQ2**, **RQ3** and **RQ4**.

Concerning the “*Context-Based Operationalization via Gamification*” phase, they stated that: **(i)** suggestions obtained (as a gamification model), by Agon in this phase, help the analyst in finding the most appropriate gamification concepts and strategies for the users (characterized) to motivate; **(ii)** the gamification model obtained is a ready-to-use well-structured gamification solution that really help the analyst in starting from this for instantiating the gamification design for her system, having elements that are the most suitable for the users to motivate, and are compliant with the psychological factors and tactics selected in the previous phase; **(iii)** analyst’s decisions (discarding some gamification goals suggested by Agon) help to have a gamification design that is, not only the most suitable for the users, but thanks to the interaction of the analyst, it become also more suitable concerning the needs of the system to be gamified; **(iv)** it is useful that part of this phase is interactive by providing the analyst with the possibility to take decisions. These elements contribute to addressing **RQ2**, **RQ3** and **RQ4**.

In relation to the “*Domain-Dependent Instantiation of Incentive Mechanisms*” phase, they highlighted that the notation supported in this phase, by Agon, for the instantiation of the gamification model (in relation to the specific system needs), has enough elements to allow the analyst to define a formal instantiation. These elements contribute to addressing **RQ3** and **RQ4**.

Moreover, we calculated the statistical significance of the data collected within experimental activities of **Eval2** with non-experts. Such results are provided in Table 7.17. Specifically, we performed non-parametric Chi-2 tests [Wohlin et al., 2012], and used as *observed values* the answers grouped, for each question, in 3 answers groups, respectively: the negative group (responses tied to answer values “1” and “2” according to Figure 7.1), the neutral group (responses tied to answer value “3” according to Figure 7.1) and the positive group (responses tied to answer values “4” and “5” according to Figure 7.1). In particular, we compared **H1** *observed values* with the *Null Hypothesis* [Wohlin et al., 2012] **H0** formulated as “Agon and its method do not support adequately *non-experts*”. Therefore, on the basis of the number of participants of **Eval2**, i.e. 21, and due to the fact that Chi-2 does not support *expected values* assuming values less than 5 [Wohlin et al., 2012], we had to specify *expected values* for **H0** as: “11” (negative group), “5” (neutral group), “5” (positive group). Furthermore, Table 7.17) shows that all the results we obtained, from our tests, are *statistically significant*, and, above all, most of them are

Table 7.17: Statistical Significance results obtained by performing non-parametric Chi-2 tests [Wohlin et al., 2012], over data observed within experimental activities of **Eval2** with non-experts

Observed Data (Table Reference)	Degrees of Freedom	Chi-2 Value	P-Value	Result: by conventional criteria, this difference is considered to be
Table 7.8	2	14.255	0.0008	Extremely Statistically Significant
Table 7.9	2	11.855	0.0027	Very Statistically Significant
Table 7.10	2	17.455	0.0002	Extremely Statistically Significant
Table 7.11	2	45.600	Less than 0.0001	Extremely Statistically Significant
Table 7.12	2	52.000	Less than 0.0001	Extremely Statistically Significant
Table 7.13	2	37.818	Less than 0.0001	Extremely Statistically Significant
Table 7.14	2	45.600	Less than 0.0001	Extremely Statistically Significant
Table 7.15	2	40.000	Less than 0.0001	Extremely Statistically Significant
Table 7.16	2	38.691	Less than 0.0001	Extremely Statistically Significant

*extremely statistically significant.*

In **Eval1** and **Eval2** we achieved positive evaluation results, confirming that our solution answers to the RQs and establishes **H1**. Regarding **RQ1**, it is dependent from the other RQs and, above all, from **RQ2**. Therefore, we addressed **RQ1** firstly through (i) our literature review (Chapter 2), review of success cases from the industry (Chapter 2), practical experiences from gamification case studies (Chapter 3) within the STREETLIFE EU project<sup>24</sup>, and, above all, implicitly, (ii) by answering positively to the other RQs. Concerning the *extensible* aspect mentioned in **RQ2**, we extensively discuss and address this in Chapter 8.

Moreover, after the first evaluations, we needed to perform another evaluation, i.e. the **Eval3** case study where we conducted exploratory qualitative research [Wohlin et al., 2012] (Table 1.1), for establishing that our solution answers also to the *generic* aspect mentioned in **RQ2**. Thus, in *Phase 2: Evaluation with Non-Experts in Heterogeneous Cases*, in order to confirm the *generality* of Agon, we applied Agon to a higher number of heterogeneous domains (**Eval3**, case studies in Table 7.2), as described in Section 7.3. In total, we applied Agon successfully to 8 software systems from 8 real and realistic heterogeneous domains (Table 7.2), respectively: 2 from **Eval1** and **Eval2**, 5 from **Eval3** and 1 from **Eval4**. Furthermore, in **Eval3**, we had also the opportunity to re-evaluate all the RQs, through evaluation reports written by the executors of the related case studies and (semi-structured) interviews to them. We achieved similar positive results to the previous evaluations and established again **H1**, in a higher number of realistic cases, and

<sup>24</sup><http://www.streetlife-project.eu/>

this time with *non-experts* also concerning *real cases* (in the previous phase the cases were realistic).

Afterwards, in **Eval4**, *Phase 3: Evaluation with Experts in a Real Case* within the PACAS<sup>25</sup> EU project, we achieved positive evaluation results, analogous to the ones obtained in the previous evaluations, confirming that our solution answers to the RQs also in relation to **H2**. Specifically, in the **Eval4** case study, we performed exploratory qualitative research [Wohlin et al., 2012] (Table 1.1). Concerning this evaluation conducted in the context of the PACAS EU project, at the beginning, some experts totally supported the idea to employ Agon, whereas other experts were less favorable. They were thinking that an engineering supported approach impedes the analyst to employ her creativity, during the analysis and design, having a result that is a gamification solution, but not a complete gamified experience for the user. Actually, it is important to clarify that we designed Agon without the ambition to replace completely the analyst, but, instead, with the aim to support her in carrying on a systematic acceptance analysis and gamification design, by following the Agon method, in a interactive way, giving her the possibility to take decisions in each phase. Nevertheless, after employing Agon in the project and on the basis of the Agon suggestions, the experts found that it supplied a valuable ready-to-use gamification structure made of the most suitable gamification concepts for the intended users and valuable guidelines to put concepts together. Furthermore, they recognized that, at the same time, Agon leaves the analyst the proper flexibility for employing her creativity to customize the solution as a gamified experience. In fact, this has been confirmed during the application of gamification to the PACAS platform, involving the experts in customizing with them the Agon suggestions, and producing a platform supporting a gamified experience for the user.

Finally, in *Phase 4: Evaluation with Users in a Real Case*, we conducted exploratory qualitative research [Wohlin et al., 2012] (Table 1.1) within the PACAS<sup>26</sup> EU project. In particular, in **Eval5**, we evaluated if the gamification solution, designed by using Agon in the previous case study, **Eval4**, and implemented in the PACAS platform, was appreciated by real users through real usage of the gamified platform. We evaluated this in the last workshop of the PACAS project with 4 participants, Advisory Board (AB) members and ATM experts external to the project, who use similar platforms in their job. After they used the platform, we discussed (semi-structured interviews) with them their experience, then asked them to fill a semi-structured questionnaire and to write an evaluation report. We collected positive results, and in the following we discuss this. Specifically, for this

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<sup>25</sup><http://www.pacasproject.eu/>

<sup>26</sup><http://www.pacasproject.eu/>

case study (**Eval5**) we conducted exploratory qualitative research (Table 1.1), and, even if in the next we show histograms, we are not claiming for a quantitative statistical analysis, due to the small number of participants, 4 in total. However, it is important to highlight that the participants are very relevant users, as explained above. Therefore, even **Eval5** produced preliminary qualitative results, coming mainly from our semi-structured interviews and observations, it is interesting to report contextually to them also histograms coming from the questionnaire. Additionally, even if there are no statistical quantitative results, data collected from our questionnaire are in line with the qualitative results.

In particular, in the first part of the semi-structured questionnaire, we asked to confirm the relevance of the most important requirements and anti-requirements we took into account and that guided us in designing the gamification solution. Next figures showing answers of participants, follow the scale of Figure 7.1. For instance, in relation to requirements, participants confirmed, for the PACAS platform, the relevance of *promoting collaboration* among the users, as illustrated in Table 7.18. Regarding anti-requirements,

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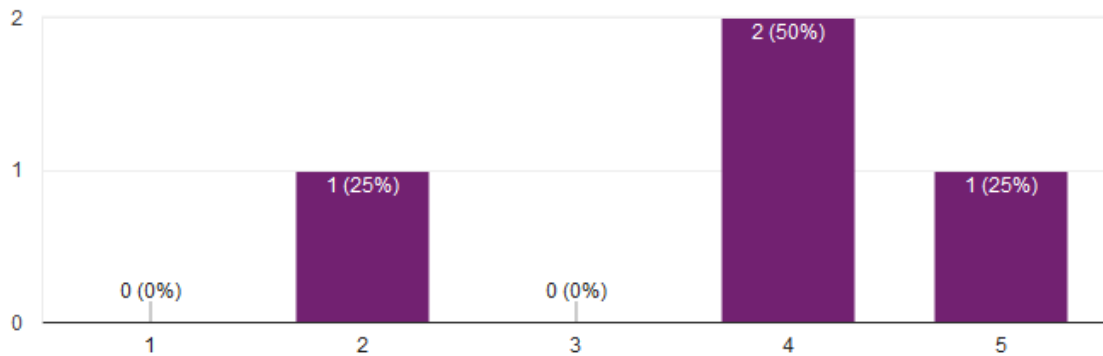


Table 7.18: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the requirement considering the importance of stimulating the user to collaborate with the others, in the PACAS platform, is relevant

participants affirmed, for the PACAS platform, the importance of *avoiding competition* among users, as in Table 7.19. In fact, it could lead to potential conflicts among the users, obstructing their collaborative work and blocking the harmonious process that is required for designing high-quality ATM solutions. Participants highlighted also, for the PACAS platform, the importance of *avoiding time pressure* among users, as in Table 7.20. In fact, it could lead to produce poor solutions to satisfy too strict deadlines. While, in the ATM domain it is particularly critical to ensure the quality of solutions.

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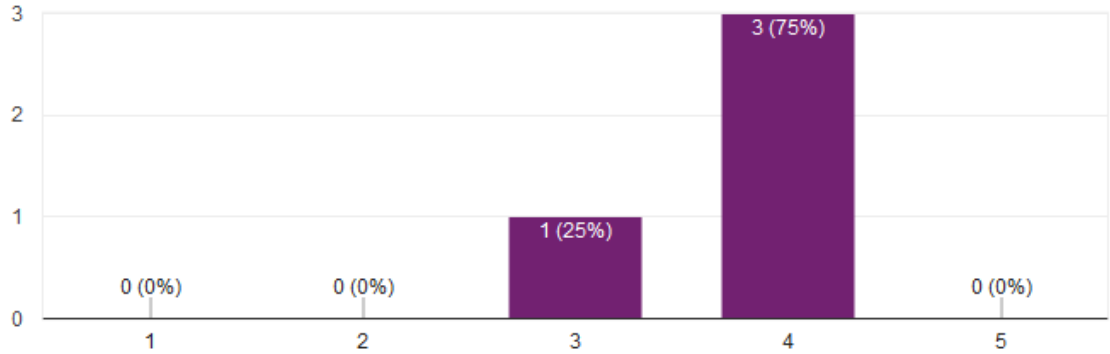


Table 7.19: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the anti-requirement considering the importance of avoiding competition among users, in the PACAS platform, is relevant

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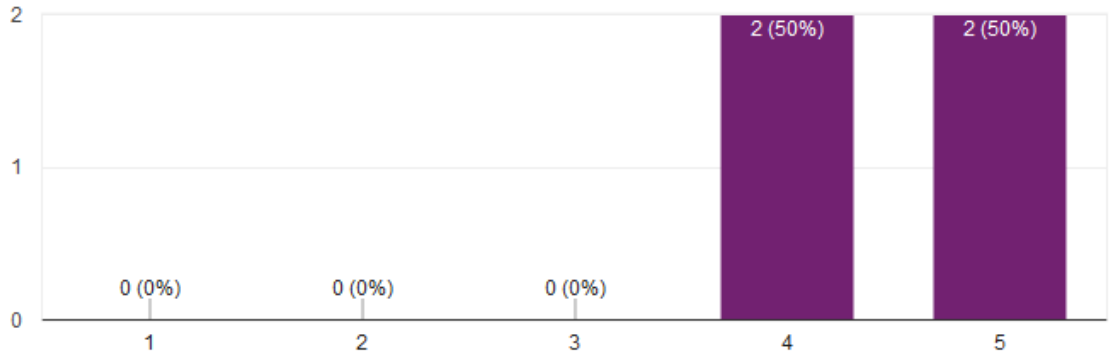


Table 7.20: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the anti-requirement considering the importance of avoiding time pressure among users, in the PACAS platform, is relevant

In the second part of the semi-structured questionnaire, we investigated on the engagement produced by our gamified platform. Participants stated that the gamified platform promotes important behaviors, for the PACAS context, such as *participation* to the PACAS activities (Table 7.21), *collaboration* (Table 7.22) and *communication* among users (Table 7.23), *checking and improving solutions* more frequently (Table 7.24), designing solutions with a wider *interdisciplinary coverage* (regarding safety, security, organizational and economic perspectives) thanks to better interactions among heterogeneous professionals (Table 7.25).

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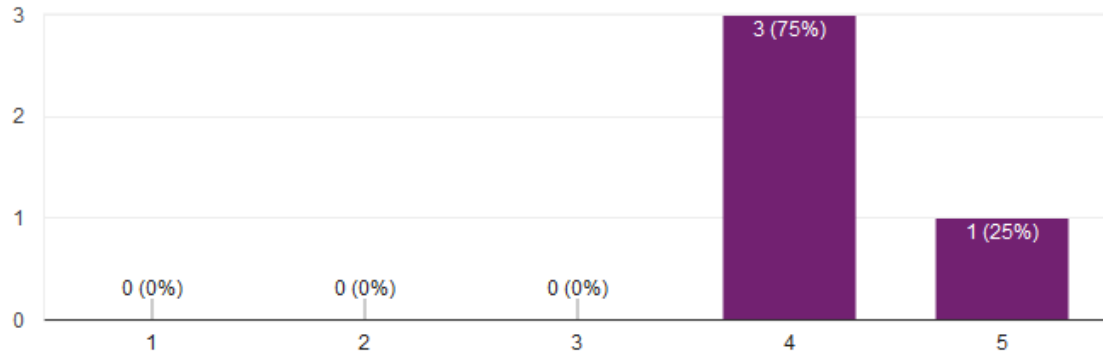


Table 7.21: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the gamification design of the PACAS platform can stimulate the user in participating actively to the PACAS activities

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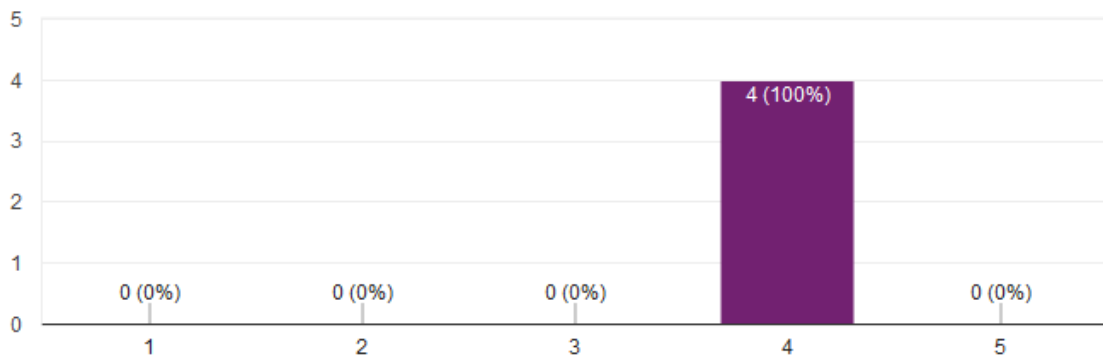


Table 7.22: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the gamification design of the PACAS platform can favor collaboration among users

In summary, considering the results of **Eval5**, including elements from the semi-structured questionnaire, the discussion we had with the participants after they used the platform, and the evaluation report they have written, the participants affirmed that our gamification design is really useful and can really engage the users. Additionally, the participants suggested also some improvements that are outlined, as well as for the other evaluations, in Subsection 7.6.2.

It is important to note that the main aim of our evaluation, for addressing the

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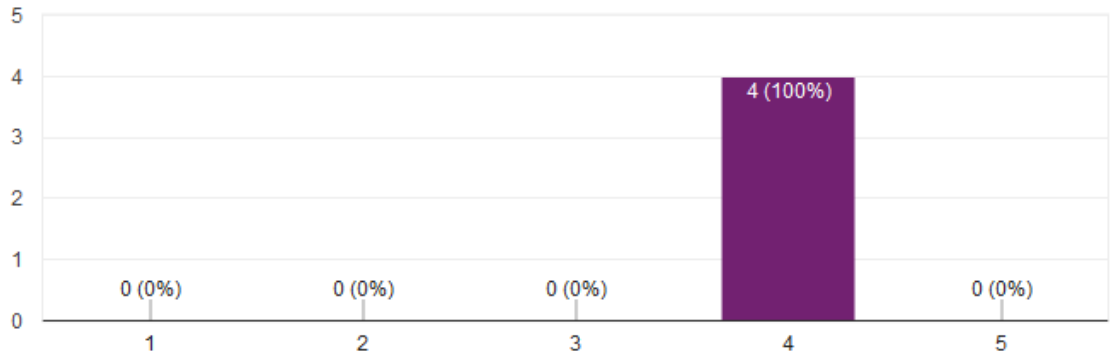


Table 7.23: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the gamification design of the PACAS platform can favor communication among users

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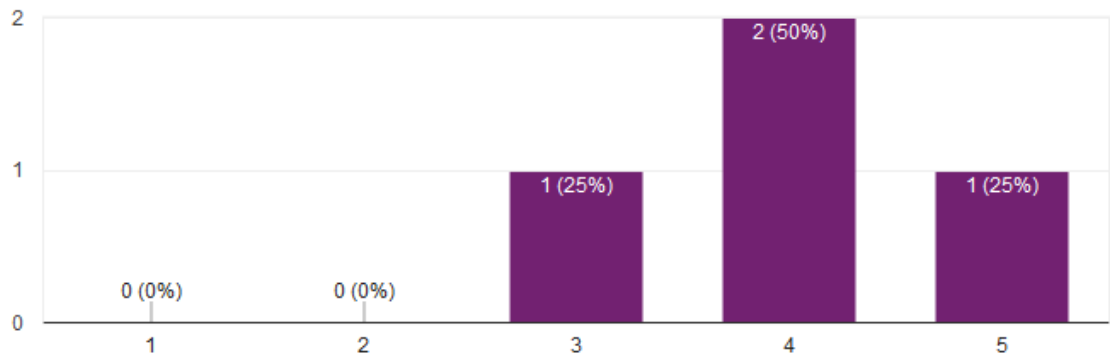


Table 7.24: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the gamification design of the PACAS platform can stimulate the user in checking and improving, more frequently, the PACAS solutions

hypotheses and RQs of this thesis, has been to evaluate Agon from the perspective of the requirements engineer. In fact, we investigated principally on analysis and design activities conducted by requirements analysts, and, accordingly, we evaluated if the support received was adequate from the perspective of non-expert and expert analysts. Therefore, **Eval5** and *Phase 4: Evaluation with Users in a Real Case* are to be considered as preliminary parts of a broader future work, we already started. This future work will investigate on the next level of evaluation, centered on the user perspective, with the objective of

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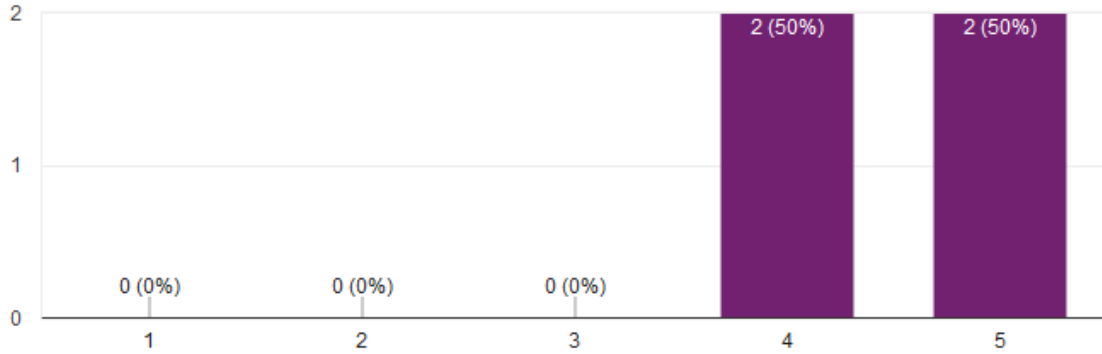


Table 7.25: Answers to a question of the **Eval5** questionnaire, *Phase 4: Evaluation with Users in a Real Case*, confirming that the gamification of PACAS can favor heterogeneous professionals to interact better for designing solutions with a wider “interdisciplinary coverage” (regarding safety, security, organizational and economic perspectives)

understanding if the gamification implementation, of the design produced by using Agon, is appreciated by the users.

Concluding, after analyzing the results of all the case studies and experiments, we can say that **H1** and **H2** have been established, and our solution positively answers to our RQs. Furthermore, we collected interesting comments and suggestions and we will try to address them in the future.

### 7.6.2 Ideas, Potential Improvements and Considerations

During the evaluation phases, case studies and experiments performed, we collected from the participants also ideas and suggestions for improving Agon. Additionally, we noticed also further minor advantages, disadvantages, problems concerning employing Agon and devised further potential improvements. In the following, we discuss these elements.

In **Eval1**, one of the non-experts (Table 7.1) discovered a potential problem. Agon during the reasoning on the acceptance or gamification meta-models discards some goals. If the analyst is interested in having more options for refining a goal, unfortunately, discarded goals are no longer available. Accordingly, we plan to extend Agon so that discarded goals can be restored if the users chooses so.

Regarding open comments of **Eval2**, a participant suggested a visualization improvement for the tactics in the diagram:

*“Sometimes tactics are not on the same ‘level’ in the diagram. I would put*

*them on a ‘line’ so that it is easier to scroll the whole graph and select/deselect them.’*

This can help in facilitating the analyst concerning “*Phase 5: Acceptance Requirements Refinement*” and “*Phase 6: Context-Based Operationalization via Gamification*” of the Agon method. We will implement this suggestion.

Another participant highlighted that Agon meta-models are very big, and sometimes the analyst has problems in navigating on them. As future work, for navigating the models, we will investigate ways for improving the usability of the models, probably further guiding the user in analyzing smaller pieces, according to some criteria and a rationale we will devise. We will implement also the next suggestion:

*“To provide an opportunity to perform searches in the model.”*

Moreover, at the moment, the glossary on the Agon concepts is outside the framework, specifically in our website [Piras et al., a]. This can waste the analyst’s time. In fact, if the analyst needs clarifications on the meaning of specific Agon elements, she has to move from the framework to the website. We will integrate, in the next future, the tool with the glossary with a function that will allow the user in moving the cursor over an element and a tooltip will appear for providing the definition.

Additionally, we collected further interesting positive comments:

*“I appreciate its systematic and exhaustive way of helping the analyst to explore the solution design space.”*

*“I found it interesting where the analysis goes layer by layer.”*

*“Very interesting and complete, I already suggested it for other projects.”*

*“It permits a broad inspection of useful characteristics.”*

*“I appreciate the requirements layer because it helps one to systematically capture the functionalities of the system in terms of goal models.”*

*“It helps during the phases of choice, making the choices much more intuitive.”*

*“It restricts choices to the most likely correct ones, while still allowing the analyst to consider the excluded elements for case-by-case fixing.”*

*“I like the way it helps you to not being lost in such big models.”*

*“I like the pre-defined goal structure for gamified solutions.”*

*“It provide very useful suggestion about gamification elements, that I didn’t think about it.”*

*“It is more expressive, show a lot of things that not coming in mind.”*

*“Using Agon is good because it virtually motivate users.”*

We can summarize them as: the usage of Agon in tackling such complex analysis and design - thanks to the support provided by the systematic acceptance requirements analysis of Agon, its suggestions, and the acceptance and gamification knowledge offered by its meta-model - enables the analyst, in a systematic way, to discover the most suitable solutions for the intended users, and even unexpected solutions, more than the ones an analyst has in mind, and stimulates her, with its support, in carrying out these activities.

We collected also some negative aspects dealt in the following.

*“Good approach, I just hope it does not ‘block’ the creativity of the analyst (especially in the case of inexperienced users who tend to stick to what is suggested).”*

This comment is similar to the problem we had, at the beginning, with some experts ( 7.1) in **Eval4**. However, we discovered, during the analysis and design performed in **Eval4**, in a real case within the PACAS<sup>27</sup> EU project, that Agon supports not affecting negatively the creativity of the analyst, but, on the contrary, inspiring her by offering a broader set of elements to consider. Other negative comments are the next ones:

*“It’s difficult to understand how to use it.”*

*“No particular drawbacks, but the only thing it needs time and commitment.”*

Previous statements are true, it is needed preliminary training to take advantage of Agon. In fact, during our evaluations, especially in **Eval1**, **Eval2** and **Eval3**, we trained the participants. However, this problem is to be taken into account when approaching to the use of a new framework and/or method. In fact, this is a typical issue common to these kinds of powerful supporting tools. Them usually require a steep learning curve, but, after the initial training, the benefits for the user are very valuable, as in the case of Agon. However, in the future we will try to simplify, where possible, the usage of Agon, and

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<sup>27</sup><http://www.pacasproject.eu/>

improve training strategies, the quality of training resources, making the process more effective in less time.

Concerning **Eval3**, a participant used Agon in an iterative way. He has progressed from a phase to the next one, and in case of needing to refine the solution, for example to evaluate other aspects or alternatives, he has been able to easily move back to the previous phases, receiving further adapted and valuable suggestions from Agon. Our framework has been used in this way effectively also in other cases. Thus, we can say that Agon, its meta-model, and its method are flexible enough, and helpful, also if used with iterative approaches, by refining progressively at different abstraction levels the solution.

Moreover, the same participant proposed to automatize the elicitation and definition of acceptance requirements (*“Phase 2: Acceptance Requirements Elicitation and Analysis”*) over the system to be gamified (modeled in *“Phase 1: Base System Requirements”*). At the moment, we are working with him on improving related phases. The idea is to define an algorithm, able to reason on the goal model representing the system, that, on the basis of the Agon guidelines and new annotations (we are defining) applied to the elements, can suggest to the analyst the system functions that need to be gamified. Then, the analyst will take further decisions over such set of elements.

Another participant of **Eval3**, found a limitation of Agon, i.e. the fact that Agon can focus on one user typology per time. It is a problem if there are different groups with heterogeneous kinds of users, as in the Mobility Assistance for Children (MA4C) case study outlined in Section 7.3.2 (e.g., children, parents, grandparents, teachers, neighbors, etc.). In fact, an assumption of Agon is that it considers as users to motivate, the average of the typologies of the intended users. For instance, in some case studies we derived the characterization through structured questionnaires filled by real users. Then, we considered a representative user of the group, as the one having the average of characterization variables calculated on the basis of the structured questionnaire answers. As future work, we will investigate on how to improve this aspect of Agon. According to this, the participant, for the execution of the MA4C case study, took into account the grandparents category. When he executed *“Phase 1: Base System Requirements”* and *“Phase 2: Acceptance Requirements Elicitation and Analysis”*, he had to elicit functions to gamify. Due to the fact that some elements of the goal model (representing the system to be gamified), had to be carried out by different categories of users (e.g., parents, grandparents, teachers, neighbors, etc.), and he had to find the ones in charge of grandparents, he had an idea for improving such phases making them automatic. This idea is inline with the previous one, and envisages to annotate functions of the system also on the basis of who can fulfill objectives of the system by using such functions. This

can help in enriching the algorithm outlined above, for providing the analyst with a set of candidates functions to be gamified, by inserting this additional criteria. In that way, the candidates are selected also on the basis of the functions that interest the user to be motivated. We are considering also this enhancement for improving such phases.

In the context of the PACAS EU project<sup>28</sup> we carried out 2 case studies, **Eval4** and **Eval5**, and, also in these experiences, we collected further comments and suggestions. In particular, an expert (Table 7.1) of **Eval4** suggested to improve the visual aspect of the Agon meta-models by having different colors for acceptance, tactics and gamification goals (we improved our meta-models [Piras et al., a, 2017b] as in Figure 4.6). While, during **Eval5**, executed in the final workshop of the PACAS project, real users tried the gamified PACAS platform - the outcome of the gamification process we performed by employing Agon - and discussed (semi-structured interviews) with us the gamification of the platform. The participants supplied also an evaluation report. In summary, they affirmed that our gamification design is really useful and can really engage the users. Additionally, participants notified us also some minor problems and suggested some improvements, outlined in the following.

Specifically, they think that the platform is worthwhile for remote interactions, but also in face to face meetings as a tool for supporting debates. They suggested to change some visual aspects. For example, due to the fact that the PACAS domain involves professionals, icons of characters, shown in the paths and badges, and in general all the gamification elements, should be presented with a more professional visualization. For this, they proposed to use symbols or impersonal icons for badges, paths and levels; for the co-pilot (i.e. the gamified avatar) an impersonal figure like an hat of a magician or something similar. Moreover, they appreciated a lot the gamification design of the the platform, and it would be a pity if, due to visual problems, professional people did not use it, just because it is considered childish. For instance, the PACAS project icon<sup>29</sup> is a good example, it is impersonal, it represents an animal, but it is not shown the face or expressions (e.g., smiling, etc). They recommended avoiding to show facial expressions of the character, or other personal aspects.

In relation to the challenges, they like the mechanism we designed, and think that this can help on motivating people to collaborate more for critical change management aspects (e.g., finding and solving problems). They had only a doubt: users could not appreciate that there is the possibility to evaluate each other. This could be an issue, because in some companies employees could start thinking that their work will be evaluated on the basis

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<sup>28</sup><http://www.pacasproject.eu/>

<sup>29</sup><http://www.pacasproject.eu/>

of this. Additionally, there could be also normative problems because, in some countries, it may not be legal to evaluate tasks of the employees in this way. As future work, the PACAS consortium will consider this aspect by checking norms and privacy aspects.

Additionally, participants argued that further cases should be investigated, and the gamification should be improved accordingly. For instance, a user by rejecting a challenge could offend the person that has thrown the challenge. However, we have had already considered a solution, i.e. to make the challenges hidden, and using the co-pilot for proposing the challenges to the other users. In this way, the potential problem solver, i.e. who solve challenges, just sees a challenge and does not know who has thrown it. They agreed with this solution.

Another useful suggestion was to give the challenger, i.e. who proposes a challenge, the chance to add comments on the evaluation associated to a challenge, in order to motivate such decision and to stimulate further debates. A similar feature should be envisaged also for the problem solver, by allowing her to provide also comments on the solution proposed (a summary of what she did, which elements have been uploaded, for instance models and reports, or by indicating very precisely the elements changed/improved, etc.), in order to help the challenger in evaluating the solution.

A final consideration is related to the fact that, in our evaluations, we have not used standard questionnaires, related to the technology acceptance area (e.g., the ones regarding TAM, UTAUT, etc.). This is because most of our experiments and case studies are focused more on evaluating the adequacy of the support provided to the analyst, by our framework and its method for designing engaging software systems, than the technology acceptance. In fact, in order to collect such evidences we had to prepare very specific activities and questionnaires. For instance, the evaluation activities related to Table 7.15, with the aim of evaluating if the Agon method supports the analyst in considering psychological factors and strategies, which can affect positively intended users.

However, those standard questionnaires (e.g., the ones related to TAM, UTAUT, etc.) could be very valuable for case studies such as **Eval5**, where we investigate more on the user concerning her engagement, perceived usefulness, satisfaction, and other important elements regarding the usage and acceptance of the gamified software from the user perspective. Even though, at the moment, we had not the possibility to employ such standard questionnaires in **Eval5**. This is due to the fact that such approaches, usually, are employed in larger samples. While, **Eval5** has been a preliminary case study, with a reduced number of participants (i.e. 4 experts), where it is not possible to conduct statistical analysis on the results. Accordingly, we preferred to base this research mainly on observations with semi-structured interviews and discussions. In the future, we will

try to use such standardized questionnaires, by repeating **Eval5**, and involving a higher number of participants. We will do the same for our future research for evaluating, from the user perspective, other software systems gamified by using Agon.

### 7.6.3 Threats to Validity

In the following, we report threats to validity related to the evaluations performed and related results, classified according to [Wohlin et al., 2012].

#### Conclusion Validity

The threats to validity related to this category are discussed in the following.

**Low Statistical Power.** In all the case studies (i.e. **Eval1**, **Eval3**, **Eval4**, **Eval5**, see also 7.2 and Table 1.1) it has not been possible to apply statistical analysis to the elements observed, due to the kind of research performed, i.e. exploratory qualitative research. However, qualitative results obtained have been adequate and positive concerning the constraints, the interdisciplinary nature of this research and of the human subject observed. In the future, we could try to consider, if it is possible, to further support our qualitative results, with explanatory qualitative and quantitative research results as in the case of **Eval2**.

In particular, in **Eval1** and **Eval5**, being preliminary exploratory qualitative research studies, the number of participants has been low. In the future, we will repeat them with a higher number of participants, by conducting explanatory qualitative and quantitative research, if it is possible, for trying to obtain also statistical evidences.

Furthermore, in **Eval3**, the aim has not been to involve a high number of participants, but to test Agon in a representative number of realistic and real cases to evaluate the *generality* (**RQ2**) of Agon to be employed in heterogeneous domains. In total, we applied Agon successfully (in some cases also within EU projects) to 8 software systems from 8 real and realistic heterogeneous domains (Table 7.2) respectively: 2 from **Eval1** and **Eval2**, 5 from **Eval3** and 1 from **Eval4**. Thus, on the basis of the objective of **Eval3**, we can consider this number of domains satisfactory to be representative and, thus, to address the *generality* (**RQ2**) of Agon being employed in heterogeneous domains.

Moreover, in **Eval2**, we performed explanatory qualitative and quantitative research (Table 1.1), by involving 21 participants in our human-oriented experiment, and obtained very positive statistical results as reported in Table 7.17 and discussed in Section 7.6.1.

**Reliability of Measures.** In all of our evaluations ( 7.2 and Table 1.1) subjects involved are humans, i.e. analysts. Therefore, all of them have been human-oriented evaluations [Wohlin et al., 2012], and, in particular, **Eval2** has been a human-oriented experiment [Wohlin et al., 2012]. In all the evaluations, we tried to be as precise as possible to collect evidences from analysts. However, due to the nature of the subject, we cannot claim measurement as precise as in deterministic cases [Wohlin et al., 2012] (e.g., technology-oriented evaluations in general and, above all, technology-oriented experiments [Wohlin et al., 2012]).

**Reliability of Treatment Implementation.** In our evaluations, we tried to keep the treatment implementation as linear, homogeneous as possible. However, the configuration of our evaluations has been not exactly the same for each treatment, mainly due to (i) availability of human subjects involved (i.e. experts and non-experts), (ii) EU projects organization constraints, and (iii) Master classes organization constraints. In fact, there were slight differences in some cases. For instance, in relation to the duration of the exercises and the lectures (**Eval1** and **Eval2**). In the following we discuss these differences.

In **Eval1** and **Eval2**, due to lecture timing constraints, Master classes constraints, and availability of subjects, the order of the tasks changed. For example, **Eval1** has a gamification exercise without Agon before introducing Agon, while **Eval2** presents Agon before the experiment with the gamification exercise. However, it is important to highlight that the outcome of the 2 evaluations, and the sample considered, has been very different in dimension and importance. In fact, **Eval1** is a preliminary case study aiming at evaluating and exploring the feasibility of our approach with a small number of participants, and confirmed this in a preliminary way. While **Eval2** is a human-oriented experiment with a representative number of subjects, i.e. 21, which confirmed the feasibility and, above all, the concreteness of the support provided by Agon to the analyst, both with qualitative and quantitative statistical results. Specifically, such experiment obtained very positive statistical results as reported in Table 7.17 and discussed in Section 7.6.1. Furthermore, the most important thing was not to evaluate the solution itself, but rather the experience in using Agon compared with the case without employing it.

Concerning **Eval4**, we confirmed **H2** in a different way from the case of **H1**. In fact, in **Eval2**, non-experts have used directly and individually Agon. While **Eval4**, being in a EU project context, i.e. the one of PACAS, we had to conduct it in a different way. In fact, experts have been continuously involved in considering suggestions of Agon and in taking decisions, according to the Agon method, but in team collaboration. Furthermore, the two research methods employed are different (Table 1.1), and the same is for the

scenarios (Table 7.2) and timing. Concerning the scenario, in the first case it is realistic, and real in the second one (Table 7.2). Regarding research methods (Table 1.1), in **Eval2** we conducted explanatory qualitative and quantitative research, while in **Eval4**, exploratory qualitative research. In relation to the timing, in the first case 3 hours of experiment, and, taking into account also lectures, a total of 3 weeks; in the second case, approximately 2 years with different iterations with experts, which helped us to test Agon also concerning its iterative employment. Therefore, we can say that, due to these differences, (i) concerning the research methods, probably **Eval2** has stronger results, and also quantitative ones, (ii) regarding the scenario, **Eval4** delivered more important results towards the application of Agon in real cases, (iii) in relation to the time, it depends on the dimension of the software system to gamify and related requirements, thus in proportion **Eval2** timing could be relevant, however it appears more interesting to have applied Agon and its method in a long complex process as the one of **Eval4** in a EU Project like PACAS. Moreover, even using different evaluations, as discussed in Section 7.6.1, results obtained in both the evaluations established our hypotheses and addressed our RQs. However, as a future work, it could be interesting (i) to involve experts in a human-oriented experiment as **Eval2**, possibly with a real scenario as **Eval4**, (ii) to repeat **Eval2** with non-experts, but in a real scenario, (iii) and, vice versa, to involve non-experts in a real project as in **Eval4**.

Furthermore, **Eval5** had even another kind of configuration, due to aiming at a different result. In fact, it is important to underline that, regarding our evaluations within PACAS, with **Eval5** we started going towards the next future step, i.e. to evaluate not only the experience of the analyst (objective of this Thesis), but also to test the gamification solution produced, by using Agon, with real users. Especially, in **Eval5**, even though in a preliminary way, we confirmed the feasibility and usefulness of the gamification solution produced and implemented in the gamified PACAS platform. In summary, our overall evaluation, performed so far, indicates a positive analyst attitude towards the use of Agon, and useful support, from the analyst perspective, in gamifying software systems in a range of case studies and experiments. As a future work, we will investigate on establishing if the use of Agon can produce gamified software that concretely is able to engage the user in real cases. Specifically, this is a future work, we already started, beyond the objective of this thesis, as further explained in Section 7.6.1.

**Random Heterogeneity of Subjects.** Non-experts subjects involved in all the related evaluations were enough homogeneous and representative of the category of non-experts (Table 7.1) we intended to investigate on, for instance junior requirements engineering

analysts approaching to working in the industry. Specifically, subjects involved have been master students with limited expertise concerning gamification and acceptance, no expertise regarding Agon and its method, but good expertise in relation to requirements engineering. Furthermore, we trained them for guaranteeing they had good knowledge of such topics (Table 7.1).

Analogously, the *experts* that participated in **Eval4**, 10 members of the PACAS project, were homogeneous and representative, in line with the skills we indicated in (Table 7.1) for defining experts.

The same is valid for subjects of **Eval5**. Specifically, to evaluate the gamified PACAS platform, we involved *real users* (our subjects) in using concretely the gamified platform. Such users were Advisory Board (AB) members and ATM experts external to the PACAS project, which really use similar software in their job.

### Internal Validity

The threats to validity related to this category are discussed in the following.

**Maturation.** The only evaluation we performed that can be considered long according to its time duration, intensiveness and effort required, has been the **Eval2** human-oriented experiment. It lasted 3 hours and has been intensive. This could potentially affect the results obtained. However, participants appeared, from the beginning to the end, very interested in using the Agon method and in relation to the realistic scenario we proposed, i.e. “The Smart Canteen”. In fact, this topic has been of their interest, being university students, facing to the possibility to really improve a university canteen as the one where they go daily. For this reason, their level of attention appeared good, suggesting that probably data collected have not been particularly affected.

**Testing.** Non-experts, in **Eval1** and **Eval2**, executed the same exercise two times. The second time they could have been affected by decisions taken and the solution designed during the first exercise. However, the most important thing was not to evaluate the solution itself, but rather the experience in using Agon compared with the case without employing it. Concerning this, non-experts reported many advantages in using Agon (as deeply discussed in the previous Sections). We can summarize the most important as: (i) Agon supplies a valuable ready-to-use gamification structure made of the most suitable gamification concepts for the intended users and best practices to put concepts together; (ii) thanks to the interactive method, where the analyst can take decisions over

the suggestions received in different moments, Agon allows the analyst to preserve enough flexibility in adapting valuable solutions, for the intended users, also to the requirements of the specific domain and relative platform; **(iii)** Agon fosters the creativity of analysts by offering many variants and solutions at different abstraction levels.

### External Validity

The threats to validity related to this category are discussed in the following.

**Interaction of Selection and Treatment.** Subjects selected for all the evaluations have been adequate to the kind of Treatment applied. For instance, in all the evaluations related to the usage of Agon from non-experts, we involved subjects adhering with our non-experts definition (Table 7.1) and related skills, i.e. good expertise in relation to requirements engineering and good knowledge of gamification and acceptance after our training (Table 7.1). Such subjects represented junior requirements engineering analysts approaching to working in the industry.

The same is for **Eval4**, where it was needed the involvement of experts (Table 7.1) for collaborating also by using the Agon method, and taking decisions over Agon suggestions. Also in this case, analyst to be involved for this kind treatment were analysts. Especially experts with the skills indicated in (Table 7.1).

In **Eval5**, the treatment was usage of the PACAS platform gamified by using Agon in **Eval4**. Also in this case, users involved have been representative as intended subjects. i.e. potential real users of the gamified PACAS platform. In fact, we involved Advisory Board (AB) members and ATM experts external to the PACAS project, which really use similar software in their job.

**Interaction of Setting and Treatment.** At the moment, Agon is a prototype, not an industry product. This could be a threat for Agon to be enough representative as a tool that could be used in a industry setting. However, even though it is at a prototype stage, it has been implemented with updated and innovative technologies, similar to the ones used in the industry, as discussed in 5.2.

Another threat could come from using toy problems. In our evaluations (Table 7.2), the only scenario that can be defined close to a toy problem is the one of the preliminary evaluation **Eval1**, where we employed the DLMSE. While, in **Eval2** we used a realistic scenario of a *University Smart Canteen* that is complex enough for the objective of our experiment, as described in the related Section. In **Eval3**, we have heterogeneous realistic

and real case studies, in some cases related also to EU projects (Table 7.2). Finally, **Eval4** and **Eval5** make use of real scenarios from the PACAS EU Project (Table 7.2). However, according to this kind of threat, evaluations dealing with a real scenario are more representative. In this Thesis, according to Table 7.2, we have in total 5 evaluations related to real settings.

## **7.7 Chapter Summary**

In this Chapter, we present the activities we carried out for the evaluation of the Agon framework, and discuss the results obtained.

The Chapter starts providing an overview (Section 7.1) of how we organized our evaluation plan, and which have been the objectives of each phase, for the Agon evaluation. Then, in the subsequent Sections (7.2, 7.3, 7.4 and 7.5), we describe such phases in detail. Specifically, we performed experiments and case studies in real and realistic settings for gamifying software systems and evaluating the usefulness of Agon for the requirements analyst, obtaining positive results. Such settings concerned the gamification of software systems in the context of European projects and master courses (Chapter 5, 6, 7, 8), involving experts and students.

Finally, in Section 7.6, we discuss results, findings, lessons learned and threats to validity, concerning all the evaluation phases, experiments and case studies performed.



## Chapter 8

# Conclusions and Future Work

In this Chapter we conclude this Thesis with the following elements.

In Section 8.1, we summarize the Agon framework, its meta-model, its method and related contributions. While, current limitations, ongoing and future work are discussed in Section 8.2.

Furthermore, in Section 8.3, 8.4 and 8.5, we illustrate some future works we already started, which are also part of new potential lines of research that could be created starting from this Thesis (discussed in Section 8.6). In such Sections, we provide the guidelines for extending the Agon framework, and discuss advantages obtainable by integrating it with other frameworks and methodologies.

Specifically, in Section 8.3, we introduce and briefly recap concepts related to the importance of extending Agon, and integrating it with other frameworks and methodologies. In fact, the possibility of extending Agon is important for guaranteeing the effectiveness of the framework. Agon is based on theories coming from behavioral, cognitive, social, psychological fields and best practices from the gamification field. Therefore, it is crucial to update the framework by keeping the pace of new discoveries coming from such fields. Analogously, the possibility to extend and enhance Agon, by integrating it with other frameworks and methodologies, enables the requirements analyst to have a wider space of solutions, alternative strategies and further techniques opening to new opportunities illustrated in these Sections.

Especially, the first aspect is discussed in Section 8.4, where we provide the guidelines for extending and updating Agon. Furthermore, we show also a concrete example of potential extension of *Agon* with the *Motivational Antecedents Framework* (MAF), related context variables and theories coming from the *Organizational Behavior* field. In this Section, we provide also the comparison between the Agon and MAF frameworks.

The second aspect is illustrated in Section 8.5, where we discuss the possibility to integrate *Agon* with *Design Thinking*, for enhancing *Agon* as a framework for collaborative gamification design.

Finally, in Section 8.6, potential new lines of research starting from this thesis are presented.

## 8.1 Summary

In this thesis, we have proposed *Agon*, an *Acceptance Requirements Framework* able to support *Acceptance Requirements Analysis* for designing a software system that is accepted by its target users. *Agon* captures in its meta-models psychological strategies, gamification best practices and constraints (context dependent rules) that guide the selection of gamification solutions, able to motivate the target users and, therefore, to fulfill different *Acceptance Requirements*. This knowledge is offered to the analyst in the *Agon* method phases guiding her in carrying out a systematic and effective analysis.

Moreover, we have presented evidence, in different quantitative and qualitative evaluations, that *Agon* and its method can support both non-experts and experts with acceptance analysis and gamification design of a software system. Most important findings and lessons learned that emerged from the evaluations were that *Agon* provides: **(i)** a systematic method for analyzing and designing engaging software systems; **(ii)** a broader set of elements to consider for gamifying a software system; **(iii)** valuable semi-automatic support for analyzing and designing gamified systems with guidance, suggestions and ready-to-use solutions; **(iv)** a ready-to-use gamification structure made of concepts and best practices suitable for target users, on which the analyst can take decisions; **(v)** decision making over suggestions provided, with an interactive approach, supporting the analyst, but leaving her the possibility to take final decisions, thus, not affecting her creativity.

Our approach for tackling the research challenges of this thesis, and most important contributions, are summarized in the following.

Reviewing the literature we selected Acceptance and Gamification as candidate techniques for analyzing and designing engaging software systems. From industrial cases and case studies from the literature, we found different difficulties that often are encountered in the analysis and design performed through these techniques. In particular, there are many complex aspects to consider, and usually it is needed to include, in the process, heterogeneous professionals coming from very far fields, and to make them to collaborate in a proficient way.

In fact, designing gamification solutions is a complicated work that requires a lot

of time and resources. Specific abilities and professional skills are essential, and the process usually involves gamification designers, IT engineers, psychologists, sociologists, economists, etc. The problem is complex. We must design a well-structured and functioning solution, choosing the best game elements and methodologies, and put the pieces together in a coherent way. But, at the same time, the solution must be efficient in cognitive/psychological and emotional terms, keeping in mind the target audience that you want to involve and motivate.

In order to support the requirements analyst in these activities, we designed a comprehensive meta-model capturing the acceptance knowledge such as psychological, behavioral, cognitive factors and strategies, and gamification knowledge such as gamification concepts, best practices, guidelines and strategies, and discovered how to connect acceptance and gamification together in a interoperable way. Moreover, we designed a method, a *Systematic Acceptance Requirements Analysis Based on Gamification*, for leveraging the meta-model and guiding the analyst in a semi-automatic interactive way providing solutions and suggestions. We enclosed all these elements in Agon, an *Acceptance Requirements Framework Based on Gamification*, and developed its supporting software as a prototype, the Agon-Tool. Specifically, it is the tool we are using for supporting our framework and method. We have developed it as a software system able to guide the analyst in the usage of the Agon meta-models by following our method, and to determine optimal gamification solutions for a specific set of acceptance requirements.

Furthermore, we performed case studies and experiments (in total 8 case studies and 1 human-oriented experiment within 8 heterogeneous domains, see Table 7.2 and Table 1.1), by using Agon, in real and realistic settings for gamifying software systems, and evaluated the usefulness of Agon from the requirements analyst perspective. Real and realistic settings concerned evaluations for the gamification of software systems in the context of European projects (e.g., the PACAS<sup>1</sup>, VisiOn<sup>2</sup> and SUPERSEDE<sup>3</sup> EU projects), master courses, involving experts and students, where we obtained positive results and confirmed to have answered successfully to our research questions with our contributions.

The most important contributions coming from Agon are summarized in the following, such contributions are: the *Agon meta-model* and the *Agon method*.

The *Agon Multi-Layer Meta-Model*, shown in Figure 4.1, is composed of an *Acceptance Meta-Model (AMM)*, a *Tactical Meta-Model (TMM)*, a *Gamification Meta-Model (GMM)* and a *User Context Model (UCM)*. AMM captures psychological factors that can positively

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<sup>1</sup><http://www.pacasproject.eu/>

<sup>2</sup><http://www.visioneuproject.eu/>

<sup>3</sup><https://www.supersede.eu/>

contribute towards acceptance of a software system. GMM is composed of gamification concepts and best practices, guidelines concerning the gamified design of software systems for favoring the software usage. TMM is a mediator layer including tactics for refining the problem space of AMM and relating its elements to the design space of GMM. UCM is the model that describes acceptance-related traits of the users we want to engage.

Moreover, we have enriched our models with *Context Dependant Rules (CDRs)* to describe the circumstances that lead people to use a system. In fact, usage depends largely on *Context*: user characteristics (e.g., gender, age, player type, etc.) and the kind of relation that the users have regarding the Acceptance Subject (e.g., awareness and expertise of the system to be accepted). The literature has many examples of CDRs for improving user involvement in different situations Bartle [1996], Koivisto and Hamari [2014a], Venkatesh et al. [2003], Zichermann and Cunningham [2011]. We model context by extracting from CDRs important dimensions of UCM. Furthermore, we annotate the AMM and GMM with CDRs to guide the design towards suitable solutions for a given set of acceptance requirements and intended user community.

We designed AMM, TMM and GMM by using and extending the NFR framework Chung et al. [2012], Li et al. [2013], Mylopoulos et al. [1992]. UCM is founded on Context Dimension Trees Orsi and Tanca [2011].

Agon has different abstraction layers, as shown in Figure 4.1. The acceptance layer includes AMM and identifies psychological needs that lead or contribute to acceptance. The tactical layer includes TMM and identifies tactics for influencing these psychological needs, while the gamification layer includes gamified solutions for engaging the user and supports GMM. These meta-models are instantiated with specific goals for a gamified design.

Thus, our aim has been to provide the requirements analyst of engaging software systems with a framework that supports and guides her during acceptance requirements analysis, having as a final target the software usage maximization. In summary, the Agon framework [Piras et al., 2017b] and its method [Piras et al., 2016, 2017a] are the state of the art in the requirements engineering research community, concerning supporting the analyst in analyzing acceptance requirements and fulfilling them with gamification design concepts. Agon provides the analyst with models [Piras et al., 2017b], techniques [Piras et al., 2016, 2017a] and a tool for executing its method, a systematic acceptance requirements analysis based on gamification.

In the first phases of the *Agon method*, i.e. the *Systematic Acceptance Requirements Analysis Based on Gamification*, the analyst defines and elicits acceptance requirements on the basis of the context characterization. Thus, the analyst, being supported by Agon,

analyzes and characterizes the (as-is/to-be) software, looking for the crucial functionalities to be gamified. The functionalities selected by the analyst are the ones that respond to the next characteristics: **(i)** repetitive, boring, complex, not interesting or not attractive functionalities and, thus, the user is not stimulated to use them [Piras et al., 2017a]; **(ii)** functionalities where their fulfillment coincides with the fulfillment of the software goals and/or the software success [Piras et al., 2016] and, the functionalities fulfillment depends on the human contribution [Piras et al., 2017a], which is the execution of the related tasks by using these functionalities [Piras et al., 2016]. Then, the user to be motivated is characterized, for example concerning: **(i)** her user characteristics (e.g., age, gender, etc.), **(ii)** her player categories (e.g., socializer, achiever, explore, killer, etc.), **(iii)** her awareness/expertise regarding software usage, **(iv)** how are and how she perceives the tasks and the goals correlated to the software use, **(v)** in which social context she will use the software and **(vi)** which kind of good will be produced by using the software [Piras et al., 2017a], etc.

In the next phases, the analyst gives in input the context characterization variables analyzed [Piras et al., 2017a] before. Agon, for producing suggestions as psychological needs and strategies that best fit the specific context [Piras et al., 2016, 2017a], reasons over a knowledge base, its Acceptance Model [Piras et al., 2017b]. Such a model has been designed on the basis of the most important acceptance models capturing behavioral, cognitive, motivational, psychological needs, factors and strategies [Piras et al., 2016]. Thus, the analyst receives those suggestions and interactively decides which of them to keep. Then, Agon, by using its acceptance and tactical models [Piras et al., 2017b], refines them proposing to the analyst, for each psychological strategy, which set of more concrete elements, tactics, can be employed in the design. Again, this is an interactive step, thus, the analyst can decide which tactics to keep [Piras et al., 2016].

In the last phases, Agon, for producing a gamification design as a solution, reasons over a knowledge base, its Gamification Model [Piras et al., 2017b]. This model encloses gamification concepts organized on the basis of best practices coming from the literature and the industry. Therefore, the solution suggested to the analyst has a high-quality gamification design [Piras et al., 2017b]. Moreover, concepts and gamification strategies are selected by Agon on the basis of the context characterization, acceptance requirements, psychological and tactical strategies chosen until this stage. Thus, the gamification design proposed fits best the specific context [Piras et al., 2016, 2017a].

## 8.2 Limitations, Ongoing and Future Work

Here, we discuss current limitations of the Agon framework, and illustrate ongoing and future work. Figure 8.1 represents the big picture including ongoing, future work discussed here, and future lines of research illustrated in Section 8.6. In this Section, and in Section 8.6, we show specific parts of Figure 8.1 for helping us in outlining the concepts.

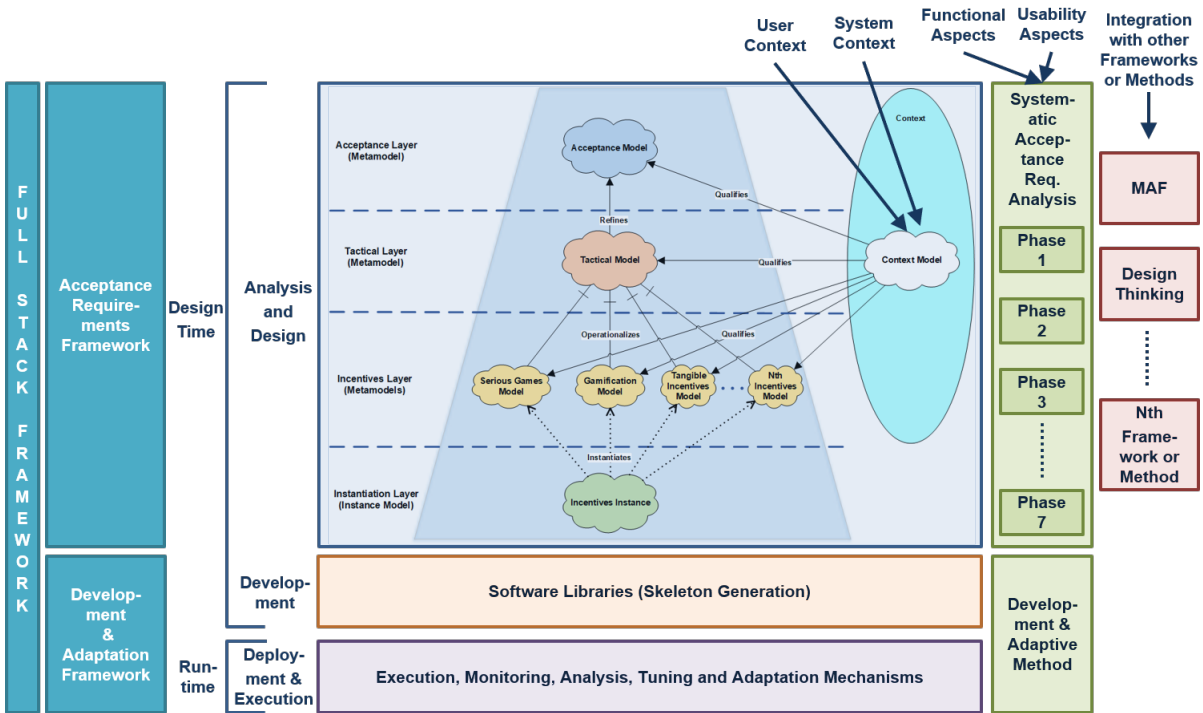


Figure 8.1: The big picture including graphical representations of ongoing, future work and future lines of research that could be started on the basis of this thesis

### 8.2.1 Agon Meta-Model Evolution

As previously highlighted, the Agon framework is based on dynamic theories coming from psychology, human behavior and cognitive studies, sociology, etc. Therefore, in order to keep it effective, i.e. guaranteeing Agon is able to produce high-quality gamification design, it is needed to update the framework according to those fields. This is a sort of inevitable limitation, due to the nature of the subject covered. Thus, on the basis of new theories, discoveries, it is important to reconsider and update different aspects of Agon, in the following we discuss this. It is noteworthy to say that following the guidelines, we provide in Section 8.4, can help to evolve Agon.

The User Context Model (Figure 8.2) is a transverse component, it affects all the other Agon models. It is useful to consider to update variables that can affect the user and to add new ones. For instance, it is possible to evaluate adding new, or more complex, taxonomies of players. Accordingly, such variables are then expressed in form of Context Dependant Rules (CDRs) annotating the relations of the other models. Therefore, it is necessary to update the previous ones and/or adding new ones.

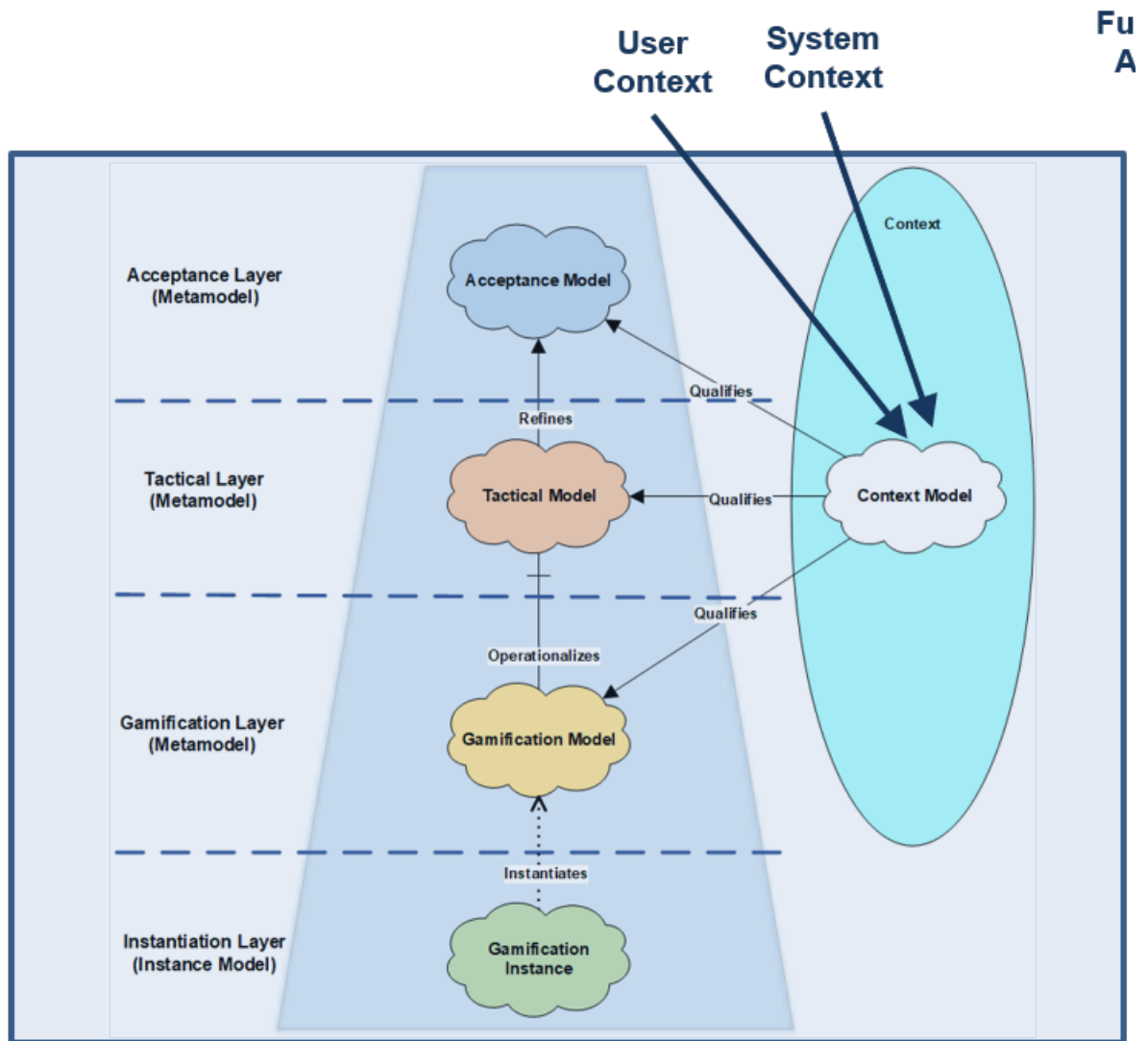


Figure 8.2: Screenshot of the big picture focusing on the Agon Meta-Model Evolution

The Acceptance Meta-Model (AMM) can require updates on its needs and/or adding new ones. It is also possible to evaluate integrating more acceptance models in AMM than the ones we inserted. Then, it is necessary to find ways for refining needs with tactics

of the Tactical Meta-Model (TMM). TMM can be made evolved analogously. Often new theories, strategies, best practices and concepts related to gamification are proposed, therefore, it is better, also to improve the gamification expressiveness and effectiveness offered to the analyst, to improve accordingly the gamification goals of the Gamification Meta-Model (GMM) and related structures.

Finally, according to the extension guidelines (Section 8.4), during and after applying these modifications it is fundamental to re-check the intra- and inter-model implications concerning restoring the right balance, coherence and interoperability among heterogeneous elements involved.

### 8.2.2 Agon Method Evolution: Functional Improvements

Also the Agon Method, i.e. the *Systematic Acceptance Requirements Analysis Based on Gamification*, and its phases can be improved (Figure 8.3). For instance, it could be possible to automatize the elicitation and definition of acceptance requirements (“*Phase 2: Acceptance Requirements Elicitation and Analysis*”) over the system to be gamified (modeled in “*Phase 1: Base System Requirements*”). This is an ongoing work we are carrying out supervising a master student. The idea is to define an algorithm, able to reason on the goal model representing the system, that, on the basis of the Agon guidelines and new annotations (we are defining) applied to the elements, can suggest to the analyst the system functions that need to be gamified. Then, the analyst will take further decisions over such set of elements.

Another improvement could come from a limitation of the framework. Agon can focus on one user typology per time. It is a problem if there are different groups with heterogeneous kinds of users, as in the Mobility Assistance for Children (MA4C) case study outlined in Section 7.3.2 (e.g., children, parents, grandparents, teachers, neighbors, etc.). In fact, an assumption of Agon is that it considers as users to motivate, the average of the typologies of the intended users. For instance, in some case studies we derived the characterization through questionnaires filled by real users. Then, we considered a representative user of the group, as the one having the average of characterization variables calculated on the basis of the questionnaire answers. As future work, we will investigate on how to improve this aspect of Agon. This can impact on both method (Figure 8.3) and meta-model evolutions (Figure 8.2).

According to the previous points, there could be another improvement for the Agon method. In fact, the student we supervised for the execution of the MA4C case study, took into account the grandparents category. When he executed “*Phase 1: Base System*

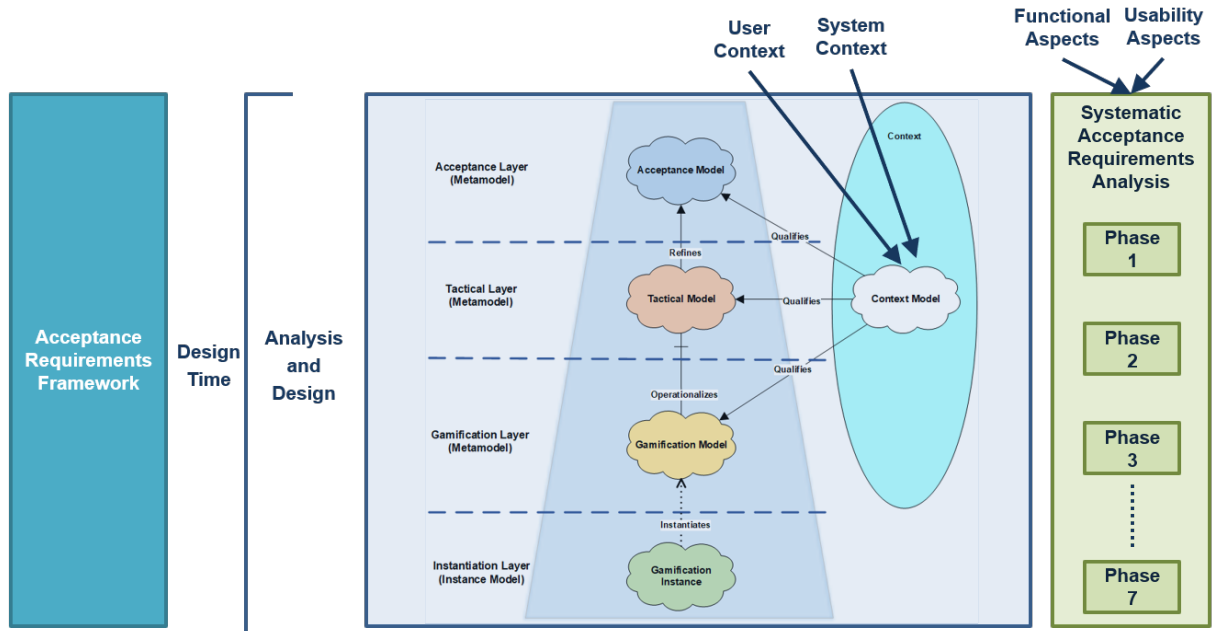


Figure 8.3: Screenshot of the big picture focusing on the Agon Method Evolution

*Requirements*” and “*Phase 2: Acceptance Requirements Elicitation and Analysis*” (Figure 8.3), he had to elicit functions to gamify. Due to the fact that some elements of the goal model (representing the system to be gamified), had to be carried out by different categories of users (e.g., parents, grandparents, teachers, neighbors, etc.), and he had to find the ones in charge of grandparents, he had an idea for improving such phases making them automatic (Figure 8.3). This idea is inline with the previous one, and envisages to annotate functions of the system also on the basis of who can fulfill objectives of the system by using such functions. This can help in enriching the algorithm outlined above, for providing the analyst with a set of candidates functions to be gamified, by inserting this additional criteria. In that way, the candidates are selected also on the basis of the functions that interest the user to be motivated. We are considering also this enhancement for improving such phases (Figure 8.3).

Another limitation is related to a phase of the Agon method, which could create a sort of “bottleneck” in the process. It is the final instantiation phase, called “*Phase 7: Domain-Dependent Instantiation of Incentive Mechanisms*” (Figure 8.3). Unfortunately, it requires conspicuous time and effort, much more than the other phases (Figure 8.3).

This fact is predictable and - at least in part - normal, because it is a manual phase (Figure 8.3). In fact, most of the other phases are semi-automatic, interactive and, specifically, the analyst receives, from Agon, suggestions as ready-to-use solutions fitting

the context at different levels of abstraction (Figure 8.3). Even it is still true that executing these phases the Analyst has to take decisions, however the related effort is minimized, thanks to Agon that provides the analyst with relevant support. While, in the last phase, the analyst has to perform manual activities that - even she is supported by Agon through the availability of a notation and formal modeling elements to instantiate and customize generic solutions obtained (Figure 8.3) - are still time-consuming.

This problem could be apparently valid also for the first phase, “*Base System Requirements*” (Figure 8.3). However, in this case, the work is less difficult, because the difference is that (i) in the last phase you have to integrate Agon solutions with system functions, which is a more complicated task, (ii) while, here you have to describe system functions. Additionally, the activity of the first phase is something to be done regardless of the need of gamifying a system and using Agon. For this reason, the first phase help the analyst, but it is out of scope to improve it. Therefore, we think that, above all, the last phase need further research to be improved, probably by providing semi-automatic support, for reducing the related effort (Figure 8.3).

### 8.2.3 Agon Method Evolution: Usability Improvements

Given that Agon models are large and will get even larger, and in the execution of the method Agon makes the analyst work directly with the models, this could create problem concerning the usability of the method (Figure 8.3). This is particularly critical for the gamification meta-model, which is the biggest model of the framework (Figure 8.3). Therefore, as future work, we will try improve such aspect. For example, having different views, or guiding in a visual way the analyst to analyze parts of the models, according to a logic we will devise. We could evaluate to use other visual mechanisms, e.g., tables as in other requirements engineering works, and compare the different visual techniques.

### 8.2.4 Context Dependency

Another limitation of Agon is related to the fact that, to provide most suitable results strictly depends on the user context characterization (Figure 8.3). In fact, sometimes it could be difficult to have the characterization of intended users to engage. However, in the last few years user data are getting more and more available, above all, through social networks (e.g., Facebook, Twitter, Instagram, etc.), and there are many studies, also related to big data, for automatically characterizing users. Therefore, even it is a limitation of Agon, it is bounded to few situations. In fact, in most of the cases Agon can be used leveraging all its characteristics (Figure 8.3). Additional ways for characterizing

users, as we did in most of our case studies, regard the possibility to ask users to fill questionnaires or to interview them. Those approaches can fit, especially, small scenarios.

However, even Agon is more powerful having a user characterization, it is still useful for the analyst also without it, because it can provide the analyst with a wide space of psychological factors, strategies and gamification solutions - organized according to effective structures and best practices - that are navigable, ready-to-use and customizable (Figure 8.3).

### **8.2.5 Enhanced Automation: System Typologies**

Agon supports a semi-automatic interactive method, where the analyst has to take decisions in different moments and at different abstraction levels (Figure 8.3). On the one hand, this enables the analyst in being creative by taking decisions over the valuable suggestions received. On the other hand, it could be useful to reduce this by automatizing some aspects, lowering the total effort of the analyst, and, at the same time, trying to keep a certain level of decision-making for guaranteeing the creativity. We think that the second option is gradually achievable, and future research could try to address it. Partly, we have individuated in Subsection “*Agon Method Evolution: Functional Improvements*” some improvements that could help also in supplying more automation regarding specific phases. In the following, we discuss an important aspect that, if addressed, could help in automatizing the entire method (Figure 8.3).

Agon focuses mainly on selecting solutions on the basis of the user context characterization variables, which do not consider adequately the typology of the system to gamify (Figure 8.3). In this way, suggestions obtained by Agon are still very valuable, being the most suitable for the intended users, but they are not chosen on the basis of the system’s characteristics. In fact, this is something that, at the moment, the analyst has to do, taking decisions on solutions received by considering also these aspects (Figure 8.3).

Accordingly, as future work, we will try to enhance Agon for addressing this potential improvement. We envision to add further context elements and related annotations, for enabling the Agon method to provide the analyst with a even more ready-to-use solution, fitting not only the user context as currently supported, but also the specific system to be gamified (Figure 8.3). This can help in further reducing the related effort, but we think it is important to do not totally automatize the entire process, in order to guarantee the analyst’s creativity. We envision that, even having this enhancement, there will still be manual activities (e.g., taking decisions, customization and instantiation of elements) that the analyst will have to do (Figure 8.3), but they will be drastically reduced thanks to

this research.

### 8.2.6 User Case Studies and Experiments

At the moment of writing, we have concluded 1 case study with real users (i.e. **Eval5** in Chapter 7), within the PACAS<sup>4</sup> EU project, where participants used the gamification solution obtained by employing Agon. We achieved positive results that are discussed in Chapter 7.

Currently, in relation to the other case studies (Chapter 7), we are implementing the related gamification solutions, produced by using Agon, and we will involve real users to try the resulting gamified software. Thus, our aim is to collect even more evidences that gamification solutions, designed through Agon, are effective also from the user perspective. At the moment, we have collected positive results that in most of the cases concern the requirements engineer perspective. In fact, as explained in Chapter 7, the aim of this thesis was to evaluate the usefulness of the Agon framework, its meta-model and the method offered in relation the requirements engineer perspective. This is the first fundamental primary step for evaluating Agon, and on the basis of this result, as future work, we will evaluate also the gamification solutions produced from the user perspective (as we already did in 1 case study, i.e. **Eval5** in Chapter 7, achieving positive results; more details in Chapter 7).

## 8.3 Importance of Extending and Integrating Agon

Due to the dynamic nature of the concepts involved in an acceptance requirements framework such as Agon, it is particularly crucial to guarantee the capacity of the framework to be updated and extended, in order to favor the effectiveness of the framework itself [Piras et al., 2017a]. This requires, especially, the evolution of the knowledge of the framework [Piras et al., 2017b]. Thus, in the case of Agon, it is really important to deal with a flexible, extensible meta-model, as the Agon meta-model [Piras et al., 2017b], and to have guidelines for extending it [Piras et al., 2017a]. In fact, the evolution is a fundamental aspect, because, in order to keep Agon effective, it is necessary to be able to make the meta-model [Piras et al., 2017b] evolve for being compliant with the newest physiological changes (typical of fields strictly dependent on Human Sciences as Acceptance and Gamification) coming from discoveries of new acceptance theories (e.g., psychological theories) and gamification strategies [Piras et al., 2017a,b]. Specifically, this

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<sup>4</sup><http://www.pacasproject.eu/>

allows the extension of Agon by including factors, concepts and strategies coming from other fields, having alternative solutions, that can contribute to the engagement of the user [Piras et al., 2017a]. Thus, in this Chapter, specifically in Section 8.4, we provide general guidelines for extending Agon, and individuate also additional concepts from other fields, *Organizational Behavior* [Simperl et al., 2013, Tokarchuk et al., 2012], that could further enhance Agon [Piras et al., 2017a].

Furthermore, another important aspect regards how it is possible to integrate Agon with other frameworks, and which could be possible related advantages and opportunities [Piras et al., 2017a, 2018a]. Accordingly, Section 8.4 discusses also, by providing concrete examples, how including factors, concepts and strategies, enclosed in frameworks coming from other fields (e.g., *Organizational Behavior* [Simperl et al., 2013, Tokarchuk et al., 2012]), having alternative solutions, can contribute to making Agon a framework with even more possibilities for producing solutions for the engagement of the user. Moreover, in Section 8.5, we describe another concrete opportunity concerning the integration of Agon with Design Thinking [Piras et al., 2018a]. In fact, the latter can enhance Agon by turning it into a participatory framework for collaborating more with stakeholders in the analysis and design of engaging software systems [Piras et al., 2018a].

As a final remark, the studies, described in Section 8.4 and 8.5, are future works for further improving Agon, by extending it and integrating it with other methodologies and frameworks, that we already started.

## 8.4 Agon Extension Guidelines and Integration with the MAF Framework

*Gamification* is a powerful paradigm and a set of best practices used to motivate people carrying out a variety of ICT-mediated tasks [Piras et al., 2017a]. Designing gamification solutions and applying them to a given ICT system is a complex and expensive process (in time, competences and money) as software engineers have to cope with heterogeneous stakeholder requirements on one hand, and *Acceptance Requirements* [Piras et al., 2016, 2017b] on the other, that together ensure effective user participation and a high level of system utilization [Piras et al., 2017a]. As such, gamification solutions require significant analysis and design as well as suitable supporting tools and techniques [Piras et al., 2017a]. *Agon* [Piras et al., 2016, 2017a,b] is a relevant *Acceptance Requirements Framework* supporting these techniques, and the standard for such kind of requirements analysis within the *Requirements Engineering research community* [Piras et al., 2016, 2017a,b, 2018a].

#### 8.4. AGON EXTENSION GUIDELINES AND INTEGRATION WITH THE MAF FRAMEWORK

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In this Section, we show how to further empower the Agon framework by extending it embracing concepts, factors and strategies coming from other fields [Piras et al., 2017a]. The main contribution of this Section is to provide *guidelines for extending the Agon framework* [Piras et al., 2017a]. In order to describe the guidelines, we use an example of their application within a case study [Piras et al., 2017a], where we compared *Agon* with the *Motivational Antecedents Framework* (MAF) for extending Agon with concepts of MAF. Specifically, in such case study, we compared concepts, tools and techniques for gamification design drawn from *Software Engineering* and *Human Behavior*, supported by Agon, and *Organizational Behaviors*, supported by MAF [Piras et al., 2017a]. We conducted the comparison by applying both techniques to the specific Meeting Scheduling exemplar [Piras et al., 2017a] used extensively in the Requirements Engineering literature.

Furthermore, the case study aimed at comparing the two frameworks for integrating them in a future work. Therefore, the other contributions of this Section are the comparison, and, above all, the elements for a future integration of the 2 frameworks [Piras et al., 2017a]. In fact, the comparison allows us to highlight overlapped concepts of the 2 frameworks, and, above all, concepts not in common (coming from MAF and related fields, e.g., *Organizational Behavior*) to be integrated in the Agon framework, for making it even more powerful by offering a wider space of alternatives and solutions for the analyst [Piras et al., 2017a]. Thus, this is also a concrete example showing how to consider strategies and solutions from other fields, useful for enhancing Agon and for making it more effective. Further interesting possible integrations of Agon with other frameworks and methodologies, coming from other fields, are further discussed, with one more case [Piras et al., 2018a], in Section 8.5.

Finally, guidelines provided, even illustrated taking as an example the specific case illustrated here, are generic and can be used for extending Agon in most of the cases [Piras et al., 2017a].

The rest of this paper is organized as follows. Section 8.4.1 briefly recaps the research context, introduces this study, and highlights advantages obtainable by integrating Agon and MAF and related opportunities that can arise. Section 8.4.2 analyzes the Motivational Antecedents Framework (MAF). Section 8.4.3 applies MAF to the meeting scheduler exemplar showing its method in action (while, Agon applied to this exemplar has been already shown in Chapter 5). Section 8.4.4 presents and discusses results of the comparison. Section 8.4.5 provides the guidelines for extending and integrating Agon with other frameworks. Finally, Section 8.4.6 concludes and outlines future work.

### 8.4.1 Requirements Engineering and Organizational Behavior Techniques for Software Acceptance Analysis and Gamification Design

An important criterion for the success of a software system consists of measuring the degree of acceptance of the system by its intended user community [Piras et al., 2017a]. Thus, *Requirements Engineering* (RE) and, above all, the elicitation and analysis of user requirements and acceptance requirements [Piras et al., 2016] are key phases towards the creation of a gamified software [Lombriser et al., 2016] aimed at involving and motivating users. In fact, right from the early phases of gamification engineering, it is fundamental to conduct an accurate and extensive analysis concerning the most important variables needed to design a successful gamification solution [Piras et al., 2017a]. According to the literature, this is not systematically done by practitioners, resulting in less accepted software than what its owners had hoped for [Deterding et al., 2011, Zichermann and Cunningham, 2011]. Gamification fails when people are not engaged and it is directly correlated to the fact that *human factors* are not adequately considered in the gamification process and, above all, during the crucial phase of RE analysis [Piras et al., 2017a]. Therefore, during the analysis, the most important variables concern *Human Behavior* and related context [Piras et al., 2017a]. By extensively analyzing gamification, behavioral, cognitive, psychological, social/economic studies [Bartle, 1996, Deterding et al., 2011, Kapp, 2012, Koivisto and Hamari, 2014b, Simperl et al., 2013, Venkatesh et al., 2003, Zichermann and Cunningham, 2011], we derived important variables (Figure 8.4) that are related to the characterization of [Piras et al., 2017a]:

- the **User** to engage;
- the **Acceptance Subject**, which is the software to be used (focusing on the perspective of the user);
- the **Activity** to carry out by using the software and related variables from the perspective of the user;
- the **Social Context**, the set of social relations in which the software is used;
- the **Outcome** produced by using the software, especially, user expectations and how the user is affected by the outcome.

These variables are the starting elements to be considered before designing any gamification solution, they can be unveiled during the RE phase and are important for all gamification phases [Piras et al., 2017a]. On the basis of those variables, another fundamental activity

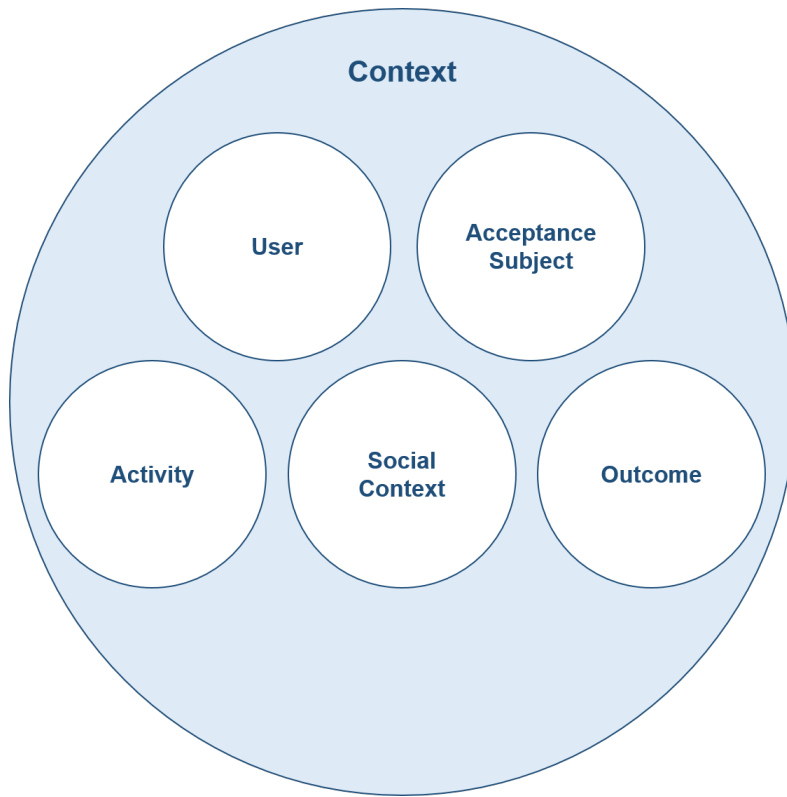


Figure 8.4: Context variables relevant for the acceptance and gamification requirements analysis and design [Piras et al., 2017a]

that should be carried out, in order to maximize the chances of success of the gamification solution, is to analyze and select psychological strategies and gamification best practices that can positively affect human behavior vis-a-vis acceptance [Piras et al., 2017a].

In summary, in order to produce an extensive high-quality gamification solution from acceptance requirements, the following activities need to be conducted [Piras et al., 2017a]:

1. analysis and characterization of context variables;
2. analysis, selection of psychological/cognitive strategies for stakeholder acceptance requirements;
3. analysis and design of gamification best practices for the problem-at-hand.

In the scientific literature and in the software development market, there were important gaps regarding the existence of tools for supporting the analyst in applying gamification systematically during the RE process [Piras et al., 2017a], and to cover these gaps, two different frameworks have been proposed: *Agon* [Piras et al., 2016, 2017a,b] and the

*Motivational Antecedents Framework* (MAF) [Simperl et al., 2013, Tokarchuk et al., 2012]. In this study we carefully compare them [Piras et al., 2017a].

*Agon* [Piras et al., 2016, 2017a,b] has been developed in the RE field, intended to support the gamification phase (activities 2 and 3 above), including the characterization of the *User* and the *Acceptance Subject* (activity 1).

The *Motivational Antecedents Framework* (MAF) [Simperl et al., 2013, Tokarchuk et al., 2012] has been developed in the field of *Organizational Studies*, intended to support the analysis of human behaviors in physical and organizational contexts [Piras et al., 2017a]. There is a huge field of studies on human behaviors, motivations and incentives in organization referred to as *Organizational Behavior* since the pioneering work of Mayo and his famous "Hawthorne and the Western Electric Company" case study [Mayo, 1949] in 1930. Even though MAF has not been designed with an engineering perspective, and its method is largely organizational studies-based, it can support the RE analysis phase analogously to *Agon* [Piras et al., 2017a]. Even though MAF was conceived in a field far away from RE, it has been used as a gamification framework to develop a set of incentives embedded and implemented in IT solutions [Piras et al., 2017a].

We envision that MAF (covering activity 1 above and the *Activity*, the *Social Context* and the *Outcome* context variables of Figure 8.4) and its method constitute an excellent candidate for comparison with *Agon*, to understand areas of similarity and difference in the concepts and techniques they use to support gamification [Piras et al., 2017a]. These considerations are extensively discussed [Piras et al., 2017a] in the next sections.

In summary, the main objectives of this study have been [Piras et al., 2017a]:

1. the analysis and comparison of two different frameworks, *Agon* and MAF, and their methodologies;
2. the definition of guidelines for extending *Agon* and integrating it with the MAF framework creating a comprehensive framework.

Due to the remarkable dissimilar origin of the two frameworks and respective methodologies, the comparison and guidelines provided by this study are also valuable prerequisites for extending *Agon* to produce a holistic framework that encompasses engineering, behavioral, cognitive/psychological and social/economic concerns [Piras et al., 2017a]. We conducted the comparison by applying the two frameworks to gamify a meeting scheduling software system example as a simple case of social software that comes with acceptance requirements and needs to be gamified [Piras et al., 2017a].

#### 8.4.2 The Motivational Antecedents Framework (MAF)

MAF derives from a study based on *Organizational Science* and *Game Theory* Osborne and Rubinstein [1994]. The basic idea here is that success of an IT solution requires a blend of well designed software (i.e., usability) and carefully crafted policies aimed at achieving user participation [Piras et al., 2017a]. Moreover participation strongly depends on the inner motivation of participants [Piras et al., 2017a]. A number of studies on organizational theories have concluded that motivation can be the result of heterogeneous reasons, and might result from incentives offered to the performer or from intrinsic desire [Piras et al., 2017a]. Motivation is intrinsic if the performer enjoys the act of performing the task *per se*. In all other cases, a set of extrinsic incentives can be provided in order to make an individual/team perform. Incentives are a set of instruments (e.g., money, reputation, rewards, prices, credit points, medals) assigned by an external “judge” according to an evaluation of the effort exercised by the performer. In principle, these can be totally uncorrelated to the nature of the task [Piras et al., 2017a].

In order to achieve a satisfactory level of participation a set of methods and techniques have been adopted, often referred to as mechanism design in the field of economics, that can be used to develop incentives, which can be embedded into IT solutions (as in a gamified solution) Cuel et al. [2011]. *Mechanism Design* is a field of game theory developed in economics that studies the effective design of rules for human behavior [Piras et al., 2017a]. If individuals follow these rules, they achieve the outcome desired by the game designer [Piras et al., 2017a]. The underlying hypothesis is that individuals act according to their own private interests and only a careful development of appropriate incentives can enable the alignment of individual and social interests [Piras et al., 2017a]. To develop a set of incentives from the *Mechanism Design* perspective, developers need to understand the social environment (the context) and codify its constraints in game theory terms Osborne and Rubinstein [1994].

MAF focuses on sociability design Bouman et al. [2007] and in particular on the first two phases of the software development process: the analysis of the use scenario prior to application design and the fine tuning process of the incentive structure [Piras et al., 2017a].

MAF is based on four main variables that play an important role in influencing the performance of actors Simperl et al. [2013], Tokarchuk et al. [2012]. The four variables are [Piras et al., 2017a]: **(i) Goal** of any activity; **(ii)** the set of **Tasks** a person has to carry on in order to pursue the goal; **(iii)** the **Social Structure** within which the actor acts (a team of peers, a company, a community); **(iv)** the **Nature of Good** being produced

(public, club or private good). These are represented in Figure 8.5 and briefly summarized below.

Goal		Tasks		Social Structure	Nature of good being produced
Communication level (about the goal)	High	Variety	High	Hierarchy-neutral	Public good (non rival, non exclusive)
	Medium		Medium		
	Low		Low		
Participation level (in defining the goal)	High	Specificity	High		
	Medium		Medium		
	Low		Low		
Clarity level	High	Identification	High	Hierarchical	Private good (rival, exclusive)
			Low		
	Low	Required skills	High specificity		
			Triivial common		

Figure 8.5: The Motivational Antecedents Framework and its context variables [Piras et al., 2017a]

The **Goal** is what people want to pursue and their aspiration to achieve it [Piras et al., 2017a]. Three main elements shape the pursuit of a goal by a group of people [Piras et al., 2017a]:

- the **communication level** about the goal. This element determines the kind of communication that exists among participants. A low communication level implies that the goal is not clearly defined and communicated;
- the **participation level** of actors. This element is key to understand the role of actors in defining the goal to be achieved;
- the **clarity** of the goal. This element identifies whether and to what extent the goal to achieve is clear to the actors.

These three elements shape the aspiration level of actors in achieving a goal [Piras et al., 2017a]. For instance, a designer might raise the aspiration level of the player by means of intensive communication and participation, through which individuals understand and redefine the goal, getting more and more committed [Piras et al., 2017a]. So, a reasonable difficulty level significantly correlates with motivation and how much effort and persistence individuals will exert to achieve their goals Barnard [1968], Locke and Latham.

The **Task** refers to the set of actions actors have to carry out in order to achieve a goal [Piras et al., 2017a]. Various elements affect individuals' inner motivations that, in

#### 8.4. AGON EXTENSION GUIDELINES AND INTEGRATION WITH THE MAF FRAMEWORK

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turn, influence their performance in terms of quality and speed of performed actions [Piras et al., 2017a]. These elements are [Piras et al., 2017a]:

- **Variety.** Refers to the multiplicity of activities needed to perform the job. It correlates positively with individuals' competencies and ability to coordinate multiple activities and adapt to change;
- **Specificity.** Refers to the level of knowledge uncommonness required for the task;
- **Identification.** Refers to the extent to which people perceive a job as a complete set of steps that lead to clear results Griffin [1982] individuals tend to appreciate being able to produce a meaningful outcome that is identifiable as their own;
- **Required skills.** It is the set of knowledge and competences required to carry out the tasks. As much as the required skills are meaningful the motivation of participants is crucial.

The **Social Structure** denotes a set of relationships that occur among individuals involved in pursuing a goal [Piras et al., 2017a]. Social norms have a strong influence on the channels of communication, coordination mechanisms, beliefs and views, feelings, and motivations that affect these relationships Prendergast [1999], Ross [1973], Simon [1967]. The social structure might be summarized in two main scenarios [Piras et al., 2017a]. The first scenario is that of the social structure being a **hierarchical** organizational. This means that there is a hierarchy among people working within the organization. It also means that the relationships among people may be affected by the so called *Principal Agent* relationship in which the principal delegates an agent to deal with a specific task [Piras et al., 2017a, Ross, 1973]. In this case the agent has the obligation to deal with the task and the principal needs to control it (as in a employer-employee relationship) [Piras et al., 2017a]. In **hierarchical neutral** organization there is no formal obligation among actors; participants are thus a group of peers [Piras et al., 2017a].

The **Nature of the Good** describes the relationship between the producer and consumer of the good [Piras et al., 2017a]. **Private goods** are excludable and rival, namely a specific user can take exclusive advantage of it (consumers might have to pay to use it) [Piras et al., 2017a]. By contrast, **public goods** are neither rival nor excludable [Piras et al., 2017a]. Namely, as soon as they are created any individual can use them, and nobody can be excluded [Piras et al., 2017a]. Typically, if the good is private the creator wants to be payed for it, while if it is public the creator creates it for free as a “noble” cause [Piras et al., 2017a].

As explained in Cuel et al. [2011], the ideal process of design and development of an incentivized (gamified) application should start from an analysis of the concrete situation. The field analysis is crucial to identify the motivations of both individuals and the social groups they belong to [Piras et al., 2017a]. Direct observations, interviews and questionnaires are very effective techniques that can be used to unveil and better define the crucial elements discussed earlier [Piras et al., 2017a]. Then, mechanism design, as a set of techniques, allows the modeling of the situation by using game theoretical predictions about the behaviors of the actors described in the model [Piras et al., 2017a]. Given a set of goals, this model enables the analysts to design a set of incentive schemes that would spur users to behave in line with desired outcomes [Piras et al., 2017a].

### 8.4.3 Case Study Using Agon and MAF

In order to conduct our case study [Piras et al., 2017a], for showing the two different frameworks and methodologies in action, we use the *Meeting Scheduler Exemplar* [Piras et al., 2017a], a well-established exemplar used in the *Requirements Engineering* research. To focus on game mechanics, motivational factors, and other incentives that spur people to coordinate via ICT tools, we propose a *Doodle-like version* of it [Piras et al., 2016, 2017a]. This version is the one described in Section 5.1.1. In the meeting scheduler exemplar, as in most of social software systems, participation is a critical requirement, since lack of participation renders the system a failure.

In the following, we first briefly recap the exemplar (for the full description see Section 5.1.1), then apply the MAF framework for purposes of gamification. In this case study [Piras et al., 2017a] we applied also Agon to the exemplar, this is fully illustrated in Chapter 5.

### Doodle-Like Meeting Scheduler Exemplar and Intended Users

The system to gamify, in this case study [Piras et al., 2017a], is the Meeting Scheduler Exemplar adapted to Doodle Piras et al. [2016, 2017a]. It is fully illustrated in Section 5.1.1 Piras et al. [a]. In summary, the requirements for this meeting scheduler include scheduling of meetings, after taking into account participant constraints. In addition, the system should be used by the majority of intended users. Specifically, they should use a Doodle<sup>5</sup> table to input their time constraints for the period when the meeting is to be held [Piras et al., 2016, 2017a].

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<sup>5</sup><https://doodle.com>

#### 8.4. AGON EXTENSION GUIDELINES AND INTEGRATION WITH THE MAF FRAMEWORK

In addition, we need to characterize intended characteristics of the users and the social context in which they act [Piras et al., 2016, 2017a]. The scenario used in this case study is a meeting scheduled for full professors at a university. As it may happen in various universities, the group of people for this case study is composed mostly of senior male professors and achievers as potential players Bartle [1996]; the users are not experts regarding use of Doodle or similar software, and it is not mandatory for them to fill the Doodle [Piras et al., 2016, 2017a].

#### Using the Motivational Antecedents Framework

MAF enables designers to focus the analysis on individual inner motivations, the motivation of the social group (interaction with others), the task that should be performed and the social context in which actors are involved [Piras et al., 2017a].

The designer can analyze the goal, the task, the social structure and the nature of good being produced via direct observations, interviews and questionnaires with the users of the IT solution [Piras et al., 2017a]. In the specific case of the meeting scheduler, the results are highlighted in bold in Figure 8.6.

Goal		Tasks		Social Structure	Nature of good being produced
Communciation level (about the goal)	High	Variety	High	Hierarchy-neutral	Public good (non rival, non exclusive)
	Medium		Medium		
	Low		Low		
Participation level (in defining the coal)	High	Specificity	High		
	Medium		Medium		
	Low		Low		
Clarity level	High	Identification	High	Hierarchical	Private good (rival, exclusive)
			Low		
	Low	Required skills	High specificity		
			Triivial common		

Figure 8.6: Motivational Antecedents Framework and its elements highlighted (in bold) for this study [Piras et al., 2017a]

The **Goal** is to find a suitable time slot for the meeting [Piras et al., 2017a]. The **Goal** is simple and very clear, therefore it is very intuitive. As a consequence people do not need to understand it any better, nor do they need to communicate or participate in defining the goal. The participants, all professors, clearly understand the single message sent to them asking for a free slot in their agenda. Participation also is easy and can be even asynchronous or via short messages [Piras et al., 2017a].

Analyzing the **Task** we reason as follows [Piras et al., 2017a]: the set of activities needed to achieve the goal are very simple, easy to understand, and have low level of variability. Namely if the task is getting to be repeated several times, participants will get bored. The task also requires a low level of specificity and trivial skills. Even if professors are not used to technology for scheduling meetings, the user interface and the actions to be taken are very intuitive and the identification of the task is very low [Piras et al., 2017a].

In the case study the **Social Structure** refers to the interaction that professors have in their context [Piras et al., 2017a]: the university. Considering the fact that they belong to the same institution, they play the same role in the organization (as described previously, they are all full professor), thus, we can consider the social structure as a hierarchical neutral setting [Piras et al., 2017a].

Finally, the **Nature of Good being produced** is a public good, or better a club good [Piras et al., 2017a]. This means that the final result will be shared by all invited professors, the benefit is shared even if one or more professor did not spend any effort in performing the task and providing the date. In a public good and club good situation, the free riding effect is a concrete risk that designers should take into consideration when a set of incentives/game mechanics are developed [Piras et al., 2017a].

Once the main variables have been analyzed, the designers can take advantage of mechanism design theories and best practices to gamify the IT solution [Piras et al., 2017a]. By using game theoretical predictions about human behaviors, some game mechanics can be implemented in the IT solution in order to address specific behaviors [Piras et al., 2017a]. These activities are not supported by MAF, because they are usually carried out by experts who master specific knowledge and make decisions based on their own expertise and experiences [Piras et al., 2017a].

In any case, the set of game mechanisms that should be implemented are as follows [Piras et al., 2017a]:

- training is not important because the task is very simple, clear and intuitive;
- reward points are helpful only if there is a sort of competition among participants, better if the group is small and is composed of friends;
- in order to improve task significance, the number of participants in the scheduling activity should be reduced. In this case, the final result will strongly depend on the active participation of all the professors;
- considering the social structure of the case study, professors will be motivated more if the meeting refers to a very important issue that may affect the professors' careers.

In this case, no matter what technology is available, participants will act;

- in order to improve the task significance, information about participation (points, stars, etc.) should be made available to all, this reduces the so called free riding problem. The free riding problem occurs when the nature of good is public, namely the result provide benefit to all participants even those who didn't make any contribution.

One of the most common practices in organizations is to implement a set of incentives (game mechanics) *ad hoc* created and tested with real users [Piras et al., 2017a]. Due to the fact that humans learn and change their behaviors accordingly, the set of incentives and game mechanics should be continuously fine tuned [Piras et al., 2017a].

#### 8.4.4 Comparison of Agon and MAF

In the following, we compare the two frameworks [Piras et al., 2017a], and then in Section 8.4.5 suggest the guidelines for extending Agon and integrating it with other frameworks/methodologies [Piras et al., 2017a], by considering the future integration of Agon and MAF as a valuable specific case for illustrating the guidelines [Piras et al., 2017a]. The comparison is a necessary step for identifying distinct and common elements or procedures of the two frameworks [Piras et al., 2017a].

Our comparison covers [Piras et al., 2017a]:

1. the context variables used by each framework;
2. special cases of context variables;
3. how acceptance and gamification concepts and best practices are captured and supported by the two frameworks;
4. the analysis supported by each framework for each of the gamification phase.

#### Comparison of Context Variables

It is important to emphasize that context variables are strategic elements because different solutions apply depending on their values [Piras et al., 2017a]. Looking at MAF context variables, mainly characterize the social environment (e.g., the task and the working environment) that affects user behavior [Piras et al., 2017a]. On the other hand, Agon adopts a user perspective, the software to be used, and the psychological and cognitive factors for engaging the user [Piras et al., 2017a]. Therefore, according to Figure 8.4,

MAF is more focused on the **Social Context**, the **Activity** and the **Outcome**, plus the related sub-variables expressed in MAF [Piras et al., 2017a] (Figure 8.5). Instead, Agon is focused on aspects of the **User** and of the **Acceptance Subject** (Figure 8.4), plus related sub-variables supported in the framework [Piras et al., 2017a].

In Figure 8.7, we can see that most of the variables of the two frameworks are largely disjoint [Piras et al., 2017a]. Some concepts have overlaps in meaning [Piras et al., 2017a]

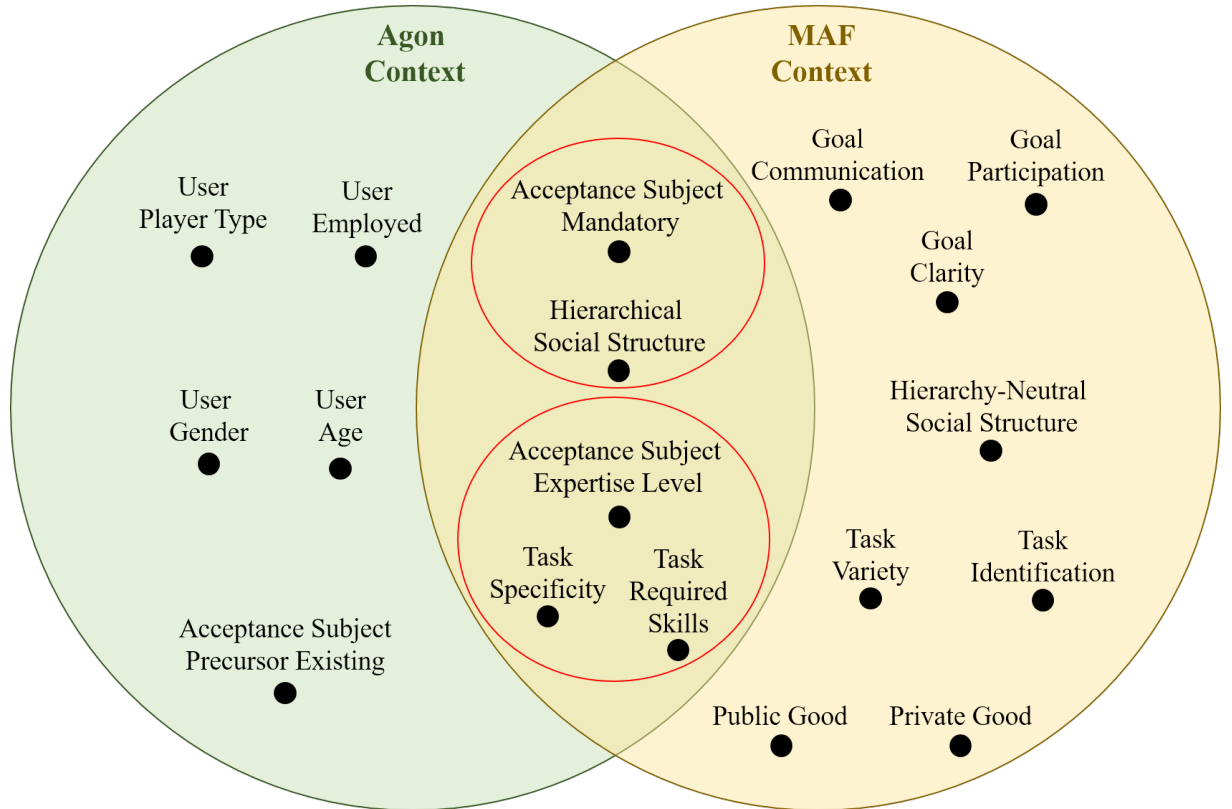


Figure 8.7: Comparison of the context variables of the two frameworks [Piras et al., 2017a]

(circled groups in the middle of Figure 8.7):

1. the couple **Acceptance Subject Mandatory** and **Hierarchical Social Structure**;
2. the triple **Acceptance Subject Expertise Level**, **Task Specificity** and **Task Required Skills**.

In the first case [Piras et al., 2017a], the social perspective focuses on the presence or not of a hierarchy, namely if a person has to use the system in a social context that is hierarchical, meaning that the person is obliged to do it. Moreover, the **Acceptance Subject Mandatory** variable of Agon has the same meaning. The second case [Piras et al.,

2017a] is analogous to the previous one, but refers to common elements related to similar facets of the user experience that encourage acceptance.

Additionally, there are some hidden aggregated concepts (Figure 8.7) that are not explicit [Piras et al., 2017a]. For instance, the complexity of the task expressed by the triple **Task Variety**, **Task Specificity** and **Task Required Skills** (required skills for executing the task, which in MAF can be trivial common or highly specific), or social aspects differentiated by individual ones [Piras et al., 2017a]. In fact, **Acceptance Subject Expertise Level**, **Acceptance Subject Mandatory** and **Acceptance Subject Precursor Existing** can be classified as individual aspects, differently from social aspects such as **Hierarchical Social Structure** and **Hierarchy-Neutral Social Structure** [Piras et al., 2017a].

### Comparison of Special Cases for Context Variables

In the following, we examine more closely special cases where the two framework interpret differently some concepts or, as in the case of Agon, capture them through other models beyond the user context model [Piras et al., 2017a].

MAF includes the concept *Role of the User* in the social structure, referring to relationship among individuals according to their competences and abilities in dealing with the task or in maintaining relationships with others [Piras et al., 2017a]. Agon considers *Role of the User* as derived from the characterization of the user and it is to be considered in selecting psychological factors to employ [Piras et al., 2017a].

Regarding *Goal*, MAF considers it as a dependent variable affected by other sub-dimensions [Piras et al., 2017a]: communication level, participation in defining the goal, and clarity level. For instance, when a goal is very simple (propose a date for a meeting) the clarity level is very high and people do not need to discuss it. Therefore a set of individual incentive/game mechanisms can be implemented [Piras et al., 2017a]. For Agon, this goal constitutes a stakeholder goal and it is complemented by acceptance requirements to be fulfilled through psychological factors and gamification strategies [Piras et al., 2017a].

Regarding *Social structure*, MAF considers it as a collection of relations that actors may establish, even offline [Piras et al., 2017a]. On one hand, these can be "peer to peer relations" where reputation matters. On the other hand, they may represent the so-called principal agent situation where an agent can take actions on behalf of the principal. If agent and principal have different goals, the agent can act in her own best interests, even against the principal's goals. Therefore, a set of incentives and game mechanics should be implemented in order to spur the agent to act according to the principal goals [Piras et al., 2017a]. Agon, considers this only indirectly because it is focused on acceptance

requirements to be fulfilled by psychological factors and gamification strategies [Piras et al., 2017a].

### Comparing Acceptance and Gamification Concepts and Best Practices

Agon models the knowledge related to acceptance as psychological strategies in the acceptance model [Piras et al., 2017a]. Gamification concepts and best practices are captured in the gamification model. Psychological/cognitive rules that affect positively the user concerning the psychological and engagement levels are captured in Agon by CDRs annotating the relationships of the acceptance and gamification models. CDRs refer to important characterizations aspects (for acceptance and gamification) captured in the context user model [Piras et al., 2017a]. Analogously, MAF models context variables relevant to acceptance and gamification in a tabular shape [Piras et al., 2017a]. Those context elements and their sub-variables concerning the goal, task, social context and good are valuable for the selection of the most suitable incentives. However, MAF does not support or model directly best practices/patterns from acceptance and gamification [Piras et al., 2017a]. Therefore, the analyst needs to have sufficient expertise and knowledge to identify game mechanisms for gamified IT solutions [Piras et al., 2017a]. Nonetheless, the method used with MAF encompasses techniques, drawn from Organizational Behavior and Mechanism Design, that can help the analyst. Accordingly, these are important candidate elements to integrate with the Agon framework [Piras et al., 2017a].

### Comparison of Analysis

Table 8.1 compares the two analysis techniques supported by the two frameworks [Piras et al., 2017a].

Table 8.1: Comparison of methodologies and support provided by the two frameworks to the analyst [Piras et al., 2017a]

	Agon and its Method	MAF and its Method
<b>Context Analysis</b>	[Supported, Manual, Analyst experience]	[Supported, Manual, Analyst experience]
<b>Acceptance Analysis</b>	[Supported, Systematic and tool-supported, Analyst experience]	[Not supported, Manual, Analyst experience]
<b>Gamification Analysis</b>	[Supported, Systematic and tool-supported, Analyst experience]	[Not supported, Manual, Analyst experience]
<b>Gamification Instantiation</b>	[Supported, Manual, Analyst experience]	[Not supported, Manual, Analyst experience]

Concerning *Context Analysis* (Table 8.1), Agon includes the user context model that captures important context variables to analyze [Piras et al., 2017a]. The analyst uses her experience and knowledge of the specific domain (of the system to be gamified) for instantiating manually the variables of the user context model [Piras et al., 2017a]. MAF

#### 8.4. AGON EXTENSION GUIDELINES AND INTEGRATION WITH THE MAF FRAMEWORK

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offers analogous support presenting its context variables in a tabular form [Piras et al., 2017a].

Regarding *Acceptance Analysis* (Table 8.1), Agon supports the analyst in a systematic, tool-supported and interactive process [Piras et al., 2017a]. The analyst feeds as input an instance of the user context model, then Agon reasons over the acceptance model, and finally suggests the most suitable set of psychological strategies. The analyst then decides which strategies to adopt [Piras et al., 2017a]. MAF, being a theoretical model, does not offer a direct support for this phase. Nevertheless, thanks to the results of the context analysis carried out before and the analyst expertise, the framework supports the selection of the most suitable strategies [Piras et al., 2017a].

For *Gamification Analysis* (Table 8.1), Agon supports the analyst in a systematic, tool-supported and interactive process [Piras et al., 2017a]. As with the previous phase, Agon takes into account the instance of the user context model provided, the final set of needs and the tactics selected by the analyst in the previous phase. On the basis of these elements, Agon reasons over the gamification model and recommends to the analyst the most suitable set of gamification goals and best practices for the problem-at-hand. Finally, the analyst decides on the recommendations provided [Piras et al., 2017a]. MAF, on the contrary, does not offer direct support for this phase, but rather relays on the analyst's experience and competence to select gamification concepts and strategies to adopt. Nonetheless, context analysis done with MAF can help the analyst also for taking some decisions during this task [Piras et al., 2017a].

The last phase, *Gamification Instantiation* (Table 8.1), selects and completes the gamification solution. Agon proposes instantiations of the generic gamification goals and best practices by using a modeling notation adopted from the *NFR Framework* Chung et al. [2012]. Even though Agon supports tools for carrying out this activity, the analyst has to do it manually, by instantiating generic gamification solutions into specific solutions including specific domain elements [Piras et al., 2017a]. MAF method does not support the gamification instantiation and the analyst has to do it manually. Nonetheless, context analysis done with MAF can help the analyst to make some of the relevant decisions [Piras et al., 2017a].

##### 8.4.5 Guidelines for Extending and Integrating Agon

Here, we provide the guidelines for extending Agon and integrating it with other frameworks/methodologies [Piras et al., 2017a], by considering the future integration of Agon and MAF as a valuable specific case for illustrating the guidelines [Piras et al., 2017a].

Furthermore, the comparison we performed allows the collection of information valuable for carrying on the activities related to the guidelines. In fact, the comparison helps in identifying valuable elements or procedures to be extracted from the other frameworks/methodologies, and to be integrated in the Agon framework [Piras et al., 2017a]. Moreover, on the basis of the guidelines provided, and the information collected with the comparison, we envisage the integration of the two frameworks [Piras et al., 2017a]. Therefore, the following guidelines, even described by using the case of Agon and MAF, have general applicability to most of the cases where it is desired to extend Agon or to integrate it with other frameworks/methodologies [Piras et al., 2017a].

Agon, thanks to its engineering perspective but also an orientation toward cognitive analysis, can provide a baseline architecture where to insert theoretical concepts coming from the motivational framework of MAF [Piras et al., 2017a]. For the integration, we envision the following activities [Piras et al., 2017a]:

1. design of a common context model;
2. collection of psychological strategies and gamification best practices;
3. translation of collected elements in CDRs and application of them in Agon models;
4. intra-model and inter-model revision for the entire framework to ensure balance and coherence.

Firstly, we have identified important high-level context variables for gamification regarding user acceptance of a system, as in Figure 8.4, and we should start the integration from this. In fact, those variables are partially covered by Agon and MAF. Thus, it is needed to design a common context model able to capture all these elements [Piras et al., 2017a]. As discussed in the comparison, among the two frameworks there are some variables that are disjoint, while others have overlaps and others include implicit, aggregated concepts. Therefore, the context model will be designed by [Piras et al., 2017a]:

- including additional variables;
- deciding how to represent variables that have similar meaning;
- refactoring the entire model for reaching homogeneity among concepts.

We propose to start from the User Context Model of Agon and decide how to integrate MAF variables [Piras et al., 2017a]. At the moment the model is focused on the user, thus, we envision a more general perspective where the user is one of the high-level context

#### 8.4. AGON EXTENSION GUIDELINES AND INTEGRATION WITH THE MAF FRAMEWORK

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variables. Moreover, during the integration of MAF variables, we need to consider overlaps among Agon and MAF variables and implicit aggregated concepts for refactoring the entire model [Piras et al., 2017a]. Finally, during and after the refactoring it should be verified the homogeneity of all the concepts keeping a coherence with the result in Figure 8.4 and studies and theories behind it [Piras et al., 2017a].

Then, on the basis of the new context model we need to design new psychological strategies and gamification best practices [Piras et al., 2017a]. Their elements will be extracted mostly from MAF context variables and background theories. Most of them will be translated into CDRs and/or goals to be included in the acceptance, tactical and gamification models of Agon [Piras et al., 2017a].

The intra-model and inter-model revision of the entire framework is a crucial task [Piras et al., 2017a]. It is fundamental for re-establishing balance and coherence among all the new concepts and rules introduced inside the single model and, keeping in mind a comprehensive framework perspective, in relation to the dependencies among the different Agon models [Piras et al., 2017a]. It is important, because the integration starts using the architecture of Agon that is a well-balanced and coherent structure of goals organized at different abstraction layers, and adding new CDRs and concepts this stable situation can be altered and, thus, the entire framework has to be checked and tuned [Piras et al., 2017a]. We suggest to consider it during the entire integration process in parallel with the other activities, evaluating for each new addition both the intra- and the inter-model implications [Piras et al., 2017a]. Eventually, it could be further verified and evaluated also if in the new resulting framework special cases of context aspects, analyzed in the comparison of the context variables, are properly captured by the context model or other models [Piras et al., 2017a].

##### 8.4.6 Discussion and Conclusions

We have presented the guidelines for extending Agon and integrating it with other methodologies/frameworks [Piras et al., 2017a], and a comprehensive comparison of two frameworks for software gamification, Agon and MAF [Piras et al., 2017a]. The two frameworks have their origins in strikingly different disciplines, even though they are tackling basically the same problem. Our comparison consisted of applying each framework to a meeting scheduling system, noting concepts used, forms of analysis employed, and the final outcomes consisting of gamification solutions for the meeting scheduler. Given the outcomes of the meeting scheduling case study, we have conducted a careful comparison of the two frameworks, noting relative strengths and weaknesses as well as gaps in the

concepts, tools and techniques they offer [Piras et al., 2017a]. In addition, we have conducted an initial investigation on how to combine elements of the two frameworks into a single framework for designing gamified solutions for acceptance requirements [Piras et al., 2017a].

A major conclusion of our study is that MAF is more focused on behavioral game-theoretic interactions between user and system, while Agon emphasizes individual cognitive characteristics of users and how gamification mechanisms can affect them [Piras et al., 2017a]. Moreover, the support provided by MAF is mostly conceptual, rather than operational, providing the theoretical elements for analyzing and characterizing the contextual dimensions of the problem. This support can help the gamification analyst to take into consideration crucial elements that are useful in selecting the most suitable incentives to design a gamification solution [Piras et al., 2017a]. Moreover, MAF, in contrast to Agon, considers additional relevant behavioral dimensions for gamification. On the other hand, Agon is a requirements engineering framework that supports the analyst to derive a gamification solution, given acceptance requirements for a base system [Piras et al., 2017a].

As for future work, we envision an integration of the two frameworks to accommodate their respective concepts and analysis techniques for generating gamification solutions for acceptance requirements [Piras et al., 2017a]. In particular, we envisage that Agon, thanks to its gamification engineering nature but also an orientation toward cognitive analysis, will serve as baseline architecture [Piras et al., 2017a]. The resulting innovative and holistic framework will guide the requirements engineer in designing a gamified solution while taking into consideration organizational behavioral and social contextual aspects as much as cognitive and psychological ones [Piras et al., 2017a].

## **8.5 Integrating Agon with Design Thinking**

In this Section, we illustrate the research preview concerning the integration of Agon and Design Thinking, a future work we already started within the SUPERSEDE<sup>6</sup> EU project, for defining a collaborative method for gamification design [Piras et al., 2018a]. Unfortunately, Agon is not specifically designed to perform collaborative gamification design. Therefore, it is necessary to find another method, closer to collaborative design, for enhancing Agon. First of all, we started abstracting the concept related to our final objective, and identified key requirements for a collaborative gamification design method. Then, we individuated two candidates, fulfilling the key requirements, for building such

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<sup>6</sup><https://www.supersede.eu/>

method, i.e. Agon and Design Thinking. In the following, we briefly introduce the research context and outline the research questions of this study [Piras et al., 2018a].

The acceptance of a software system, i.e. motivating people in accepting and using a software system is a crucial factor for the success of such systems [Piras et al., 2016, 2017a,b]. *Gamification* has been identified as a mean to meet such *acceptance requirements* [Piras et al., 2016, 2017a,b] through the inclusion of game elements and mechanisms in systems that operate in non-game contexts [Deterding et al., 2011] (e.g., air traffic management and decision making [Piras et al., 2017b], software engineering tasks [Pedreira et al., 2015]). Practitioners tend to use available gamification guidelines and resources, which are provided in commercial platforms or in publicly available wikis<sup>7</sup>. However, research literature on gamification design and on the evaluation of the effectiveness of the resulting solutions, points out the limits of current practices, identifies key concepts and discuss the need of specific methods to design engaging software, e.g. [Hamari, 2015, Koivisto and Hamari, 2014b, Piras et al., 2017a, 2018a]. In particular, systematic methodologies should guide designers in the exploration of a design space of alternatives [Piras et al., 2016, 2017a,b]. Such a design space is defined in terms of motivational, psychological, cognitive, behavioral factors [Piras et al., 2017a] that influence the fulfillment of *Acceptance Requirements* [Piras et al., 2016, 2017b].

The goal of our research is to define a collaborative, lightweight and effective method at support of designers of gamified solutions [Piras et al., 2018a]. We structure our research along the following research questions (RQs) [Piras et al., 2018a]:

**RQA** What are the key requirements for a collaborative, lightweight method for designing engaging software systems?

**RQB** How can we select and combine existing methods to obtain such method?

To answer **RQA** we analyzed related literature and lessons learned from documented case studies to derive key requirements for such method [Piras et al., 2018a]. A first set of requirements [Piras et al., 2018a] is described in Section 8.5.1. We addressed **RQB** by analyzing characteristics of existing methods that can be related to the stated key requirements [Piras et al., 2018a] and, in Section 8.5.2, we provide an example of two candidate methods that, integrated together, can build such a method fulfilling those requirements [Piras et al., 2018a]. One is *Design Thinking* (DT) [Brown and Katz, 2009], a popular design technique for solving problems in IT, Medicine, Architecture and other disciplines concerned with design problems [Piras et al., 2018a]. The other is the method

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<sup>7</sup>e.g. [https://en.wikipedia.org/wiki/Game\\_mechanics](https://en.wikipedia.org/wiki/Game_mechanics)

of the *Agon framework* [Piras et al., 2016, 2017a,b] for analyzing acceptance requirements and operationalizing them through game elements [Piras et al., 2018a]. In Section 8.5.3, we conclude with future work and final remarks.

### 8.5.1 Towards Identifying Key Requirements for a Collaborative Gamification Design Method

Towards addressing **RQA**, we analyzed the literature and practical experiences, from real case studies (e.g., 3 industrial use cases [Busetta et al., 2017, Kifetew et al., 2017] within the SUPERSEDE<sup>8</sup> EU project) and from the industry, and reflected on aspects related to the gamification of tasks in terms of stimuli and game elements and, more generally, on the need of a structured method that supports designers to explore in a systematic but creative way alternative gamification solutions [Piras et al., 2018a]. Specifically, we extended the lessons learned derived for Agon, and the key requirements for Agon, including aspects necessary for a *collaborative* gamification design method [Piras et al., 2018a]. In the following, we provide such lessons learned and key requirements.

The next ones are the lessons learned we derived [Piras et al., 2018a]: **LL1** points-based game elements have to be integrated with other game mechanisms to achieve a deeper and more persistent engagement; **LL2** understanding users' motivations and identifying appropriate leveraging mechanisms call for the use of the integration of creative and collaborative design methods; **LL3** a deeper understanding of acceptance requirements is key to help to identify design elements to keep the software system attractive and engaging, in relation to the specific context of use; **LL4** a balance among a systematic approach, collaboration and creativity should be enabled by a method at support of gamification designers.

While, the key requirements for a collaborative, lightweight and effective method, we identified so far, are [Piras et al., 2018a]: **R1** systematic approach; **R2** participation/collabo-  
ration; **R3** creativity; **R4** acceptance orientation; **R5** gamification orientation; **R6** context characterization; **R7** guiding approach; **R8** solution ideation.

Therefore, the method [Piras et al., 2018a] has to be systematic [Piras et al., 2016, 2017a,b] (**R1**, **LL4**) (**a**) allowing the exploration of most of the factors influencing the user in being motivated to use software [Koivisto and Hamari, 2014b, Piras et al., 2017a] (**LL3**), and (**b**) employing effective techniques for analyzing those factors and designing mechanisms able to satisfy them [Piras et al., 2017b] (**LL1**, **LL3**).

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<sup>8</sup><https://www.supersede.eu/>

To address factors of **(a)** [Piras et al., 2018a], techniques and mechanisms mentioned in **(b)** [Piras et al., 2017b] are needed as well as deeply involving stakeholders [Busetta et al., 2017, Inayat et al., 2015] (**R2, LL2**) in a collaborative (**R2, LL2**), creative (**R3, LL2**) way [Inayat et al., 2015]. To involve stakeholders in the design is fundamental [Piras et al., 2018a], because they have the knowledge required for analyzing deeply the specific domain, the situation and the user [Busetta et al., 2017, Inayat et al., 2015]. Collaboration [Busetta et al., 2017] (**R2**) pushes them to a good brainstorming finding more valuable ideas together. Creativity [Inayat et al., 2015] (**R3**) stimulates them in finding more enriched and complete solutions [Piras et al., 2018a]. Thus, techniques mentioned in **(b)**, to maximize their effectiveness [Piras et al., 2018a], should be executed in a participatory, collaborative and creative fashion [Busetta et al., 2017, Inayat et al., 2015].

The final aim of the method is to design engaging software for the user, thus, it is fundamental to explore most of the factors [Piras et al., 2018a] (see **(a)** above) that positively influence the user such as psychological, motivational, cognitive and behavioral factors [Piras et al., 2017a] (**R4, LL3**). These are usually referred to *Acceptance Requirements* [Piras et al., 2016, 2017a,b] and related techniques [Piras et al., 2017b]. They are crucial for selecting psychological strategies as design mechanisms to use to make attractive the software [Piras et al., 2016]. Thus, the method has to be acceptance oriented [Piras et al., 2018a] (**R4, LL3**).

Factors analyzed through acceptance requirements have to be mapped with gamification concepts able to fulfill such requirements. It is important to choose those concepts as well as to decide properly how to put them together in a coherent and effective gamification design [Piras et al., 2016]. Such method has to support both these aspects [Piras et al., 2018a], namely it has to be gamification oriented (**R5**). With **R5**, we mean that the method incorporates the gamification design knowledge [Piras et al., 2017b] (**LL1**), and related techniques, able to support the designer in producing a high-quality gamification design made of concepts, satisfying acceptance requirements, organized according to gamification best practices [Piras et al., 2016] (**LL1, LL3**).

The identification of acceptance and gamification strategies that are effective for a specific kind of user, depends strictly on the specific context variables [Piras et al., 2016, 2017a,b] (**LL1, LL3**). Thus, such method has to support the characterization [Piras et al., 2018a] (**R6**) of context variables such as the human as a user and as a player [Piras et al., 2016], the goals and needs of the user, the task that the user carries out by using the software and related positive and negative user feelings, what can be produced by using the software and in which social context [Piras et al., 2017a] (**LL3**). Furthermore, a method supporting **R6** [Piras et al., 2018a] uses these considerations in individuating

which acceptance and gamification strategies best fit the specific context [Piras et al., 2017b] (**LL3**).

Moreover, such method is a guidance (**R7**, **LL1**, **LL3**) for analysts and stakeholders [Piras et al., 2016, 2017a,b] meaning that it has to [Piras et al., 2018a]: **(i)** guide them in all the phases with techniques supporting all the other aspects [Piras et al., 2016, 2017b], **(ii)** make them explore as many as possible relevant elements [Piras et al., 2017a] and, above all, **(iii)** provide suggestions concerning psychological strategies, gamification concepts and best practices to use that are the most suitable ones for the context characterization [Piras et al., 2016, 2017b] (**R6**).

Finally, the method, to make more concrete suggestions obtained (**R7**) and ideas produced [Piras et al., 2018a], has to support techniques for devising a solution [Busetta et al., 2017, Inayat et al., 2015] (**R8**, **LL2**) in a collaboratively and creative way (e.g., collaborative sketching, prototyping, producing wireframes or mockups [Busetta et al., 2017, Inayat et al., 2015] (**R8**, **LL4**)).

### 8.5.2 An Example of Candidate Methods

As an example of how we intend to address **RQB**, we consider two methodologies, *Design Thinking* (DT) and the *Acceptance Requirements Analysis* of the *Agon framework*, that separately are able to cover partially the requirements above [Piras et al., 2018a].

#### Design Thinking

DT [Brown and Katz, 2009] allows participants to collaborate closely, generating many ideas and concepts, for devising a solution that best suits the initial problem [Piras et al., 2018a]. This participatory feature can be exploited involving in the process people from heterogeneous teams and, above all, having different knowledge for analyzing the problem from different design perspectives [Piras et al., 2018a]. The method is characterized by different activities [Piras et al., 2018a]: *Personas Definition*, where participants empathize with the typical users to understand their goals, needs and frustrations; *Problems Investigation*, where participants define the typical day of the user, by describing activities and positive/negative feelings; *Solution Ideation*, where participants creatively generate ideas and decide which should be used in next phases; *Prototyping* of a possible solution and *Solution Testing and Presentation*.

**Agon: Acceptance Requirements Analysis based on Gamification**

The Agon framework [Piras et al., 2017b] and its method [Piras et al., 2016, 2017a] are the state-of-the-art in the requirements engineering research community, for supporting the analyst in analyzing acceptance requirements and fulfilling them with gamification design concepts [Piras et al., 2018a]. Furthermore, Agon provides the analyst with models [Piras et al., 2017b], techniques [Piras et al., 2016, 2017a] and a tool for executing its method, a systematic acceptance requirements analysis based on gamification [Piras et al., 2018a]. In a first phase of the method, the analyst defines and elicits acceptance requirements on the basis of the context characterization. The analyst supported by Agon analyzes and characterizes the (as-is/to-be) software, looking for the crucial functionalities to be gamified, focusing on functionalities that are complex, or not attractive and whose fulfillment lead to the fulfillment of software goals. Moreover, Agon allows to characterize the user, specifying age or gender, her player categories (e.g., socializer, achiever, explorer) or her expertise regarding software usage [Piras et al., 2018a]. In a next phase the analyst can use the Agon Acceptance Model [Piras et al., 2017b] to receive suggestions, as psychological needs and strategies that best fit the specific context [Piras et al., 2016, 2017a] identified in the first phase [Piras et al., 2018a]. As last phase the analyst can use the Agon Gamification Model [Piras et al., 2017b], containing different gamification elements, for producing a gamification design as a solution [Piras et al., 2018a].

**Why Design Thinking and Agon are Candidate Methodologies**

DT and Agon and their interaction are the complementary baseline methods for the method, we envisage in this work, called DTA [Piras et al., 2018a] (Design Thinking & Agon).

In fact, DT partially covers **R6** considering user characteristics, needs and goals, while Agon fills the DT **R6** gaps by characterizing the user regarding her player characteristics and the social context where she uses the software to accomplish her goals [Piras et al., 2018a]. Though DT considers (partially) context variables, we cannot define it as completely acceptance oriented (**R4**), because DT does not guide the analyst in using context variables for eliciting psychological strategies to use, for improving software functionalities, by inserting components fulfilling those strategies [Piras et al., 2018a]. The same is for **R5**, because DT does not specifically consider gamification design and related techniques for enhancing software functionalities [Piras et al., 2018a]. While, Agon is compliant with **R4** and **R5** [Piras et al., 2018a].

Furthermore, DT is partially systematic (**R1**) in the sense that, it provides effective

techniques and design mechanisms for analyzing relevant motivational factors, but those are focused only on a subset of relevant variables pertaining **R6** and **R4** [Piras et al., 2018a]. Accordingly, DT partially covers **R7** due to the lack in providing **R4** and **R5** suggestions [Piras et al., 2018a]. Agon is **R1** and **R7**, though, focusing specifically on **R4** and **R5** aspects and related **R6** variables [Piras et al., 2018a].

In summary, DT is a powerful method for effective software design [Piras et al., 2018a]. Its best peculiarities reside in its approach that makes participants collaborate pro-actively and creatively (**R2**, **R3**) also through prototyping [Piras et al., 2018a] (**R8**). However, the DT approach is generic and, thus, does not cover specific concepts and techniques regarding gamification design (**R5**) and, it is only partially acceptance oriented [Piras et al., 2018a] (**R4**). Agon covers at all **R8**, not mainly **R2**, but stimulates **R3** offering many suggestions (**R7**) and a interactive approach [Piras et al., 2018a].

Accordingly, being DT a strong generic design process, we propose DT as the backbone of DTA [Piras et al., 2018a]. The Agon method, being specific of acceptance and gamification design, done in a systematic and guiding way, can be inserted in DTA to have a wider set of context variables to consider and, specific acceptance and gamification techniques, missing in DT [Piras et al., 2018a]. Thus, Agon contributes making DTA a systematic and guiding approach concerning acceptance and gamification, and DT, making DTA, a participatory, collaborative and creative design process [Piras et al., 2018a].

### 8.5.3 Concluding Remarks and Future Work

We illustrated the two research questions that guide our research aiming at defining a collaborative, lightweight and effective method for designing gamified software [Piras et al., 2018a]. We presented preliminary findings, derived from the analysis of literature on gamification of software applications and case studies, in terms of key requirements the method should address [Piras et al., 2018a]. This is our first step towards answering **RQA** [Piras et al., 2018a]. Concerning **RQB**, we describe an example (DTA) where we consider combining DT and the Agon framework [Piras et al., 2018a]. Moreover, we performed a feasibility study applying the resulting method, DTA, for the gamification of DMGame, a tool within the SUPERSEDE<sup>9</sup> European project, and results are promising [Piras et al., 2018a].

As future work, we intend to refine all the aspects of the method, and plan to evaluate DTA through feasibility studies in different fields [Piras et al., 2018a]. In particular, we are interested in employing it in the field of gamification applied to the design of tools in

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<sup>9</sup><https://www.supersede.eu/>

the decision-making area [Piras et al., 2018a].

## 8.6 Future Lines of Research

In this Section, we present potential new lines of research that could be started on the basis of this thesis. Figure 8.1 represents the big picture including concepts discussed in Section 8.2, and future lines of research illustrated in this Section. In the following, we show specific parts of Figure 8.1 for helping us in outlining the concepts.

### 8.6.1 A Full Stack Framework

Agon covers acceptance requirements analysis and high-level gamification design. It could be interesting to have a *full stack framework* able to cover, as much as possible, all the gamification engineering phases, starting from the analysis to the development of the gamified system (Figure 8.8). This can be considered a new challenging future line of gamification engineering research (Figure 8.8).

A solution could be to integrate Agon with the gamification engine described in Chapter 3, which is able to cover low-level gamification design and implementation by using a service oriented architecture, where gamification concepts are services that can be composed together [Kazhamiakin et al., 2015]. It could be needed also to design an intermediate component able to connect the high-level gamification design of Agon with the low-level design of the gamification engine. A possible solution could be to define a library that generates gamification mechanisms as a code skeleton (Figure 8.8) linking the design of Agon with composed services of the gamification engine. In this way, the analyst will have also the possibility to customize the code skeleton received (Figure 8.8).

### 8.6.2 An Adaptive Gamification Framework for Long-Term Engagement

Agon can favor the short-term engagement as most of the gamification solutions. While, the long-term engagement is not guaranteed due to the limitation of gamification reported in the state of the art, and discussed also in this thesis (importance of the tuning phase outlined in Chapter 2). In fact, this is a typical problem of gamification: in many cases, it has been proven that gamification is effective for short-term engagement, while to confirm the long-term engagement of gamification is an open research problem. Accordingly, when the gamified software has been deployed (Figure 8.8), it is strongly suggested to evaluate the gamification solution in action time to time, and if there are problems, to improve/update the related gamification design for guaranteeing long-term engagement [Schell, 2014,

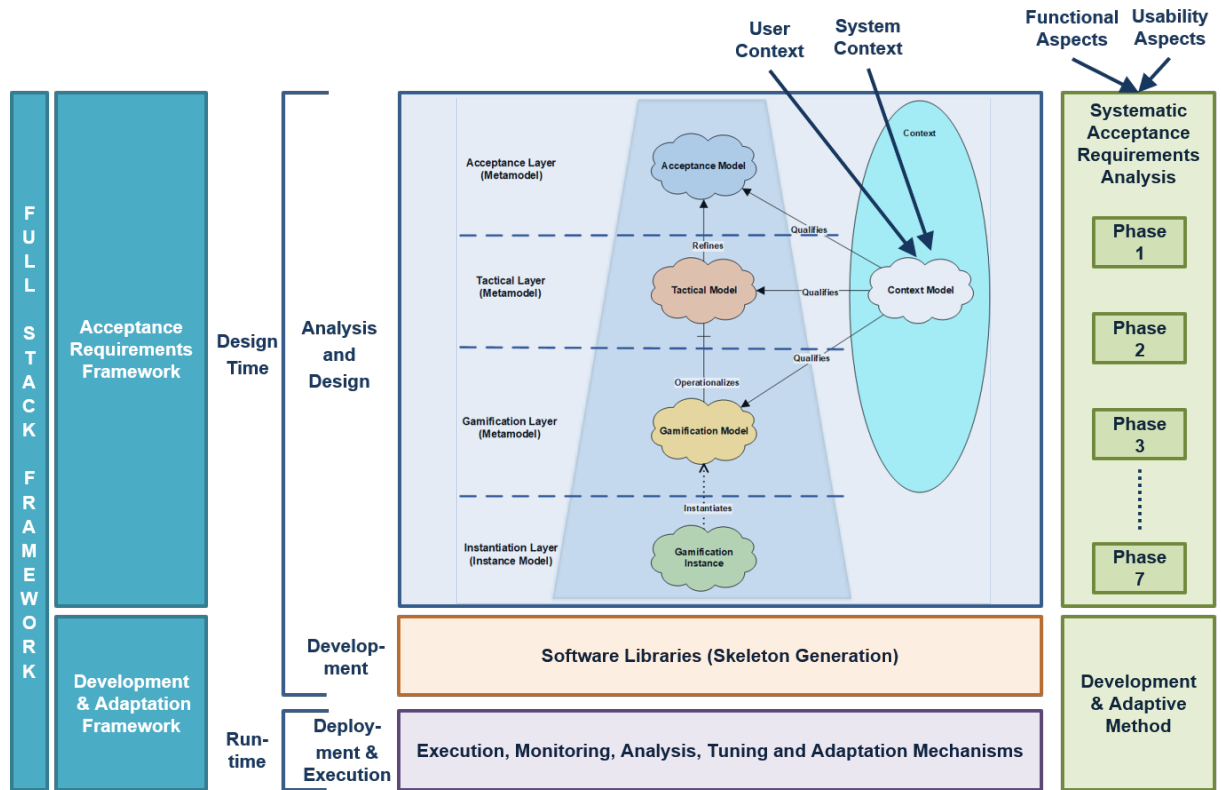


Figure 8.8: Screenshot of the big picture focusing on future lines of research for making Agon a Full Stack Framework and an Adaptive Framework

Zichermann and Cunningham, 2011]. Specifically, it is important to evaluate if the gamification solution implemented is concretely engaging the user, or if there are some mechanisms that need to be revised or replaced with other ones [Piras et al., 2016]. According to this, gamification monitoring/validation components should be designed and implemented around the gamification solution. They can be very helpful for analyzing the results and executing the tuning (Figure 8.8). The tuning can be done either at design time, for improving the current gamification solution, or, better, at runtime if it is employed an *adaptive gamification framework* (Figure 8.8).

The latter solution paves the way for a future line of research for designing a framework able, on the basis of the monitored events, to make dynamic (at runtime) decisions regarding how to improve the gamification design (Figure 8.8). Agon could be a valuable baseline element, to be enhanced, for addressing such research (Figure 8.8). We envision to enhance Agon for supporting also this capability. Especially, Agon will provide components for keeping effective a gamification solution (designed by using Agon), by employing Agon Models, and using the selected concepts of the gamification solution, for performing

monitoring and understanding what is not working; on the basis of the results collected, the analyst will be able to take decisions, and re-employ Agon for evaluating alternatives thanks to its wide space of acceptance and gamification solutions; Agon could be useful also as a baseline for an adaptive gamification framework, a framework able to automatically execute what explained above, and tuning the solution keeping it effective without the intervention of the analyst (Figure 8.8). In this case, the analyst could do supervision activities.

### 8.6.3 A Holistic Framework for The Design of Engaging Software

In relation the analysis and design of engaging software, Agon is able to cover mainly human behavior, cognitive and psychological theories. We think that a very important new line of research, is the one that can lead to the design of a *holistic framework for the analysis and design of engaging software*, with the aim of designing a framework that is able to cover most of the aspects to be considered for the user software acceptance.

We think that Agon can be a good baseline for including such theories. We already started working in this direction, by trying to integrate Agon with frameworks and methodologies coming from fields far from requirements engineering (Figure 8.9). Specifically, in Section 8.4 we discuss the possibility to extend Agon with the Motivational Antecedents Framework (MAF) coming from the the Organizational Behavior field [Piras et al., 2017a] (Figure 8.9).

### 8.6.4 A Collaborative Method for the Design of Engaging Software

Another new line of research envisages the design of a *collaborative gamification design method*, with the aim of designing a structured method that supports designers to explore in a systematic but creative way, including stakeholders in the loop, solutions for the design of engaging software. Furthermore, the right balance among a systematic approach, collaboration and creativity should be enabled by such a method at support of designers.

We already started working in this direction, by trying to integrate Design Thinking and Agon (Figure 8.9) in a unique *collaborative gamification design method* called DTA (Design Thinking & Agon). Specifically, in Section 8.5 we discuss this possibility. We already started integrating the 2 methods, and experimenting first prototypes achieving preliminary positive results.

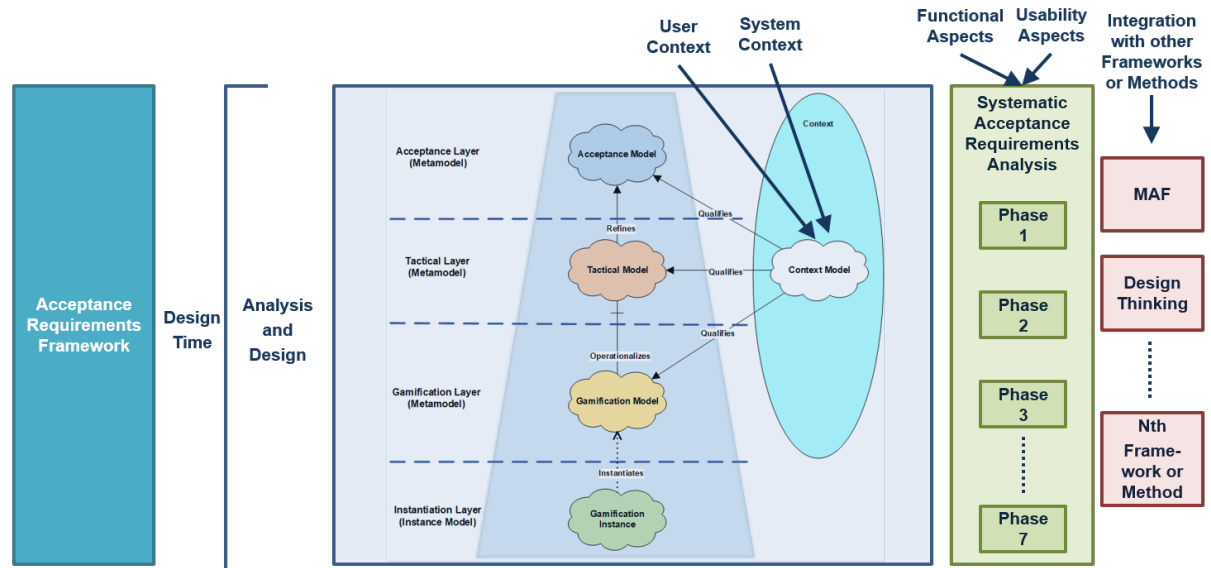


Figure 8.9: Screenshot of the big picture focusing on future lines of research for integrating Agon with other Frameworks and Methodologies coming from other fields

### 8.6.5 Future Operationalizations of Acceptance Requirements

We conclude the thesis with this Subsection, by outlining the most important aspect we think could pave the way for different valuable future lines of research.

Our framework, Agon, supports Acceptance Requirements [Piras et al., 2017b] and operationalize them with a particular class of solution, i.e. gamification. Moreover, we think that there are also other solutions for operationalizing acceptance requirements, for example (Figure 8.10):

- serious games;
- game metaphors;
- game-inspired design;
- tangible incentives;
- marketing strategies;
- advertisement;
- persuasive messages;
- nudge theory.

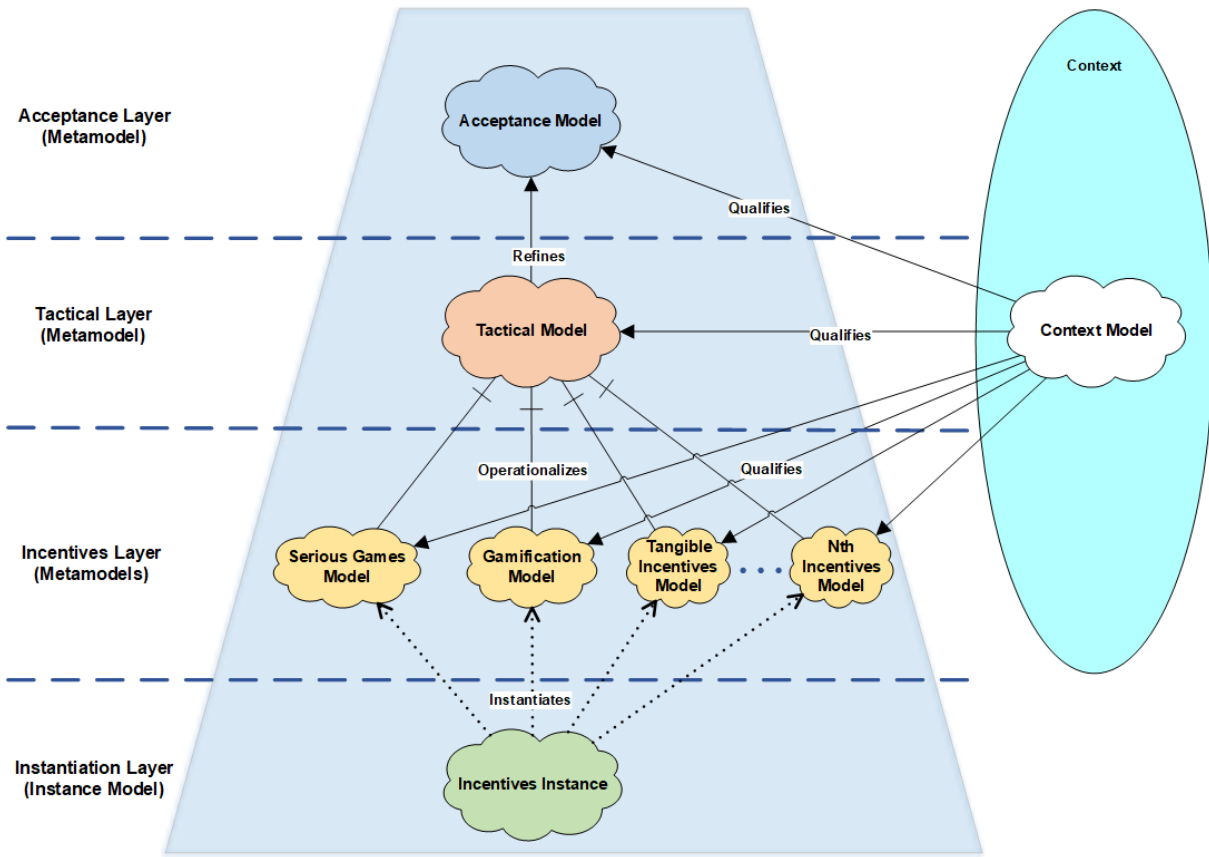


Figure 8.10: Operationalizations of acceptance requirements related to future lines of research

We think that each of them can be considered as a new future line of research (Figure 8.10). Moreover, a more advanced line of research, depending on these lines of research, is the one that will consider building a final solution made of a mix of solutions coming from the different spaces supported in the *Incentives Layer* (Figure 8.10). Specifically, the challenge will be to find strategies, methods and techniques for guaranteeing the design of a final coherent and effective solution made of heterogeneous elements (Figure 8.10).

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