Model-Based Gamification Design with Web-Agon: An Automated Analysis Tool for Gamification

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***Abstract*—Designing effective gamified solutions is a difficult and highly complex task. Supporting tools for requirements analyst are very rare, while most existing tools provide automation for reasoning over complex knowledge models. Drawing from our involvement in EU Projects and extensive analyst feedback, this paper presents crucial lessons learned on automating gamification analysis and design. We employed these lessons to guide the development of Web-Agon, a web-based solution that automates reasoning over models to support the analyst. Web-Agon, based on the Acceptance/Gamification Requirements Agon Framework, facilitates systematic gamification analysis of software systems. This approach, driven by acceptance (psychological, sociological, behavioral) requirements, has proven effective in designing systems that positively engage users. Based on models and gamification principles, Web-Agon contributes to building user-centered, engaging software systems. We have evaluated the effectiveness of our tool through a case study on Participatory Architectural Change Management in Air Traffic Management (ATM) systems with the use of Web-Agon for system gamification. We obtained positive results in terms of supporting analyst in a structured, systematic and automated way, reducing potential errors, thanks to automated functionalities, as well as speeding up the gamification process.**

***Index Terms*—Model-Driven Engineering, Gamification, Acceptance Requirements, Goal Modelling, User Engagement**

I. Introduction

The integration of systematic gamification, within the software engineering life cycle, has been demonstrated to be an effective strategy for creating software systems [1]. This can improve user engagement, around the desired behavioral outcomes, by designing and implementing gamified functionalities and gamified experiences within the system [9] [10]. However, a gamified software system, to effectively engage the user, requires having a gamification design based on acceptance (psychological, sociological, behavioral) requirements analysis, able to take into account the needs of the intended user [1] [5] [6]. To perform such complex and systematic acceptance and gamification analysis, analysts require supporting tools [1] [5] [6].

This paper presents Web-Agon, a model-driven gamification engineering tool for analysing and designing gamified elements into software applications. Web-Agon tool is based on the Acceptance/Gamification Requirements from the Agon theoretical framework [3]. Our work in various EU projects involved analysts applying gamification frameworks and tools, including Agon, to gamify software systems in heterogeneous real domains [3]. Although analysts have found these tools useful for gamification activities, they have also indicated the need for further automated support, particularly for different model-based functionalities, which work on large knowledge-bases, encapsulating acceptance and gamification strategies [5] [6]. This highlights the need for a tool like Web-Agon, which can systematically support analysts in the analysis and design of gamification solutions for software systems.

The first contribution of this paper is to identify the lessons learned from the interviews with analysts using gamification tools [5] [6], which are relevant for driving the automation of functionalities to support analysts in such complex activities. The second contribution is to provide an overview of Web-Agon, the model-driven engineering tool we developed, based on such lessons learned and needs expressed by the analysts. By addressing such lessons learned, our proposed Web-Agon aims to provide a more streamlined and automated approach to gamification design, reducing the effort required from analysts and minimising potential errors.

The rest of the paper is organized as follows: Section II describes key lessons learned from our research. Section III presents the overview of the Web-Agon tool, with its automated features based on the lessons learned, and discusses our preliminary evaluation. Section IV presents related work, and Section V concludes the paper by summarizing key findings and insights while also outlining directions for future work.

The novel Web-Agon tool is available online[1]. A complete

[1]https://web-agon.vercel.app/

guide for the analyst on how to use the tool is available online[2].

II. Lessons Learned on Required Automated Functionalities for Gamification Design

The following lessons learned stem from our extensive work on gamification within EU Projects [2] [3] [5] [12], and in-depth discussions with requirements analysts who have applied various gamification frameworks and tools [1]. In summary, we have identified that the gamification frameworks and tools can help design effective gamification solutions, but more automated support is required, especially when dealing with large base knowledge, represented as models, as in the case of the Agon framework [3].

Our lessons learned have been also inspired from some of our previous works, for example like "Analysis on Large Models and Concepts Interpretation" [4]. For that, we can see the need for automated support in instantiating and configuring gamification solutions based on the selected goals. In addition to the needs for automation in filtering acceptance requirements (psychological, sociological, and behavioral requirements that focus on user needs and motivations), pruning goal models (hierarchical models to represent and analyse the objectives of both the system and its users), selecting tactics (specific strategies or techniques used to bridge the gap between acceptance requirements and game elements), and handling gamification goals as previously mentioned, our analysis of tools like the STS(Socio-Technical Systems)-Tool [14] within projects such as VisiOn[3], and Privacy SecTro Tool within DEFeND[4], revealed further key insights.

For example, tools must be user-orientated, support step-by-step guidance, and have automated support features, above all to the advantage of junior analysts, to decrease the learning curve and facilitate the use of tools, reducing difficulties through automation [5]. Additionally, tools should provide features that analysts and stakeholders can collaborate together such as brainstorming, model verification, and exchanging domain knowledge to produce good requirement models [5].

Based on our experiences and interviews in EU projects [2], [4], [5], the overall insights collected have been broken down in this work by identifying precise and specific lessons. In the following, we discuss such specific lessons learned, at advantage of future gamification tools, and outline them also by providing clarifying examples within the context of the theoretical Agon framework. In the next section, we use these lessons to outline the design and implementation of Web-Agon tool and its inspired automated functionalities.

1) ***Automation of Filtering for Acceptance Requirements***: Analysts faced difficulties in interpreting and analyzing large goal models representing acceptance requirements. Automated filtering and pruning features could help focus on relevant parts of the model. Filtering and pruning criteria are based on the relevance of the context such as user demographics and the application domain. Decisions need to be made by the analyst on high number and broad variety of acceptance requirements to consider. These decisions affect the model ability to remove large number of items, which can be automatised to speed up the acceptance analysis phase, and to reduce the possibility of manual error.
2) ***Automation on Pruning Goal Model Parts Based on Decisions on Acceptance Needs***: Once acceptance needs are identified, next goal models could be automatically pruned to show only relevant tactic concepts. Similarly to the previous lesson learned, and, even more, tactical and gamification models are huge, often encapsulating over 300 concepts and relationships. Accordingly, different types of reasoning at support of the analyst for decision making can be very valuable. For example, when analysts decide to discard other dependent concepts, the tool could remove such concepts and related hierarchies (or parallel dependent branches) automatically. Similarly, automation on pruning other dependent concepts (or concepts considered siblings in the model) based on specific relations (e.g., "and", "need" relations) could be implemented. All such automation can again be applied to further support analysts to reduce errors, making the process more systematic, and speeding it up.
3) ***Automation of Filtering and Selection of Tactics***: The selection of appropriate tactics to refine acceptance requirements on huge models, even though done via supporting and self-explanatory models, in most of the tools is a manual/demanding process. Such aspects require to be automated to support the analyst, as we implemented in the automated Web-Agon tool.
4) ***Automation of Filtering of Gamification Goals***: Interpreting large gamification goal models (encapsulating the vast variety of gamification strategies and concepts) and filtering a specific set of suitable concepts and strategies to apply to the specific case, and for motivating the intended user, and at the same time fulfilling acceptance requirements and tactics relevant for the specific case, is a challenge for analysts. Web-Agon helps to automatise these aspects via automated filtering of the most appropriate gamification goals, suitable for the specific context and intended type of user to motivate.
5) ***Automation on Pruning Goal Model Parts Based on Decisions on Gamification Goals***: Based on gamification models automatically filtered, the analyst can take decisions on the selected strategies and concepts. During such activities on big models, the analyst needs to be supported with automatic pruning of part of the model, based on analysts' decisions for further removal of elements, according to relations and dependencies. Our solution, Web-Agon, can automatically prunes the goal model to show only the relevant parts related to the selected goals, when the analyst is taking decision and discarding some concepts. This helps the analyst to focus only on the relevant gamification aspects to design.

[2]https://tinyurl.com/web-agon-notion
[3]https://cordis.europa.eu/project/id/653642
[4]https://www.defendproject.eu/

III. Overview of the Tool addressing the Lessons Learned

In this section, we discuss how we have designed and implemented the automated functionalities and the Web-Agon tool for addressing the lessons learned and needs of the analysts as discussed in the previous section. The Web-Agon tool, the Web version of the theoretical Agon Framework [3], provides the analyst with many automated functionalities that are ready-to-use in terms of reasoning over large models to speed up the design process and make it less error-prone.

A. Overview of the Web-Agon Tool

Web-Agon is a comprehensive model-driven engineering tool that is intended to assist analysts in the gamification design process. This tool goes through various phases, which covers the whole process of gamification, from requirement gathering to operationalisation via gamification. Web-Agon allows the analyst to use a structured systematic framework called Agon [3] to model the concept and strategy of gamification, which has the potential to allow the analyst to easily deliver gamification solutions.

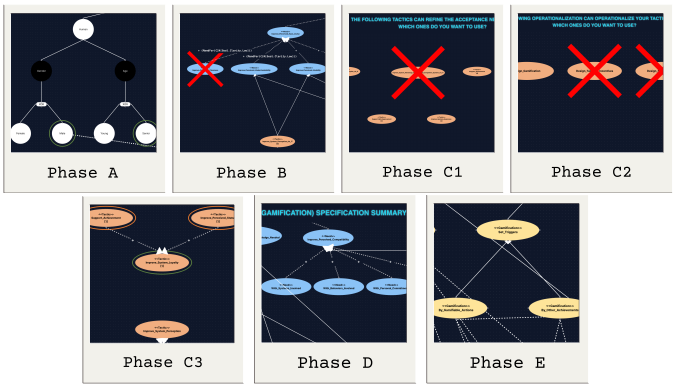

Fig. 1. Phases in Web-Agon: full picture available at [8]

The overall gamification design process followed by Web-Agon consists of the following phases (full models available at [8]): Context Characterisation (analysing the system's context and user characteristics), Acceptance Requirement Analysis (identifying and choosing user acceptance needs), Tactical Refinement (refining appropriate tactics to address acceptance requirements), Specification Summary of the selected requirements and tactics, Gamification Operationalisation (translating tactics into concrete gamification elements). In each phase, analysts interact with different models to make decisions. Figures 1 & 2 present the key phases of the Web-Agon tool.

B. Automated Model-Driven Functionalities

The Web-Agon tool supports the analyst in a systematic and automated way. Among the automated and model-driven functionalities, the following features guide the analysts during the systematic analysis of the gamification design.

In the next subsection, we discuss how this and other features of the Web-Agon tool map to the key lessons learned, detailing the specific implementations.

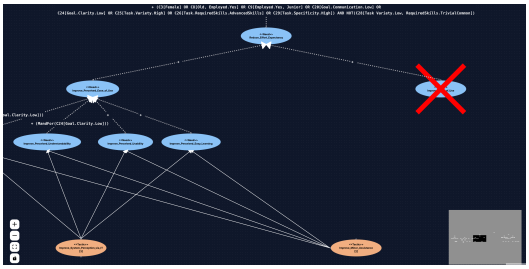

Fig. 2. Phase B in Web-Agon: full picture available at [8]

Automation of Filtering and Pruning Goal Model Parts for Acceptance Requirements: One crucial functionality is the automated filtering and pruning of acceptance requirements. Since the acceptance requirements are actually large goal models, this feature helps support the analyst in focusing on the most relevant parts, thus easing the analysis process. The tool automatically filters acceptance requirements based on previously defined context characteristics, presenting only the most relevant elements to the analyst.. Another key function is the selection of tactics that are based on the identified acceptance needs provided by the analyst. Instead of having the analyst dig through the many tactics to select what is to be suitable for the refinement and ultimately operationalisation of the acceptance needs, the tool uses the underlying Agon meta model [3] to recommend the most appropriate tactics. This automation makes the work easier for analysts and allows them to focus on important decisions.

Automation on Pruning Goal Model Parts Based on Decisions on Acceptance Needs: Web-Agon tool also offers the feature of automated pruning gamification goals. As an analyst navigates the process of designing the gamification, the analyst can uncheck goals or added elements that may not be relevant anymore. The goals or elements that relate to a deselected one show in a dynamic view, which hides the related goals or elements to keep the view tidy and clean.

In addition, the decisions made by the analysts regarding the gamification goals are used for automatic reasoning and pruning. In addition to these automated features, the Web-Agon tool also provides a very detailed glossary of several different kinds of gamification concepts and tactics, along with explanations. This turns out to be very helpful for analysts entering the field of gamification to be very well equipped with information to make the right choices in designing.

In general, the Web-Agon tool tries to ease and reduce complexity in the design process for analysts, through automated model-driven functionalities. The tool provides a way of moving through complex models of gamification in an effective manner through automation, intelligent filtering, and model-based reasoning so that analysts can make decisions in an informed manner and thus come up with engaging, user-centric and effective software systems for gamification.

C. Preliminary Evaluation and Discussion on Automated Model-Driven Functionalities

For the evaluation of the tool, we replicated the PACAS case study [3] [6], which is one of our previous EU projects.

This time, it was completed using the Web-Agon tool for the gamification of the system. The results were positive, showing significant improvements, and we were able to test Web-Agon's automated functionalities under real-world conditions.

Firstly, we observed a substantial reduction in the time required to perform model-driven engineering for the PACAS case study. For example, in relation to the original theoretical framework, the process took over 10 hours. In contrast, similar exercises, where the functionalities are automatically applied and executed, required no more than 2 hours to conclude the process, using the Web-Agon tool. This shows an increase in the efficiency during the analysis of the gamification process. This automated filtering feature saves a lot of time that would otherwise need to be done by an analyst trying to find and eliminate all the requirements from a usually large set.

We also compared the quality of the solutions produced with and without the Web-Agon tool. In the manual process without Web-Agon, there were 40 dependencies that were not pruned, even though some related concepts had been removed by the analyst manually. In contrast, the Web-Agon tool automatically ensured that all dependent elements were correctly pruned. This not only prevented errors, but also streamlined the analysis by automatically handling dependencies and relationships.

During the evaluation, it can be argued that Web-Agon's automated functionalities not only enhanced the efficiency of the gamification design process, but also contributed to the consistency and accuracy of the results and reduced the potential for human errors or oversights.

IV. Related Work

Octalysis by Yu-kai Chou is a framework for gamification design that provides suggestions on which core motivational drivers to consider and in what proportions [15]. The Octalysis Tool[5] is one of the ways through which analysts can try to evaluate existing gamified systems in terms of Chou's 8 core drives. Although this can be of great help when evaluating a gamification design, Octalysis does not have the precision and model-driven automated support that Web-Agon, for example, can provide to analysts in a systematic way throughout the gamification design process.

The RAMP model of Andrzej Marczewski identifies four main drivers for motivation: Relatedness, Autonomy, Mastery, and Purpose [16] . His HEXAD model extends this to 6 types of players. Marczewski provides tools[6] to assess which types of user motivations a gamification system addresses. However, similar to Octalysis, those models and tools focus just on the mentioned partial aspects, and do not provide a automated approach towards acceptance requirement analysis, integrated with gamification strategies, like Web-Agon does.

The tools discussed in [15] [16] cover only specific aspects and have limited automated functionalities, while with the Web-Agon Tool, and with its automated reasoning and functionalities, the analyst can perform a systematic acceptance analysis based on gamification, by considering many more gamification strategies/solutions suitable for the intended users.

[5]https://yukaichou.com/octalysis-tool/

[6]https://gamified.uk/UserTypeAnalysis/

V. Conclusion

Web-Agon is a comprehensive model-driven tool offering automated support to analysts in the process of systematic gamification analysis/design for software systems. Web-Agon integrates acceptance requirements analysis with a rich knowledge base of gamification concepts and strategies, guiding the analyst in systematic phases, such as context characterisation, tactical refinement, and gamification operationalisation.

The automated features enable reasoning and pruning capabilities with the tool, reducing most of the effort and complexity faced by analysts. Moreover, features such as automated filtering of relevant requirements, recommendations for tactics, and dynamic updating of goal models based on analysts' decisions enhance the workflow of the gamification design. In the future, our goal is to add the real-time collaboration feature and AI recommendations based on past data. This will improve decision making during the gamification design process.

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