The Third International Conferences on Advances in Computer-Human Interactions, ACHI, IEEE, pages 113-118, 10-15 Feb. 2010.

FLEXIBLERULES: A Player Oriented Board Game Development Framework

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***Abstract*—When comparing digital board games with their traditional counterparts, it becomes clear that certain features such as graphics, mundane task automation or saving and restoring the state of the game have been greatly improved. Nonetheless, the transition to a digital environment leads to a loss of the flexibility that makes traditional board games inherently popular. While modifying aspects of the game is straightforward in traditional board games, achieving such a level of customization in the digital domain requires deep knowledge of and access to the game source code. In this paper we focus on board games and by means of an in-depth online survey we validate our previous observation, namely that enhancements should be made to digital board games by incorporating gaming facets found in the physical environment, e.g. support for flexibility by means of house rules. To this end, we introduce a conceptual model for the design of digital board games, which is supported by a set of visual programming tools to enable game development according to the principles set out by our proposed model. The set of the tools along with the underlying intuitive model comprise the FLEXIBLERULES framework, which enables and facilitates flexible and extensible game design and development.**

***Keywords*-Board Games; Survey; Development Framework; Human-Computer Interaction**

I. INTRODUCTION

Recent advances in the field of human-computer interaction and in particular in the domain of multi-user interaction, such as multi-touch interactive tables [1], [2], have opened a broad range of new application scenarios that better enable the porting of natural ways of user interaction to the digital world. One of the most noteworthy applications of these devices are computer enhanced games that take advantage of elements of both the physical and the digital environment, e.g. co-located play and automation of mundane tasks respectively. We focus our research on the design and development of computer enhanced board games, aiming at ameliorating user experiences by mixing the characteristics of traditional board games played around a table with the almost endless expressiveness and computational functionalities offered by the digital world.

As pointed out in [3], [4] the freedom of players to define house rules constitutes a focal point of any successful game design, as it makes the game more enjoyable [5] and customized to player preferences. This aspect, associated with the social interactions of traditional game-play sessions, is nonetheless neglected in most existing digital board games [6] and is not easily supported in current game development frameworks, as highlighted by the results of a survey that we conducted. Our on-line survey studied board game players' preferences and satisfaction levels in both physical and digital environments. The results of the survey motivated our research toward providing a game development framework that allows the design and modification of digital board games in a fully flexible manner.

In this paper, we present FLEXIBLERULES, a board game development framework, which is comprised of a conceptual game model and a visual programming environment with a set of graphical tools allowing a user to easily design and modify digital board games.

The rest of this paper is organized as follows. The next section presents a brief overview of existing game development frameworks. In Section III, we describe and analyze our survey aimed at studying players' gaming habits and preferences. Section IV discusses the underlying conceptual model of the FLEXIBLERULES framework, while Section V gives an overview of the functionalities of the FLEXIBLERULES toolkit. Finally, in Section VI, we provide some conclusions on the presented work and insights on future work.

II. RELATED WORK

As far as the porting of traditional board games to the digital environment is concerned, two main approaches exist. In the first the user is provided with a virtual playing environment by simply creating a one-to-one mapping of the graphical game elements from the physical to the digital domain. The actual rules of the game are not enforced by the system but are negotiated between the players by means of communication channels such as email or chat (e.g. Vassal Game Engine [7]).

The second approach enables the implementation of both the game graphics and logic by means of high level game development frameworks. *XNA* [8] is an example of such a game development environment built on the .Net framework, enabling the end-user to implement advanced digital games. However, it requires a deep knowledge of the C# programming language, which could impede the engagement of casual gamers, even when enhanced by means of visual

domain-specific languages such as *SharpLudus* [9]. This limitation of *XNA* in facilitating user game development is partially addressed by visual programming environments like *Kodu* [10], *Game Maker* [11] or *the Games Factory* [12]. In particular the *Kodu* language is designed specifically for game development and promotes simplicity and flexibility in creating and modifying games even at runtime. Nonetheless, being a simple and entirely icon-based language, Kodu lacks in expressiveness when complex game logic is concerned.

In this paper, we present a holistic framework, called FLEXIBLERULES to address the aforementioned issues. In the spirit of Kodu, FLEXIBLERULES provides a simple yet expressive domain-specific language along with a set of visual tools for developing and on-the-fly editing of board games in a user friendly manner.

III. SURVEY

In order to study the gaming habits and preferences of players in both physical and digital environments we conducted an online survey with a focus on board games.

A. Profile

The activity period of the survey was 2 weeks and the survey was comprised of 16 questions that included open-ended, closed-ended and Likert-style questions. The main target audience of our survey were people who play board games on a more or less frequent basis and computer scientists in the domain of human-computer interaction, since our motivation was to study the transfer of interaction patterns from the physical world into the digital one. The survey was completed by 407 individuals classified in the aforementioned categories as follows: 219 members of the gaming community and 188 HCI researchers. 19.5% of the respondents were female. We have also identified three age groups, namely people less than 20 years old (9.4%), between 20 and 35 (52.5%) and over 35 (38.1%).

B. Analysis

Undoubtedly, of particular importance for the analysis of the survey results is the gaming profile of the respondents in terms of frequency of engaging in game-play. In this respect, 18.4% of the respondents stated that they rarely play board games, 25.6% play at least once per month and 46.7% at least once a week, while 9.1% have daily engagement with board games.

It is clear from the distribution of the responses that the target audience is well balanced across the frequency spectrum with the majority of the respondents being regular players.

An interesting observation is the fact that while 95.5% of the people who answered the survey expressed their liking for playing traditional board games (i.e. around a table) only 23.5% are currently inclined to play in digital environments, either online or using a shared screen setting. It is therefore evident that the high popularity of traditional board games has not found a corresponding acceptance in the digital environment. In order to better understand the reasons behind this contradiction we analyzed the respondents' opinions on the significance of specific game features as well as the potential areas for improvement. The corresponding survey results are presented in Tables I and II.

The following game features have been taken into consideration: the ease and flexibility of modifying the rules; the graphical appearance of the game; the social interactions between players; the use of tangible objects; the ability to customize game objects; the ability to revoke or repeat game moves; the degree of immersion during game-play.

As far as physical board games are concerned, an established satisfaction in the respondent community regarding the aforementioned features appears to exist. The latter is evident from the fact that the need for major improvements in these features is relatively low, starting from 4.7% for the ability to undo a move and reaching a maximum of 9.8% for the immersive experience, whereas their respective importance is high (from 62.8% for the ability to modify game objects to 99.2% for social interaction). It should be noted that the graphical appearance of the game and the immersive experience were assessed to be the features that would require the most improvements (61.5% and 59.5% respectively). We can therefore argue that the apparent qualities and attractiveness of traditional board games should be effectively supported when their development within the digital domain is considered.

Physical	Importance			Improvements		
	Low	Medium	High	No need	Some	Major
Customize Rules	21.9	57.1	21.0	55.3	37.4	7.3
Graphics/Artwork	14.4	54.2	31.3	38.5	54.4	7.0
Social Interactions	0.7	12.6	86.7	61.1	33.4	5.4
Tangible Objects	1.7	20.5	77.7	58.6	35.4	6.0
Customize Objects	37.2	51.0	11.7	56.3	34.2	9.5
Undo/Redo	22.8	54.7	22.5	68.2	27.1	4.7
Immersive Exp.	6.8	37.3	55.9	40.5	49.7	9.8

Table I
PHYSICAL ENVIRONMENT RESULTS (%)

Nonetheless, while in general the importance of the studied features rates approximately equally high in both physical and digital environments, the respondents have highlighted the need for minor and major improvements in the digital domain, thus indicating that the shift from traditional board games to digital ones has not been completely successful thus far. In particular there is a remarkable increase in the percentage of respondents who recognized the need for major improvements regarding social interactions

(from 5.4% in the physical to 40.5% in the digital). A similar increase is observed when it comes to the necessity for flexibility of modifying the game rules (7.3% to 21.1%).

Having established the deficiencies of current digital board games, as reflected in the collected survey results, our research goal is focused on improving them by providing gamers with a digital counterpart to traditional board games.

Digital	Importance			Improvements		
	Low	Medium	High	No need	Some	Major
Customize Rules	19.8	58.2	22.0	30.8	48.1	21.1
Graphics/Artwork	6.0	52.4	41.6	29.2	52.4	18.4
Social Interactions	12.7	53.6	33.7	18.5	41.0	40.5
Tangible Objects	28.1	49.2	22.6	39.0	43.0	18.0
Customize Objects	21.6	54.9	23.6	32.8	48.9	18.3
Undo/Redo	10.6	48.2	41.2	33.9	51.5	14.6
Immersive Exp.	4.8	35.8	59.4	16.4	49.9	33.8

Table II
DIGITAL ENVIRONMENT RESULTS (%)

In this respect and based on the survey results, the most important features are social interactions and flexibility in altering game rules and objects, since addressing them in a satisfactory manner allows players to enjoy at least the same level of game-play experience as they do with traditional board game-play. Taking into account that porting traditional board gaming to the digital domain exploits similar graphical representations and tangible objects, one can assert that the observed increased need for improvements in digital board games can be mainly attributed to the fact that they lack in freedom and social interaction. Clearly, improving the graphical aspects of a game would increase its appeal, but we deem this as a non-fundamental issue for our research. Social interactions refer to both the communication between players and the freedom that they exhibit in establishing, negotiating and modifying aspects of the game, such as the rules. While the former issue has been addressed by means of instant messaging and voice chat applications, the latter remains an open issue which we aim to address with the game development framework presented in section V.

The confirmed desire of players to change rules and properties is motivated by their intent to perform certain actions that are not currently inherently supported by digital board games. This set of actions is equivalent to the players' agreement on house rules in traditional board game-plays. The respondents of our survey were asked to provide a rank for five proposed motivational factors, which are illustrated in Figure 1. It is evident that the majority of respondents are eager to adapt elements of the game according to their needs and preferences, as all of the five suggested game customizations have been assessed as being very desirable

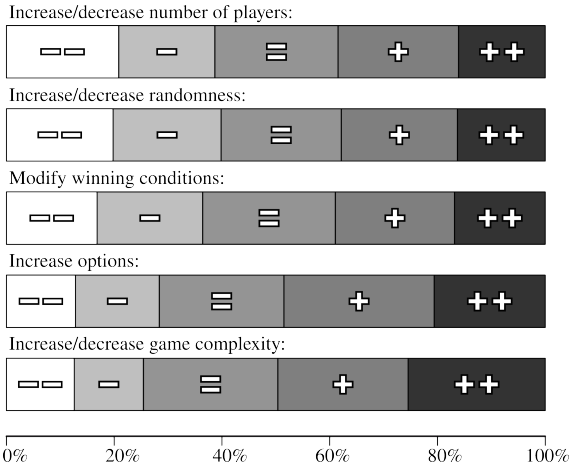

Figure 1. Motivation for Customization (−− none, ++ very high)

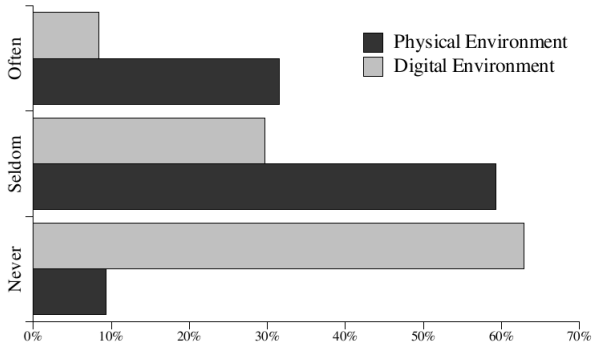

Figure 2. Customization Frequency

(from 60.2% for the modification of the game randomness to 74.5% for the adjustment of game complexity). Furthermore, the respondents were given the option of an open-ended question that yielded highly interesting results that we did not foresee when designing the survey. Specifically, house rules that were mentioned included: reducing the duration of games; fixing design flaws of the game (e.g. avoiding a stereotyped passage of play everyone agrees is optimal but uninteresting); allowing for balancing such as limiting the unfair advantage accidentally given to someone.

The last part of the survey was dedicated to examining the previous experiences of players regarding their ability to modify game rules or even create their own custom board games.

As expected, only a limited amount of respondents have been able to modify digital board game rules (38.1%), whereas a staggering 90.7% of respondents exhibited a similar capability with physical board games (Figure 2). The latter observation is contradictory to the fact that on average more than 80% have some motivation for performing such a customization (Figure 1). Among the diversity of respondents' inhibiting factors we note the lack of necessary IT

background and the fact that most games are hard-coded and do not give the option to modify them, apart from predefined simple parameters. These hindering conditions - as cited by the respondents - are also responsible for the fact that only 12.8% of the people who took part in our survey have at some point successfully created a digital board game, while 36.4% have created at least one physical board game. The main findings of the survey highlight the drawbacks of digital board games when compared to traditional ones, such as the lack of flexibility in modifying game rules in the general context of enabling social interactions that exist in the physical world. Consequently, when it comes to digital board games, there is a need for methodologies and tools to provide players as well as designers with the same degree of freedom and player satisfaction as in the physical environment.

To address these needs we present FLEXIBLERULES, a generic framework to support the game design and development process, taking into consideration the requirements that were gathered through our survey, namely the ability to change rules and game objects, a dedicated and user-friendly programming environment and intuitive game modeling.

IV. FLEXIBLERULES MODEL

The cornerstone of the FLEXIBLERULES framework is a conceptual model that facilitates the design of digital board games. In particular, our model decouples the different aspects of a game, such as the logical behavior of the diverse game entities, their graphical representation, and the rules that govern game-play, in order to promote modularity and clarity. In this respect, we also introduced a user-friendly Lisp-inspired domain-specific language that enables seamless implementation of games according to the aforementioned model. By means of a very high-level and verbose syntax, the language aims to be easily understandable, even for users with limited IT knowledge.

We distinguish between two levels of abstraction as far as game modeling is concerned, namely *logic* and *representation*, which provide us with an initial separation of concerns. These concerns are modeled separately as *logic* and *representation* layers, dealing with a low-level description of game dynamics, and the high-level user interface (typically a graphical or tangible representation) respectively. The functional core of a game is defined by a set of entities residing in the *logic* layer, which - when applicable - have a dual in the *representation* layer that reflects their internal state.

The fundamental elements of the *logic* layer of the FLEXIBLERULES model and their corresponding interactions are depicted in Figure 3. An entity is characterized by a set of functional behaviors and private properties. Messages, namely information containers that are exchanged between entities, are used to achieve communication and coordination. Each message is uniquely identified by a label. Upon reception of a message, an entity triggers a certain set of actions that have to be performed, its *behavior*, according to its current state and to the label of the message. Different states allow the implementation of separate behaviors for the same message label. The execution mechanism is thus similar to a finite-state automaton, such that actions executed by an entity are univocally defined by the input triple *entity, state, message label*.

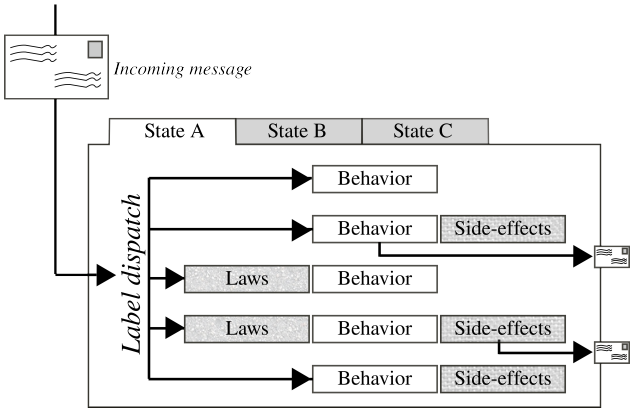

Figure 3. Entity Execution Model

In general, game-play is guided by both the entities' *behavior* and the game rules. The latter can allow or disallow certain actions to be performed and additionally control potential secondary outcomes of these actions. In the FLEXIBLERULES model we introduce the notions of *laws* and *side-effects* to refer to the aforementioned decoupling. Both *laws* and *side-effects* have read-only access to all properties of any entity, since they have a global scope in our model.

The pre-conditions of *laws* are checked for validity according to the current state of the entity and the values in an incoming message . When pre-conditions are met, *laws* either modify or prevent the execution of *behaviors*. In the case of a chain of *behaviors* resulting in a disallowed situation a *law* can act as a failsafe mechanism by performing a rollback to restore the last valid situation (e.g. the status just before the last player move). The successful execution of a *behavior* might lead to further outcomes that are defined within *side-effects*, namely performing rollbacks and sending messages to other entities (e.g. assigning points after every game turn).

While the logic and the rules that govern game-play are important aspects of game design, it is also essential not to neglect the graphical or tangible elements that decorate the game world and provide visual feedback of the current situation in the game. The latter are modeled in FLEXIBLERULES as the *representation* layer, which comprises entities that reflect the internal state of their logical counterparts. The *representation* entities control graphical objects meant to visually depict the status of game elements.

Accordingly, properties of the corresponding *logic* entity can be linked to update procedures, which are triggered upon modification of the properties' values. In this respect, the *behavior* of the *representation* layer is to observe the *logic* layer. The *representation* layer also constitutes the interface between graphical objects and the game logic, by mediating both *Intentional User Interaction* (manipulation of graphic elements) and *Forced User Interaction* (response to game events).

V. FLEXIBLERULES TOOLKIT

Building on the principles of the well-defined conceptual model, the FLEXIBLERULES framework provides a digital board game development environment taking into account the aforementioned separation of concerns and enabling rapid implementation of games.

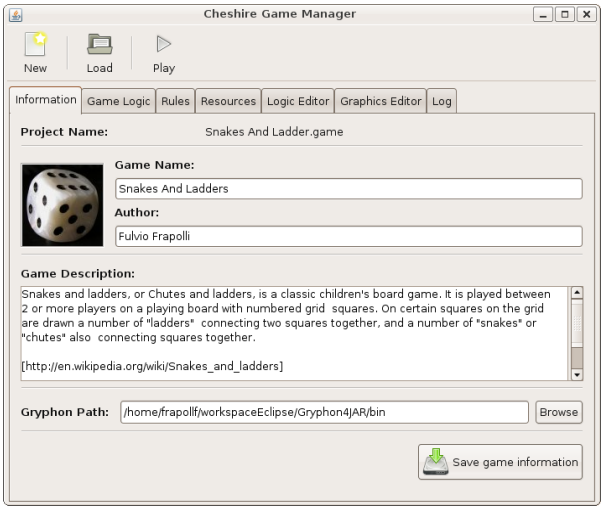

Figure 4. Cheshire Game Manager

This toolkit is comprised of a set of visual tools aimed at simplifying user development efforts regarding the logical and the graphical aspects of the game. In this respect, the *Logic Editor* (Figure 5) deals with the modeling of entities, their properties and the relations between them, while the *Graphics Editor* (Figure 6) can be used to define the appearance and functionality of the graphical elements of the game. Moreover, in order to facilitate the transition from the generic modeling offered by the two visual editors to actual game implementation, a *Programming Environment* (Figure 7) is provided to allow for the definition of entity behaviors along with their corresponding laws and side-effects. The front-end for the FLEXIBLERULES framework is the *Cheshire Game Manager* (Figure 4), which provides a unified interface to access the aforementioned tools, to create a game and to subsequently launch it.

The *Logic Editor* (Figure 5) allows the user to visually define game entities and their relationships, therefore achieving a user-friendly way of modeling the logical structure

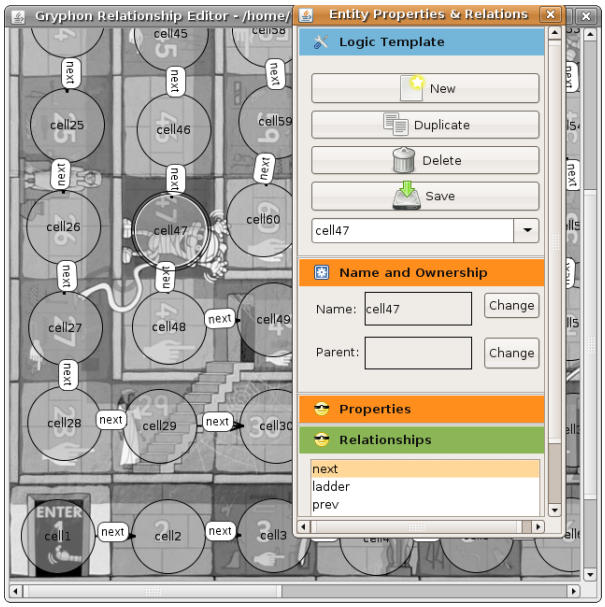

Figure 5. Logic Editor

of the game. By displaying the organization of entities and their logical connections as a graph, the user is offered an intuitive overview of every entity's role within the game. Furthermore the *Logic Editor* provides quick access to the *Programming Environment* to enable the editing of entities' specific behaviors.

Figure 6. Graphics Editor

The *Graphics Editor* (Figure 6) can be used to compose and manipulate the different graphical objects that will be displayed on the game board. These elements, typically images or text labels, can be freely arranged and resized to fit the user's needs. The editor also enables the definition of reactions (message notifications or signals) that can be triggered in response to user interaction with graphical objects.

The core part of the game development process is the

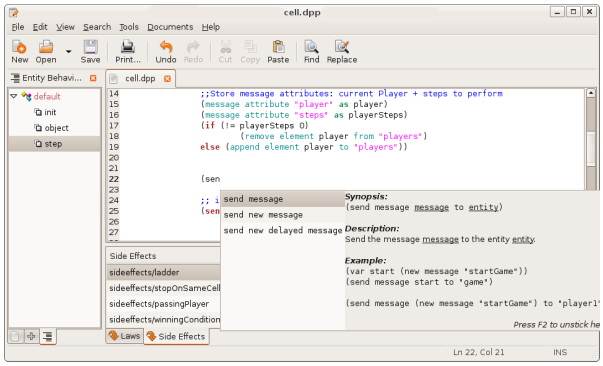

Figure 7. Programming Environment

specification of the behavior of the entities as well as the game rules, which are represented by the *Programming Environment* (Figure 7) in the FLEXIBLERULES Toolkit. This environment is based on the open source GEdit [1] text editor which has been customized and enhanced with plug-ins providing syntax highlighting, inline help and code completion. Additionally, an integrated code navigator is provided on the left side of the *Programming Environment* which facilitates the browsing of code while maintaining an overview of its structure. Provided that laws or side-effects have been defined, a pane displaying their order and allowing rapid access to their corresponding descriptions is presented in the lower part.

VI. CONCLUSIONS

In this paper we presented the FLEXIBLERULES framework to facilitate the development of computer enhanced board games with an emphasis on end-user involvement. The motivation for building such a framework has been validated by the survey that we conducted among board game players and HCI experts, which also highlighted the desired game development functionalities that have so far been neglected in existing solutions, e.g. openness in rule customization, improvements in social interactions, etc. Accordingly, we introduced a conceptual model for board game design promoting the decoupling of the different game aspects, namely game logic (*laws*, *behavior* and *side-effects*) and graphics. Building on this model, the FLEXIBLERULES toolkit provides a set of visual tools that support the development of new games or the modification of existing ones. It therefore becomes clear that the goal of the FLEXIBLERULES framework is to provide the user with an intuitive model along with a visual programming environment promoting simplicity and flexibility in game development. In this respect, we argue that FLEXIBLERULES effectively addresses the issues raised by the respondents of our survey.

As an initial proof-of-concept we have implemented several board games using the FLEXIBLERULES framework, which can be played on our website [2]. While the survey motivated the need for our research, we are currently undertaking an extensive user evaluation to validate the performance and efficiency of FLEXIBLERULES. In particular, we first plan to conduct introductory tutorials to help users to get comfortable with the framework. Following this first stage we intend to assess the ability of users to successfully use both the model and the tools for modifying and extending an existing board game.

VII. ACKNOWLEDGMENTS

The authors would like to thank Dr. Agnes Lisowska for her invaluable help and useful comments.

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