The RAGE Software Portal: Toward a Serious Game Technologies Marketplace

Wim Westera[1]([✉]), Baltasar Fernandez-Manjon[2], Rui Prada[3],
Kam Star[4], Andrea Molinari[5], Dominic Heutelbeck[6], Paul Hollins[7],
Rubén Riestra[8], Krassen Stefanov[9], and Eric Kluijfhout[1]

[1] Open University of the Netherlands,
Valkenburgerweg 177, 6419 DL Heerlen, The Netherlands
{wim.westera, eric.kluijfhout}@ou.nl
[2] Universidad Complutense de Madrid,
Prof Jose Garcia Santesmases 9, 28040 Madrid, Spain
balta@fdi.ucm.es
[3] Instituto de Engenhariade Sistemas e Computadores,
Investigacao e Desenvolvimento em Lisboa,
Avenida Alves Redol 9, S Joao De Deus, 1000 029 Lisbon, Portugal
rui.prada@gaips.inesc-id.pt
[4] PlayGen Ltd., Princelet Street 42-46, London E1 5LP, UK
kam@playgen.com
[5] Okkam Srl, Via Segantini 23, Trento 38122, Italy
molinari@okkam.it
[6] FTK Forschungsinstitut für Telekommunikation und Kooperation Ev,
Martin-Schmeisser Weg 4, 44227 Dortmund, Germany
dheutelbeck@ftk.de
[7] The University of Bolton, Deane Road, Bolton BL35AB, UK
p.a.hollins@bolton.ac.uk
[8] Inmark Europa Sa, Av Llano Castellano 43, 28010 Madrid, Spain
ruben.riestra@grupoinmark.com
[9] Faculty of Mathematics and Informatics, Sofia University
"St. Kliment Ohridski", Sofia, Bulgaria
stefanov@fmi.uni-sofia.bg

Abstract. This paper presents the RAGE marketplace portal (gamecomponents.eu), which is intended as a hot spot and neutral single point of access for serious game technologies. The portal aims at fostering collaborations and the exchange of technical artefacts and associated knowledge and resources between different stakeholders in the field of serious gaming (e.g. educators, developers, researchers, publishers, policy makers and end-users). After a brief introduction to the H2020 RAGE project, the flexible design of the marketplace portal and its underlying software repository are presented. A concise overview is given of the initial set of advanced game technology components created by RAGE, that are currently exposed in the portal. For empirical validation of these components, we have developed 7 serious games based on subsets of these components, which were then tested in educational practice with several hundreds of end-users. This game components portal want to be a neutral hub not dependent on any technology or provider and therefore it

is open for new game technologies submissions. We envision this marketplace as a knowledge and game technologies hub to support and amplify serious game development.

Keywords: Serious games · Software components · Learning technology Marketplace · Education · Learning

1 Introduction

1.1 Serious Gaming as a European Priority

For serious game development to become an actual industry in Europe, a better transfer of knowledge and technologies from research to application (and especially to SMEs) is required. Among the priorities of the European Commission investments are the creation of new jobs and growth (a.k.a. the Juncker plan) and the transition to a more efficient digital single market. Accordingly, the European Commission has spent hundreds of millions Euros in the last decade to ICT-oriented research and innovation in the context of learning, from schools to higher education, workplace learning and life-long learning. This includes the priority of serious gaming, viz. the use of game approaches for non-entertainment purposes. However, the transfer of knowledge and technologies from research to societal sectors to create economic and social value is problematic. The process of knowledge valorisation often fails, thus demonstrating the "knowledge paradox" [1], which refers to the fact that increased public investments in science and technology do not translate into economic benefits and job creation, while leaving many scientific findings unused. This is even more painful in the case of serious game technologies, because of their dual role in both innovating the domain of education and contributing to raising skills levels in other domains. Upon the transition from FP7 to the Horizon 2020 programme (H2020), innovation was identified – in addition to research – as a separate priority, and the principal funding criterion of "excellent science" has been complemented with the criteria of "societal challenges" and "industrial leadership", highlighting the importance of impact beyond the scientific communities. This means that H2020-funded research projects should not only deliver relevant scientific output, but should also aim at the practical application of research outcomes by targeted end-users and even devise sustainable exploitation models for this.

1.2 Supporting an Emerging Industry

Notwithstanding the potential of serious games in education, training, health and other domains, the serious game industry displays many features of an emerging, immature business, e.g. weak interconnectedness, limited knowledge exchange, limited division of labour and insufficient evidence of the products' efficacies [2]. The industry is scattered over a large number of small independent players (SME's). Because of limited collaborations and limited interconnections between industry and research, these small companies display insufficient innovation power to open up new markets (e.g. schools, business, governments). Consequently, the reinforcement of a "gaming

innovation ecosystem" is indicated, connecting and integrating research networks, networks of innovators and commercial parties across the entire value chain to reduce the entry cost and generate value [3].

1.3   The RAGE Project Supporting Serious Gaming

The H2020 RAGE project (www.rageproject.eu), combines advanced serious game technology research with a technology transfer mechanism. The technology research part focuses on creating advanced, reusable software components for serious games. These components cover a wide range of functionalities relevant for both the gaming domain and the technology-enhanced learning domain, including personalisation, adaptation, assessment, learning analytics, affective computing, among other topics [4]. The reuse of these dedicated components in new training applications would lead to higher quality solutions, reduced costs and reduced time-to-market. For the technology transfer part, RAGE establishes a marketplace portal to accommodate collaboration and exchange of knowledge and technologies among different stakeholders (e.g. educators, developers, researchers, publishers, policymakers and end-users). The marketplace portal would link supply and demand of knowledge and technologies and may ideally develop into a hot spot for (serious) gaming support, once a critical volume of users would be reached. The portal is readily positioned as an instrument to promote the formation of an "innovation ecosystem".

This paper presents the RAGE project as a driver of technology transfer in the serious gaming domain. First, its objectives and outcomes are presented. Thereafter, a brief overview is given of the software components and the games that were used for their validation, and a description of the marketplace portal. The paper is concluded with a discussion of critical factors.

2   The RAGE Project as a Driver of Innovation

2.1   Toward an Innovation Ecosystem

RAGE has launched a community portal that provides centralised access to a wide range of game technologies and knowledge resources. The project has created an initial collection of game software components (up to 40) and a multiple of associated knowledge and training resources, which are accessible at the portal. This collection of resources is complemented with community tools for annotation, rating, and social media integration, among other things. The portal addresses serious gaming stake-holders, which eventually will help to establish the desired innovation ecosystem. The software components and the marketplace portal are further detailed and explained in the next sections.

2.2   RAGE Reusable Software Components

To accommodate the easy integration and reuse of software in a wide diversity of development platforms, target platforms and programming languages, RAGE has

prepared a component-based architecture [5] that assures compliancy with these different environments. This supports the wider uptake and applicability of the software. Even so, the marketplace portal should be "neutral" and would welcome any software that is relevant for technology-enhanced learning or serious gaming, whether or not it is compliant with this architecture.

The RAGE Component-Based Software Architecture

The RAGE architecture [6, 7] distinguishes between server-side components and client-side components. Remote communications of server-side components with centralised applications are based on a service-oriented architecture (SOA) using the HTTP-protocol (e.g. REST), which offers platform-independence and interoperability among heterogeneous technologies. In contrast, client-side RAGE components, which need to be integrated into client-machine applications (e.g. game engines), are likely to suffer from incompatibilities. Regarding the client-side, the RAGE component architecture omits dependencies of external software frameworks to avoid interference with the application code. Instead, it relies on a limited set of well-established software patterns (Bridge, Singleton, Publish/Subscribe) and coding practices aimed at decoupling abstraction from its implementation. This decoupling facilitates reusability of a component across different game engines and other client environments with minimal integration effort. The architecture was validated for multiple programming languages (C#, C++, Java, JavaScript) and proof cases have been established with real games developed with different technologies (e.g. C++, Unity3D, Cocos2D) [6, 7].

The Initial Set of Software Components

As explained above, RAGE has developed up to 40 initial software components, all of which offer pedagogically-oriented functionality to be integrated in digital learning solutions, such as serious games. Table 1 lists the various aggregate component packages that are currently exposed on the portal (http://gamecomponents.eu). All these components use the Apache 2.0 license (white label software), which allows for reuse by third parties both for commercial and non-commercial purposes, either under

Table 1. Initial set of RAGE software component packages

Package	# components
Game Analytics Suite	8
Player Competence Adaptation Pack	3
Player Motivation Adaptation Pack	2
Other Adaptation components	5
Real-Time Emotion and Arousal Detection	4
Easy Dialogue Integrator	2
Shared Data Storage	2
Performance Statistics	1
Social Gamification Framework	1
Social Agency	5
Natural Language Processing	6
Storytelling Framework (Role Play Character)	2
Evaluation	1

open source or closed source conditions. To promote the adoption and reuse of the software products exposed all products have been enriched with user guides, instructional materials, demonstrators and proof cases.

Validation of the Approach

To validate the approach, game studios within the RAGE consortium created 7 serious games based on the various software components, which were then tested and evaluated in real end-user pilots. The games focus on various social and entrepreneurial skills and address diverse educational contexts. Table 2 shows an overview of the games, their purpose, target groups, and the main component functionality used.

Table 2. Games used for testing and validation of RAGE components.

Game title	Purpose	Target group	Main component
Sports Team Manager	Leadership and management skills	Recreational sports leaders	Social Agency
Space Modules Inc	Customer helpdesk skills	Vocational IT students	Role Play Character
IT Alert	Collaboration skills	Vocational IT students	Social Gamification
Job Quest	Job application skills	Corporate candidates	Emotion Detection
Watercooler	Conflict management skills	Art and Design Students	Dialogue Integrator
Hatch	Creative Entrepreneurial skills	Art and Design students	Essay scoring
ISPO	Interrogation skills	Police officers	Text-to-speech

The games are used as proof cases of "components in action". As an example, Fig. 1 shows a screen of the Space Modules Inc. game, which is based on RAGE's role-play virtual character components. In this game on customer communication skills, the player takes on the role of a customer service representative working at the help desk of a spaceship part manufacturer. Customers with a variety of starting moods and emotional dispositions get in touch about faults they are experiencing. The player has to manage diverse situations and has to decide how best to respond.

RAGE's role-play virtual character components are used to model the decisions and emotional reactions of the diverse customers. In this process, the Emotional Appraisal Component evaluates how the virtual character's emotional state should change as a result of player actions, whilst the Emotional Decision Making component dictates the reaction of the character based on the changes to their emotional state. In the context of this game, the facial expression of the virtual character is determined by its mood, which is calculated using the values of their various emotional states as set by the Emotional Appraisal Component. Overall, the main purpose of the role-play components is to easily establish believable social behaviour of virtual characters.
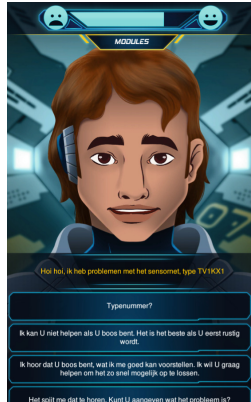
Fig. 1. A screenshot from the Space Modules Inc. game, showing one of the customers.

More than 500 participants were involved in the first pilots to formatively evaluate the games with respect to usability, user-experience, motivation, learning outcomes, and costs versus benefits. After an iteration cycle based on the evaluations, improved versions of the games were used in a second pilot series, involving over 1500 participants in total. Results are being reported elsewhere. Gathering sound empirical evidence of both the effectiveness of the games for learning as well as the added value of diverse technology components is considered essential for devising relevant business cases and promoting wider adoption by the industry. Alongside RAGE pilot studies, a survey among software component developers and game developers has confirmed the practicability of the component-based architecture and the ease of integration and reuse of the components in diverse game engines. Details are in [8].

2.3   The Marketplace Portal

The RAGE marketplace portal, available at http://gamecomponents.eu, is the technical platform for exposing game technologies and resources. In contrast with existing marketplaces, which are either driven by commercial game platform vendors (e.g. Unity, CryTec, Unreal), by vendors of other creative software tools (e.g. Adobe), or general media stock asset marketplaces (e.g. graphicriver.net), the RAGE portal is "neutral", that is, not platform driven or game engine driven, but instead domain driven. With its focus on serious games it has a clear scope, not positioned as a by-product of leisure games. At the core of the portal is a digital repository of software objects and associated knowledge resources [9]. Figure 2 shows a screenshot of the software catalogue page.

The portal provides search functionalities and a high level categorisation of software into functional areas. The look and feel of the portal largely complies to what is common at existing marketplaces.

The submission process for new software is guided by a stepwise workflow (i.e. wizard) for entering the most relevant metadata and the associated artefacts (see Fig. 3). The software can either be uploaded as a separate zip archive or included as a

Fig. 2. A screenshot of the software catalogue at the marketplace portal (gamecomponents.eu).
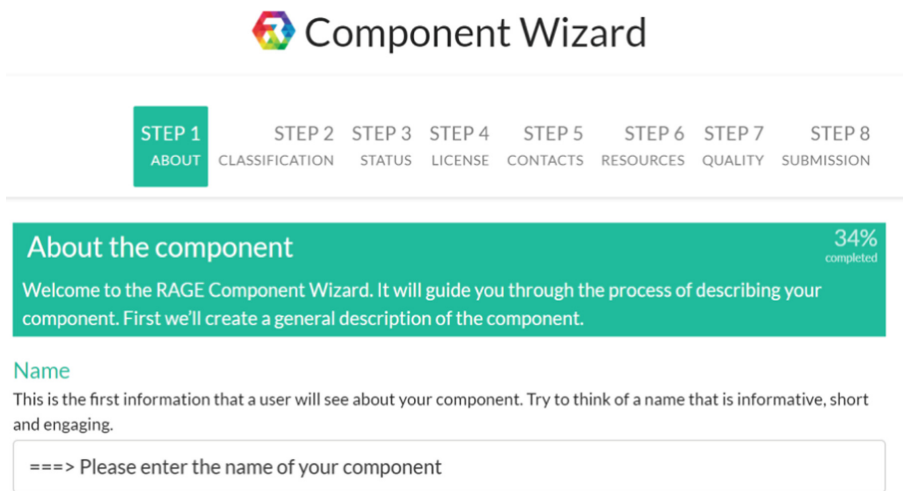

Fig. 3. A screenshot displaying part of the software submission workflow.

reference to an external archive (e.g. Github). Also, associated artefacts (e.g. manuals, tutorials, videos, demos) can be provided. Integration with social media platforms such as Mendeley and Slideshare allow for easy import of pre-existing resources [9].

Finally, to support future sustainable exploitation of the portal including software pricing and paid subscriptions, the portal also includes full e-commerce functionality, allowing for secure financial transactions between parties. Still, all current RAGE components are free, open source software.

3   Discussion and Conclusion

In this paper, the H2020 RAGE marketplace portal was presented as a vehicle and a catalyst for amplifying the domain of serious gaming. Launching a portal, however, even if it exposes high quality technologies and associated knowledge resources, does not create "per se" an innovation ecosystem. An ecosystem should be a lively social system that acts as a catalyst among diverse stakeholders across the value chain: researchers, industries, education and government. To achieve this, it is needed to raise interest among stakeholders, engage them and demonstrate the value that the portal offers, so that supply and demand are amplified, and help to establish the self-sustained community.

But to have a successful marketplace, three critical factors need to be addressed. First, it is unclear if the initial set of RAGE technologies and related resources (e.g. training) would display sufficient critical mass to create traction among in the serious game stakeholders (e.g. game studios, developers, researchers). To increase its portfolio other research partners and projects are actively being approached and invited to expose their software at the portal. Already, visitors of the portal (at http://gamecomponents.eu) can register and upload their own software for exposure at the marketplace. We have noticed that an exclusive focus on reusable software components in accordance with the RAGE architecture would be too restricted and might discourage third-part software developers to expose their software at the portal. Therefore, the portal allows for posting any software applications and platforms that are deemed relevant for serious gaming. Both production-level software and experimental software prototypes would be allowed, as well as associated knowledge resources.

Second, for professional users the quality of the exposed software and its associated resources is deemed crucial. This quality refers to correctness and style of coding, documentation of code, installation manuals, test suits, demos, evaluations, scientific evidence, maintenance info, and many more factors. In the concept of a community-driven marketplace, however, centralised quality control (i.e., checking and testing all the submitted products) is not a viable option. In the terms and conditions of the portal, it will be made explicit that all ownership, quality claims and liability of software products remain at the submitting parties. Still, to avoid low-quality software submissions four quality assurance mechanisms will be put in place:

- *Completeness of metadata*: In the submission workflow, completion of metadata is checked and indicated, as to make sure that submissions go with an appropriate set of metadata.
- *Self-assessed quality score*: In the submission workflow, the submitting party is asked to indicate the quality conditions of the software posted, such as the status of documentation, the availability of test suits and so on, which becomes visible for all users.

- *Community ratings*: To exploit the wisdom of the crowd, the portal includes a product rating system, which allows consumers to rate the products exposed. Weak software will be spotted soon and publicly disqualified. The overall software quality is raised by this reputation mechanism.
- *Automated quality checks*: To a limited extent, automated quality checks may be used to assess the submitted software. This may include generic test methodologies, such as using test suites, code coverage tests or error injection [10], but also tests specifically testing compliance with the RAGE architecture, for instance detecting incorrect implementation of software design patterns, or detection of component´s API and bridge usage [6, 7].

Third, to effectively address the knowledge paradox RAGE also includes an exploitation and revenue model for the portal so that it can continue and grow beyond the lifetime of the project. Based on extensive stakeholder consultations, a Hybrid Multi-Sided Business Model has been selected as the best option, providing the flexibility and ability to eventually accommodate multiple revenue streams, such as subscription fees, e-commerce services, and premium services, and to adapt quickly to changing market conditions in the fluid and fractured serious game development landscape [11]. RAGE seeks active involvement with stakeholders who could support sustainable exploitation, either as technology users, technology providers or as participants in the governance of the platform. To continue the RAGE activities after the ending of the project (2019), a Foundation (legal entity) has been established, that is open to third parties, to look after the implementation and sustainable exploitation of the marketplace platform.

We expect that successful maintenance and exploitation of the marketplace may truly advance synergy and coherence in the serious gaming domain.

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