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INTEROPERABILITY STRATEGIES FOR SERIOUS GAMES DEVELOPMENT

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Abstract: *Serious games have emerged as a new medium that enable players to acquire and enhance their skills and knowledge particularly in education and increasingly across a spectrum of fields from industrial and emergency training to marketing. While the use of serious games has extended rapidly to a variety of domains, their design and development remains a challenging process both for developers and teachers/trainers. This paper approaches the technological environment underpinning the development of serious games, and focuses on interoperability as a core element of a sustainable endeavour. Developing serious games in a way that enables interoperability is one means of increasing the depth and scope of instructional materials available to learners while reducing the overall development costs and time. Interoperability, the ability of computers and applications to communicate and share resources in a heterogeneous environment, is dependent on standards. Optimizing requirements of accessibility, interoperability, durability, and reusability for maximizing cost efficiency start with a proper understanding and integration of standards. The authors argue that interoperability provides a context for the development of sharable education resources and technologies which in turn allow for collaborative education in a field in which rapid technological developments are making it difficult for instructors and developers to stay up-to-date with both the science and the related technologies. The paper analyses various Serious Games interoperability scenarios and address the main gaps surrounding standardization in this field with the purpose of assisting developers and teachers in implementing successful solutions. The scenarios are based on a Serious Game Multidimensional Interoperability Framework that integrates three key dimensions: the core components included within a serious game (game mechanics, gameplay, graphics engine, graphic objects), the ecosystem where the serious game will be implemented (developing platforms, programming languages, LMS communications) and external factors that go beyond the core technical aspects of a serious game (assessment, applicability, classification, glossary of terms). The research considers the existing standards – such as SCORM and LOM - that impact serious games development, as well as gaps and fragmentation issues that hinder the development process with the purpose of identifying efficient, adaptable solutions.*

Keywords: *serious games, interoperability, SCORM, LOM, LMS, SG-MIF*

I. INTRODUCTION

Interoperability is one of the core themes of serious game (SG) development [1, 2] and it aims to support an effective exchange of information based on consistent, specific data and technical standards. Interoperability scenarios aim to enhance the interaction between serious game developers by means of alternative technological solutions that are derived from standards. Paraphrasing the famous quote of George E. P. Box, *all models are wrong, but some are useful*, and considering the fact that serious game developers reside not only in academic, but also in industry environments, it can be concluded that no standard or scenario for interoperability can constitute the ultimate solution or the panacea for serious game development. Therefore, this paper analyses various challenges and different interoperability scenarios that coexist within serious games ecosystems with the purpose of enabling adaptive solutions. This research aims to facilitate in-depth understanding of cost-efficient development and large-scale implementation of reusability in serious games (SG) environments based on a *Serious Game Multidimensional Interoperability Framework (SG-MIF)*.

1.1. Identifying the Need for Interoperability

Interoperability is a key requirement for organisations regardless of the field they operate in – education [3], commerce [4], health care [5], or military [6]. Many educational organisations already operate large environments that implement different technical solutions. When these organisations perceive the need for new/additional applications implemented within their environments, the automatic tendency is to start thinking based on currently implemented environments. This is usually referred to as Technology Aligned Environment, where decisions about enhancing the current environment are more closely connected to what it is already running rather than on the basis of which provides the best platform [7].

With the ever increasing requirements for efficiency, responsiveness, and cost reduction, interoperability stands as a core demand for the modern IT environments. The European Interoperability Framework stands out as an effort to facilitate the delivery of eGovernment services to citizens and enterprises within a multi-vendor, multi-network and multi-service European area. It has emerged from the necessity to support the development of the single market where European public administrations are interoperable to enable any supporting information exchanges [8, 9].

A sustainable, flexible development of serious games employs vehicles that enable the ability of serious game components and of serious games ecosystems to work together easily and effectively by design. The research on serious games interoperability focuses on five key areas:

- *Standardization*. Analyse scenarios that enables the creation of functionally interchangeable items, while considering opportunities, challenges that existing standards and best practices that impact SG development.
- *Interchangeability*. Identify methods that would make game components interchangeable, without having to alter the item to make the new combination possible.
- *Standards adoption*. Analyse the position of the development companies and of the educational actors towards standards adoptions in an effort to create adaptable solutions.
- *Open systems architecture*. Provide a modular design that defines key interfaces within a system using widely supported, consensus-based standards that are available for use by all developers and users without any proprietary constraints.
- *Unique specifications and proprietary devices*. Consider the fact that unique or utility-specific applications and vendor-proprietary applications and devices can be counter-productive to interoperability, but may be necessary to provide needed functionality.

1.2. The whys of serious games interoperability failures

The problem of incompatibility due to multiple hardware platforms, operating systems, and languages impacts upon the serious games development environment. At the moment, there are thousands of simulations, teaching programs and also games that cannot interoperate [10]. Such systems need to be highly interoperable, easily configurable, aligned and consistent with local and global efforts [11]. The experience of educational communities illustrates not only the need for standards, but also the need for adaptable interoperability scenarios.

Common interoperability standards could benefit both the academic and developer communities, enabling them to solve common problems with common solutions. At present, there is no consensus in the games industry on the desirability of a common set of interoperability standards [2]. Resistance to common interoperability standards is generally based on the following factors:

- Technical considerations: Common standards accommodate a wide range of potential users and therefore are not optimal for any particular use. Many game companies prefer to design custom protocols that maximize performance.

- Not-invented-here syndrome: many commercial firms have a bias against technology developed outside their own organization.

- Strategic value of proprietary solution: proprietary protocols are viewed as a strategic competitive advantage. Use of a public standard would eliminate one element of advantage by allowing competitors to use the same technology. In addition, use of a public standard could signal that a company is unable to develop a better solution.

- Control: Adoption of an industry or public standard reduces the control a company has over its protocols. Standard committees determine changes to the protocol. Companies that control their own protocols can upgrade them at their own pace, as the need arises.

Even if game developers are willing to examine protocols for suitability in their games, few have actually implemented them. Some companies find protocols too big and complex, performing operations that were not relevant to games and slowing the performance of the system. Others prefer to develop derived protocols that include only those functions needed to support their applications. Each of these implementations is proprietary to the developing company and not interoperable with other companies' protocols.

Besides the direct technical considerations, standard and interoperability failures relate to collateral elements that impact upon their success. Decisions in this area are made by private, standards bodies and industry consortia that operate largely outside of the public eye and with little input from public interest groups or public policy makers [12]. For information and communication technology standards resulting from these private processes to meet any comprehensive definition of "openness", standard developers need to consider and reflect the input from public policy experts.

Moreover, history has shown interoperability to be also a people problem, the people's failure to use best practices to develop the right processes and tools (including standards) for sharing trusted information [13].

II. INTEROPERABILITY IN SERIOUS GAMES ECOSYSTEMS

Previous researches have focused mainly on interoperability issues of singular components, like game engines [14, 15], while specific technical areas, such as distributed simulations like HLA have not been taken into consideration. This research takes a holistic approach and builds upon three key elements that impact upon serious games interoperability: the components included within a serious game, the ecosystem where the serious game will be implemented and external factors that go beyond the core technical aspects of a serious game [14]. These elements form the core research dimensions of a Serious Games Multidimensional Interoperability Framework (SG-MIF). The researchers consider that such frameworks enable prior evaluation of alternative interoperability scenarios by providing an overview on interoperability-based SG development. The following sections detail upon the different interoperability scenarios extracted based on the SG-MIF.

2.1. Serious Games and standards: SCORM and LOM

SCORM (Sharable Content Object Reference Model) is a standard developed by ADL (Advanced Distributed Learning) that enables sharing of distributed learning content across SCORM compliant learning management systems. The main questions arising in connection with the SG-SCORM relationship are: What types of information can be exchanged using SCORM? What types of serious games components can be reused using SCORM?

The SCORM specification covers two particular topics related to serious games: package and deployment, and communication between serious games and Learning Management Systems. In this

way, a SG is conceived as a SCO object, and considering the SCORM Content Aggregation Model it can be deployed in multiple commercial and open source LMS platforms already available. In addition, SGs can generate a great amount of tracking information that can be used by the instructor to evaluate the student play session. Using the SCORM Runtime Model a SG can set some of the `cmi.*` properties: `cmi.completion_status`; `cmi.success_status`; `cmi.core_score_raw`; `cmi.interactions`. `cmi.interactions` is a collection of properties, that is, multiple values can be collected inside this property. In contrast to `cmi_score_raw` and `cmi.success_status` that provide a coarse-grained evaluation of the student's performance, `cmi.interactions.*` can be used to provide a fine-grained or detailed report of the student game play session and its relation to the SG learning objectives.

These properties (and the rest of SCORM data model) can be used in game engines such as the e-Adventure authoring tool. This way, the internal game state can be translated to a platform neutral data model. Moreover, e-Adventure games sent the information back to the LMS using the SCORM Runtime API, so the game tracking information can be reviewed or used by other tools that are hosted in the LMS.

The IEEE Learning Object Metadata is a standard metadata schema that aims to provide a common vocabulary to describe e-learning content materials. In relation to SG, two key questions arise: How can serious games employ the standards defined by LOM to enable learning content classification? Is the use of metadata a feasible solution for serious games? If serious Games are to be considered as a particular case of learning objects, fostering the reuse of existing SG by adding metadata to them seems a logical path to follow. Taking into account the cost constraints related to SG development makes adding metadata to SG a necessity that fundament reusability in SG environments [14].

2.2. Interoperability between games and Learning Management Systems

The key role of a modern Learning Management System (LMS) is to facilitate the interaction between tutors and learners, detailed tracking of the students' progress, and a simple path for the delivery of content through the web. Therefore, it is important to enable the exchange of information between serious games and the learning management system(s), with the purpose of tracking user progress and behavior. Given the variety of game engines, programming languages and hardware platforms, how can interoperability between this variety of SGs and LMSs be enabled?

The game state can be changed by stimulus, such as a mouse, gamepad or game dynamics. Every game must have a container for game objects. There are two kinds of objects: one belongs to the game logic and is called an actor and other belongs to the renderer and is called a textured skeletal mesh. If the game state of actor changes, the game logic sends an event to the renderer and it reacts to this event by changing the texture. To conclude the game logic holds the object state and the game view holds model data and textures. SGs have more than just storyline, design and software. The pedagogy in this type of game plays a major role. For this reason we need a new component to check and report when the learning objectives have been met by learners. The added component is called game tracking layer.

There is little research related to the interoperability between SGs and LMS platforms, most of them use the SCORM specification to package and deploy web based SGs and to send and receive information from the LMS using the SCORM API. There is no standardized specification or standard to integrate desktop games with an LMS platform, however there is a research trend related to the SCORM High Level Architecture, aiming to integrate training simulation software with an LMS.

2.3. Interoperability between game components

In the field of SGs, the interoperability between game components has the role to sustain the reusability of basic multimedia assets and game objects of low, medium and high complexity. When referring to reusability of game components we can identify two main groups of components:

1. Basic multimedia assets that are reused and integrated into the game based on their file format, and the capabilities of the game engine. Examples of these assets: images, 3D objects, audio and video clips. These multimedia assets have the highest reusability potential of all the other game component types because they do not require complex prerequisites on the part of the game engine – the game engine just has to support the specific file format and they become available for use. Because

these assets are part of a fixed class of types, with fixed properties, it is very easy to use conversion applications that transform one file format into a compatible one, without loss of functionality (e.g. an image can have the exact same properties regardless if its file format type).

2. Complex game objects that incorporate additional semantic metadata and even custom scripting code can be executed by the game engine interpreter to maximize customization capabilities. For example: a user avatar that defines properties such weight, gender, voice characteristics, strengths, weaknesses, etc. These classes of objects have specific prerequisites on the part of the game engine – besides the actual file format, the extended properties of these games must be described in a method that can be read by the game engine and interpreted according to their meaning. Which classes of game components can be made reusable? What is the best method of describing and embedding metadata about complex game objects so that they can be effortlessly integrated into a variety of game engines?

2.4. Serious Games Multidimensional Interoperability Framework

In the light of the above, it becomes necessary to advance a method that build upon research carried within specific areas and that provides a clear overview of alternative interoperability solutions.

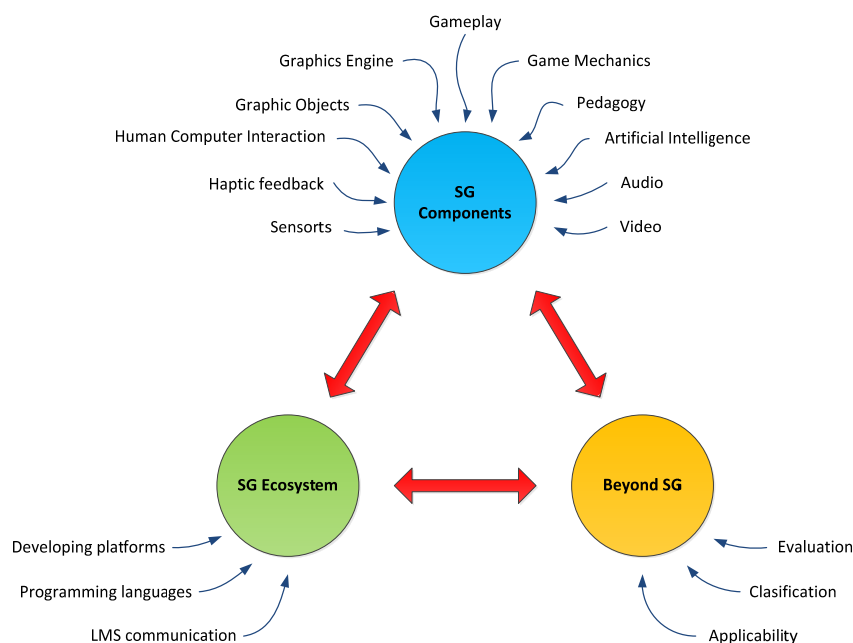


Figure 1. Extended Serious Games Multidimensional Interoperability Framework (SG-MIF)

This Serious Games Multidimensional Interoperability Framework (SG-MIF) has been developed to facilitate the in-depth analysis of this complex research topic, as well as to put it into perspective the SG development ecosystem.

III. CONCLUSIONS

The approaches in the interoperability literature [15] do not propose mechanisms for prior evaluation of interoperability solutions. This paper advances a Serious Game Multidimensional Interoperability Framework that aims to fundament prior evaluation, respectively the ability to evaluate, earlier in a serious game project, two key elements: the potential improvement that will result from the solution’s implementation; and the impact of this interoperability improvement on the achievement of the SG objectives at technical, operational and strategic level. The researchers hypothesize that the difficulty of these approaches that aim to assess the contribution of interoperability to the SG development strategy relates to the fact that they do not take into account the

entirety of the SG ecosystem. The goal of this research was to propose a framework that addresses this issue and that enables SG developers consider different levels of interoperability, as well as develop adaptable interoperability scenarios. Future research will focus on mapping the strengths and the challenges of each of the sub-elements of the SG-MIF with the purpose of offering a clear picture on the advantages and disadvantages of each interoperability solution.

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