A PROOF OF CONCEPT: CYBERSECURITY LEARNING CONTENT IN LTI BASED, EDUCATIONAL SYSTEMS

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ABSTRACT

Serious Games are an important part of technology aided learning. Since the learning outcome of intrinsically motivated learners is generally higher, a learning system should support the learner in achieving this state. Serious Games utilize the natural intrinsic motivation of playing a game by incorporating learning objectives. Concepts such as Digital Game Based Learning (DGBL) and Immersive Didactics achieve this by creating a learning environment that feels like an entertainment game by aligning learning and gaming goals. This puts players in a state of peaked intrinsic motivation which allows them to achieve increased levels of learning success - even while enjoying the game itself. Learning content for Serious Games is usually taken from existing courses or other materials. This work in progress explores the implementation of the interoperability standard LTI for integration purposes of third-party learning content into a Serious Game context.

KEYWORDS

LTI, Interoperability, DGBL, Learning Content Creation

1. INTRODUCTION

In the domain of Cybersecurity being addressed here, traditional education courses exist that offer subject-specific spotlights but few cross-topic learning opportunities. The presented concept allows to recombine existing learning content into case-specific tailored learning arrangements. The additional integration of the learning content in a game context leads to an intensified engagement of the learner with the subject matter, high intrinsic motivation and thus ensures a sustainable build-up of knowledge (Krapp et al. 2009; Prensky, 2007; Bopp, 2006).

In our previous paper (Atorf et al., 2021), a methodological and technical concept was developed with the primary goal to extend a Serious Game with a feature that allows learning content, available in third-party learning systems to be included with the lowest possible integration cost for authors. It is proposed to use the interoperability standard "Learning Tools Interoperability" (LTI) version 1.3 (IMS LTI, 2022) which links the individual systems involved in the project. The LTI standard makes a fundamental distinction between two system components: LTI-Tools provide the learning content which is consumed by the LTI platforms. The learning content considered is based on the thematic domain of cybersecurity. The content focus can be broadened to any content domain with the concept presented.

2. PROOF OF CONCEPT

Figure 1 shows the system architecture of the pre-developed concept, implemented during the proof-of-concept. Thereby, LTI layers are used to integrate different learning content providers into the serious game context. The dotnet reference implementation (LTI Advantage Platform, 2022) serves as the platform layer. For the implementation of the tool layer, two different libraries are used: a .Net-based (LTI Advantage Tool, 2022) and a JavaScript-based (ltijs, 2022) library.

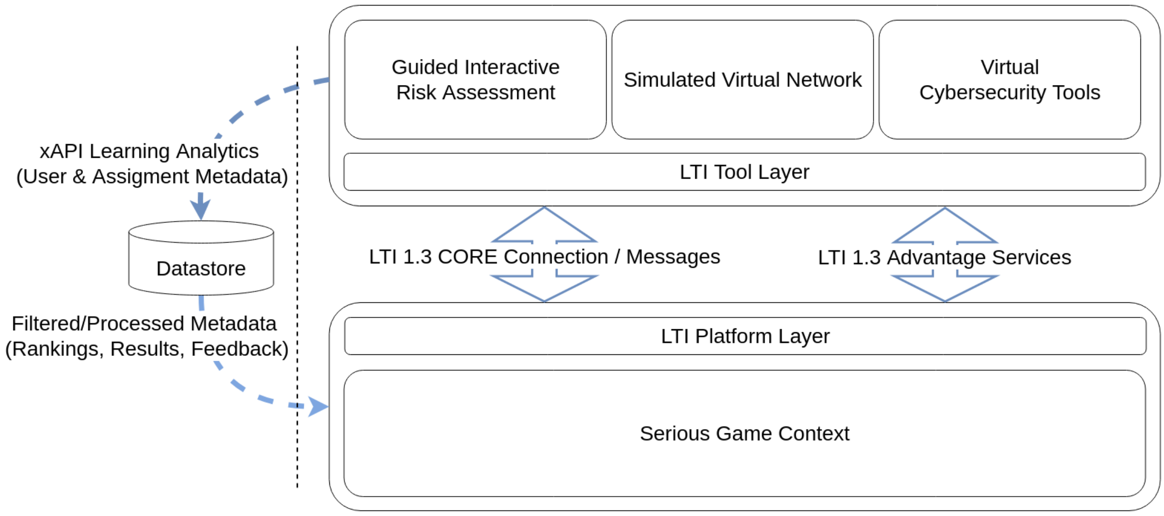

Figure 1. System architecture: LTI Tools integrated in the Serious Game Context via LTI Layers

The concept further provides for a learning record store that enables learning analytics and adaptivity response based on learner interaction using xAPI. This will be addressed in later work. Below is a brief description of the individual components shown in the figure 1.

2.1 Serious Game Platform

Serious games, and especially those that follow the digital game-based learning concept, are time-consuming to create. For each part of the development, such as the development of the story, the creation of graphic assets, sound, music, GUIs, etc., a separate expert is usually needed, to whom the idea of the game must be explained anew. This makes communication time-consuming and these experts are also subject to the fluctuations of the market. Once a Serious Game is developed, it seldom can be reused in other contexts; each application and learning purpose usually requires its own, new game. This is also true for existing learning content originating from training systems, learning platforms or simulators in schools or companies, which cannot be easily integrated, but must be reproduced in the game at great expense.

To further the required domain-specific adaptation and development of the Serious Game Platform, e.g. background story, missions, characters as well as tasks from the Cybersecurity domain, an experimental game development framework utilizing a modular concept is used. The framework provides finished game mechanics like resource management cycles, missions, story chapter structure etc. Depending on the requirements, elements can be added, adapted and extended, greatly reducing complexity of creation and improving the "recreatability" of Serious Games. Its central element is the so-called Game-Loop, which defines the general game play and game mechanics and essentially remains the same for each use case. The other elements Storytelling (if needed, a story is told in the chosen setting to give more context for the execution of missions), Setting (defining the game world), Missions (tasks from the application domain to achieve the learning goals) and Gamification (achievements and rewards for further motivational support) are only adapted or used where it becomes necessary for the use case. These customizations represent an instantiation of the framework using round-based and resource cycle approach (see Figure 2). The framework uses WebGL (WebGL, 2022) as deploy target, allowing the game to completely run in a web browser, platform independent and easily accessible. A full introduction of the framework instantiation features like core game mechanics and storyline would go beyond the scope of this work in progress paper and will be addressed in future publications.

Figure 2. Instance implementation of the used framework

Existing learning systems (Learning Management Systems, simulators, etc.) are integrated for the execution of missions. This integration is done via interoperability standards like LTI, integrating even external learning content seamlessly, making it "part of the game". The technical integration of the learning content can also be achieved with any other LTI-capable system without the possibility of using the benefits of the framework described above.

2.2 LTI Platform Layer

The dotnet reference implementation is chosen as Platform Layer (Atorf et al., 2021) and deployed on Ubuntu 20.10. The LTI platform is configured to forward content of connected LTI-Tools via LTI 1.3 Core functionality (deep linking). Additionally, LTI 1.3 Advantage Services (i.e. grading service) were implemented (see Figure 1).

2.3 LTI Tool Layer

LTI 1.3 Tool implementation is added to multiple existing learning courses, which then would be made available in the Serious Game Context via the LTI 1.3 Platform reference implementation (or any other LTI 1.3 compatible platform) mentioned before. Those courses are:

2.3.1 Guided Interactive Risk Assessment

Guided Interactive Risk Assessment (GIRA) is used to assess the risk of a particular industrial automation and control system (IACS), to identify and apply security countermeasures to reduce that risk to tolerable levels, according to the relevant IEC standard (IEC 62443-3-2, 2022). The learner is made familiar with this process by completing the risk assessment for a given system.

2.3.2 Simulated Virtual Network

The Simulated Virtual Network (SVN) is a development of a virtualized training platform in the Industry 4.0 context (Rösch et al., 2021). Its primary goal is to provide availability of a virtual platform instead of the physical platform itself. This enables learners to conduct training content themselves as a preparation or follow-up to classical classroom training without the need of physical access to the real hardware. The SVN allows the learner to observe an energy process of voltage regulation from an attacker's (blackhat) perspective by manipulating it with various simple attack techniques.

The SVN is based on a virtualization of host systems and a network for data exchange. The hosts are virtualized by implementing containerization using Docker. These hosts contain simplified functionality of the real components and provide real user and communication interfaces. The virtual network is implemented using the Containernet framework and allows the flexible construction of different network infrastructures. The learning scenario includes the use of the Nmap tool and introduces the learners to the topic of network scans, by providing a Kali-Linux container which serves as a user interface.

2.3.3 Virtual Cybersecurity Tools

A set of network and security tools (i.e. wireshark, tcpdump) are made available through a virtual Linux desktop. The tools can be used to monitor simulated (see SVN) or real networks which are connected to the Linux box.

3. CONCLUSION AND FUTURE WORK

To leverage a learner's intrinsic motivation, this paper concerned itself with a proof-of-concept of integrating external educational resources in a Serious Game context using the interoperability standard LTI. It is shown that the LTI platform reference implementation can be used to access third-party learning content. The main take-away is, that the more open standards are followed during implementation of learning content the easier the process of integration into new learning environments.

In a next step, this proof-of-concept work will be used to demonstrate the implementation of a learning record store for enabling learning analytics and adaptivity response based upon learner interaction using xAPI statements (see Fig.2). Additionally, it is planned to integrate into the overarching CLM Learning Environment (Krauss & Hauswirth, 2020).

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