Challenges for Cloud-Based Simulation Games

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Abstract

As business applications such as highly integrated Enterprise Resource Planning systems (ERP) become more complex, system-integrated business simulation games are vital for educating tomorrow's white collar work force. Especially for small and medium-sized enterprises (SME) cloud-based business applications are a serious alternative. The Education as a Service (EaaS) approach gets more and more into the focus, hence. In order to yield a fruitful scientific dispute on the matter a cloud-based simulation game design is proposed in this paper. That design also identifies challenges implementing and operating a cloud-based simulation game. It reveals issues such as the composition of the simulation model and its relation to the host system as well as communication matters (change of interfaces) and the coordination between customer, host system and the simulation itself. Furthermore, the choice of the right service and deployment model affects the design of the simulation game.

1. Introduction

Business requirements for Enterprise Resource Planning (ERP) systems are continuously getting more complex. Facing this issue, a substantial demand for interdisciplinary experts, e.g. IT specialists with process management knowledge, is existent.

Since the 1950s, the usage of business simulation games has been approved by several universities and higher schools [6]. The advantage of business simulation games lies in the easy adaption of real-world problems into simulated as well as controllable scenarios. Furthermore, games combine learned theory with applied practise. Therefore, they are used as preferred tools for classroom-teaching [22].

Simulation games describe constructed situations where participants have to come to decisions. Predefined gaming rules form the surrounding model; that is the gaming environment [9]. The tasks of the game leader lie in observation and decision analysis. Following Kriz (2001), three important components comprise such a simulation game [17]:

- The *Simulation* represents the technical implementation of the model.
- The *Game* stands for the set of rules as well as structuring and defining processes.
- *Role* is a synonym for the combination of participants and their tasks.

However, these classic business simulations reach their limitations concerning globalisation. They are hardly suitable to fulfil the demand on interdisciplinary specialists because they predominantly focus on managerial purposes and a small group of managerial decision makers. Simulation games connected or tightly integrated to an existing business application are encouraging and improve the usability of those games. With *ERPsim*, a system-integrated business simulation game combined with SAP ERP 6.0 has been offered [18]. The participants interact with the host ERP system while playing the simulation game. This allows a better job preparation because of the early interaction with real-world business applications already during the qualification phase.

Due to scarcity of skilled personal and monetary constraints, small and medium-sized enterprises (SME) often do not have own ERP systems operating within their system landscape. Hence, the approach of providing cloud-based business applications is a serious alternative to them and got widespread attention just recently. This is especially true owing the significantly reduced operational costs [1]. Nevertheless, these ERP systems also have a large range of functions and become more complex with the enduring technological progress. Referring to the success of simulation games for teaching ERP concepts [19], the adoption of those games for the cloud-computing paradigm might be a possible approach fencing ERP system complexity with the education of interdisciplinary specialists.

In this paper, we would like to propose a possible architectural blueprint of a system-integrated and cloud-based ERP simulation game. We further identify challenges and propose remedies in designing such cloud-based ERP simulation games and draw an out-

look on a design-oriented research agenda to fulfil the emergent tasks.

2. Related work

2.1. Higher Education meets Cloud Computing

Cloud Computing is increasingly attractive for educational purposes as well. Due to its different service provisioning models (Infrastructure, Platform or Software as a Service – IaaS, PaaS or SaaS) the cloud computing paradigm promises flexibility and cost advantages to the consumer [1; 16; 26, p. 111]. Therefore it is not astonishing that a variety of service providers like Amazon (with Elastic Compute Cloud (EC2) and S3), Google (with Google Apps) and Microsoft (with Azure) operate clouds for serving different needs like communication (email, messaging), organisation (file space, calendar) or collaboration. Google Docs for instance allows multiple users to work on one text file, spread sheet or a presentation at the same time) [26:111]. The principle of simplification becomes obvious when referring to the customer's view. The controls of these virtual environments are usually implemented by using web service interfaces (e.g. HTTP[1], XML[2], REST[3], and SOAP[4]) [26].

Among SME and public institutions, especially the academic sector may benefit from the advantages of cloud computing. On the one hand, their aspiration is to educate young people in modern theory and methods. An up-to-date IT infrastructure is helpful to reach this goal in special disciplines. On the other hand, public budget is limited or the model of funding can shift from the government support model to the university independence model [3]. The using of cloud services results in system maintenance reduction (especially in labs) and responsibility shifting to external providers [26:112].

Several US universities already moved into the cloud. The University of California at Berkeley developed a cloud computing curricula in combination with Amazon's EC2 [8] for instance. Others like the Medical College of Wisconsin in Milwaukee decided to leverage cloud computing power for their research [26:113] or even just because of economic concerns like the Washington State or Colorado State University [16; 26]. Even several European and African academic institutions are embracing the cloud paradigm [26:113].

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[1] **H**ypertext **T**ransfer **P**rotocol

[2] **E**xtensible **M**arkup **L**anguage

[3] **R**epresentational **S**tate **T**ransfer

[4] **S**imple **O**bject **A**ccess **P**rotocol

The distinctive need of cloud solutions within the academic sector causes Hignite et al. (2010) to create the term *Education as a Service (EaaS)*. Concerning their definition, cloud architecture, applications and services are put in context to the peculiarity of education [12]. Several processes and functions in higher education – may it be lectures, assignments, tutorials, grading/marking or student support – are covered by the term *Education*. Fogel (2010) deals with the benefits adopting EaaS in higher schools and points out advices implementing EaaS under emphasis of the architecture of services and its integration [7]. EaaS can therefore be seen as a business model rather than only a new way of delivery education [3]. Consequently, EaaS can be realised using SaaS, PaaS or IaaS [4] as such EaaS offers

- a blended learning concept [10] where the traditional lectures or exercises (with personal attendance) are enriched with additional online material like videos, games and further information of the subject as well as
- a platform to integrate the different resources to enable peer learning (interaction with group members) amongst the students [3].

The *Khan Academy* as a non-profit organisation is a particular implementer of the EaaS model. It offers a complete electronic classroom solution with a substantial coverage of different subjects in the form of online videos, comments and exercises [15]. Even more companies like *BenchPrep, 2U, Voxy, and Goalbook* are responding to the need of electronically accessible education resources and confirm the impression that "education as a service is not a temporary trend in the educational industry" [14].

2.2. Technological development of business simulation games

Business Simulation Games have a long history. The first strategy management simulation was named *Intop*, appeared 1963 and was used by universities such as the University of Chicago to train their students [13]. Computer games like *Ports of Call* (appeared 1987), *Oil Imperium* (appeared 1989) and others date back to the late 1980s, where compute resources were scarce and graphical output was poor. However, they have always attracted a profound customer base. Also business simulation games have been found to be interesting to gamers over a comparably long period of time. Whereas early games as the mentioned ones where already multi-player games, they were limited to few players that could use the same hardware and graphical output. These players needed to be in the same place effectively.

The Internet has been revolutionary to business simulation games, hence. For the first time it became possible that players all around the world could connect to a central gaming network. This network coordinates inputs of huge amounts of globally distributed gamers and simulates the economy on the basis of their inputs.

Together with the Internet revolution, computer hardware got ever more powerful. Today, it is no longer necessary even to deploy business simulation games using an own dedicated client on every computer. Instead of that, standard browser capabilities can be used to gather inputs, steer controls and do the graphical outputs. Providers can attract and bind customers in a few simply steps and over the Internet therefore.

Even if not entirely browser based, one of the predominant examples of the so-called Massive Multiplayer Online Games (MMOGs) is *Eve Online*. Eve Online simulates a Science Fiction economy in space, in which each player can obtain a certain role in the market. These roles range from providing raw materials to finished good. Also a wide range of services like transportation or research can be provided. Different stars within the game form their own market inside a global economy that consists of more than 5400 stars [5]. These markets all have their natural resources and defined environmental preconditions. Lastly, an intergalactic war on resources is established.

What is most interesting about such simulation games, is that lots of market and behavioural insight can be drawn from massive amounts of transactional data. Players that are playing MMOGs are becoming part of continuously investigated and analysed parallel economies and simultaneously an economic entity in the market experimentation.

With regard to cloud-based ERP-integrated business simulation games, this would not only allow the vendors of ERP systems to improve their products but also allow them to collect data on the students' ability to interact with the system and take superior decisions. This, in turn, would be information that is of utmost importance to the customers of such ERP systems. Companies that use ERP systems are not only interested in hiring skilled work force but instead constantly searching the best heads amongst them.

Famous amongst the classic and stand-alone business simulations are those of the *TOPSIM* series [27]. Nevertheless, these games are not combined to a real business application nor are they running in the cloud. The *ELiSA Business Simulation Game* concentrates on ERP education. This game can be played online but does only imitate an ERP system rather than being connected to a real one [25].

Léger et al. developed the ERP based simulation game *ERPsim* at HEC Montréal. It corresponds to an innovating training environment "to address the challenges in learning to use and understand ERP systems" [19:38]. It is one of the first system-integrated business simulation games. However, this game is based on a traditional on-premise business application (SAP ERP 6.0). So, the adaption of such system-integrated business simulation games for cloud computing paradigm seems all too logical.

3. Architecture design and methodology

The challenge of designing system-integrated simulation games lies in the coupling between the simulation model and the host system. Simulation and communication issues have to be solved, hence.

The proposed artefact in this paper is created in accordance with Hevner's et al. (2004) Design Science approach. When creating artefacts in Information System Research, Hevner et al. (2004) formulated seven guidelines ensuring research quality [11]. Table 1 lists the applied guidelines for the research project of crafting a cloud-based business simulation game that this contribution belongs to.

Table 1. Applied Design Science guidelines for the research project

Guideline	Meaning for this project/artefact
1. Design as an Artefact	Draft of an architectural model for a cloud-based business simulation game based on a real (cloud) business application (ERP system)
2. Problem Relevance	1. Information Systems education at higher schools 2. Increasing demand of white collar workers that need to take decisions on the basis of information
3. Design Evaluation	– *Technical*: prototyping for system (configuration) tests and performance measurement (with previously defined key performance indicators (KPI)), code and simulation result check against system model values – *Conceptual*: feedback of users (survey), play testing
4. Research Contributions	Development of an operations model for application service providers (ASP): scalability and maintenance recommendations for education games run-

	ning in a Cloud.
5. Research Rigor	– Literature study: Serious Gaming in the Cloud context – Problem and requirements analysis – Architecture model – Prototyping, implementation and testing – Evaluation
6. Design as a Search Process	– Involvement of an ASP – Starting with simplification: developing a simple high-level model – Finding tools to support the research goal
7. Communication of Research	Presenting drafts and progress reports for discussions to technology-oriented and management-oriented audiences

Regarding Kriz and Léger (see above), we identify at least three mandatory components. A simulation game should necessarily consist of

- a simulation model,
- a transformation module and
- a controller.

When building the architecture, the simulation model will contain the logic that is processing input values and generates outputs. With other words it contains the set of rules. Whilst the simulation provides aggregated information as output, its calculations must be translated into business transactions in a way the ERP system can read and process them. This can be fulfilled by a transformation module. For instance, the role of the transformation module will be to create x single order transactions when the simulation model had calculated that x customers are about to buy products (demand complies x). A transformation repository serves as a database for the transformer to enrich building transactions with spare data (e.g. descriptions and names). The controller engine takes the lead and coordinates the communication between internal modules and the host system.

The following subsections will handle the adaptation of this high-level architecture proposition for a simulation game concept based on the Software as a Service (SaaS) operation model.

3.1. Essential Cloud characteristics

The National Institute of Standards and Technology (NIST), being supervised from the U.S. Department of Commerce defines Cloud Computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources" [20:2]. Besides its deployment and service models, the proposed cloud model is composed by five essential characteristics [20]:

- *On-demand self-service*: the automatic provision of computing capabilities,
- *Broad network access*: availability and accessibility of services for the use by several client platforms,
- *Resource pooling*: serving multiple consumers using a multi-tenant model,
- *Rapid elasticity*: flexible provisioning and releases of capabilities and
- *Measured service*: automatic control and optimisation of resources.

A cloud-based simulation game architecture necessarily needs to comply with all of those five requirements.

3.2. Cloud-based business simulation game architecture

Based on the above considerations (see section 3.1), Figure 1 presents an architectural schema that illustrates the relations between the host system, the simulation platform and the customer.

The ERP system consists of various functional modules. The controller engine, simulation model and transformer with repository build up the simulation platform. The ERP system and simulation platform communicate via standard interfaces. Traditional business-to-business interfaces are for example EDIFACT[5] (DIN ISO 9735:2004, DIN 16557:2004 and DIN 16560:2004), XML and CSV[6]. The SAP Netweaver platform provides *Enterprise Services* based on service-oriented architecture (SOA) for external communication. In this case, the ERP system and the simulation platform are provided as a service (SaaS) by either one or even multiple providers. Communication can therefore be executed through web service (WSDL[7], SOAP and REST) using implementations such as the open cloud computing interface [23]. The advantage of using standard technologies such as the HTTP protocol and web services is that the user can interact with the ERP system through a standard browser and has the possibility to administrate the simulation platform using the browser application.

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[5] United Nations **E**lectronic **D**ata **I**nterchange **F**or **A**dministration, **C**ommerce and **T**ransport

[6] **C**omma-**s**eparated **v**alues

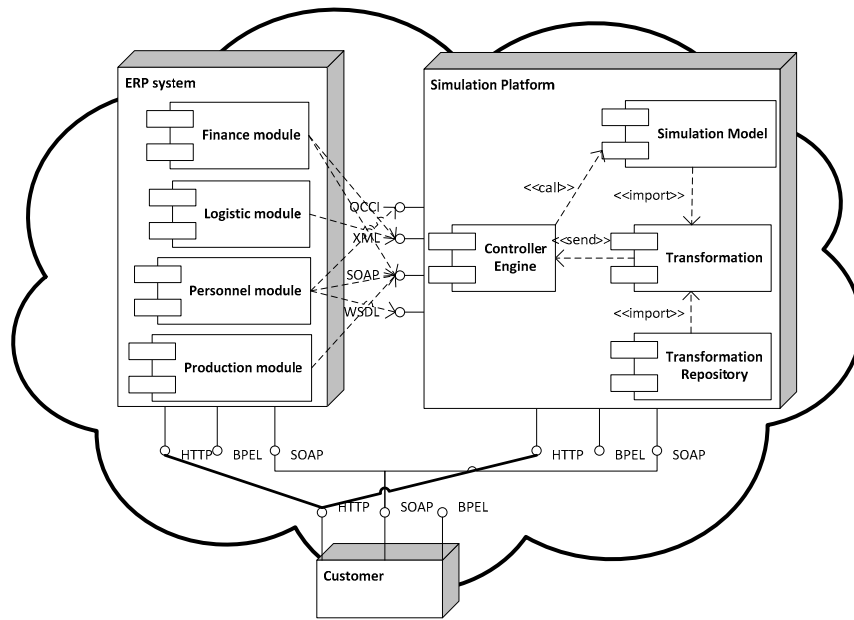[7] **W**eb **S**ervices **D**escription **L**anguage

Figure 1. Architecture of a cloud-based business simulation game

3.3. Identified challenges

According to the proposed design of a cloud-based simulation game, challenges for its realisation can be identified on different levels:

- Cloud-computing-related challenges concerning deployment, service models and characteristics and of course security.
- Technical, cloud-unaffected challenges, such as administration and operational concerns.
- Game-related, but cloud-unaffected issues, such as the curriculum design, competitive aspects and motivation.

Below, we only concentrate on cloud-related challenges.

Considerations towards the cloud deployment and service model depend on the design of the game and on its target group. If game access is limited to a special group of participants (for example students, apprentices or trainees), the game can be provided in a private or community cloud according to the NIST definition of cloud computing. Open use is reasonable in a public cloud.

Concerning service models, two service strategies might be relevant for operations. If the simulation game is offered as a cloud business application, the SaaS business model might be appropriately applied in the same way than the offer for the used on-demand ERP solution itself. In case of deploying customer-created applications in order to extend simulation platform functionality, the Platform as a Service (PaaS) approach might be the most suitable solution.

Compared to cloud characteristics, accessibility plays an important role for the entire infrastructure. Security, performance and availability concerns have still to be regulated. These are enormous challenges the simulation platform has to address. This leads us to the assumption that a simulation game has to serve multiple ERP systems or that the simulation platform has to be disassembled so that their components can be distributed on different machines (facing load distribution). Then, even the communication between simulation components needs to be established. An enterprise service bus might be a technology building block for that purpose. Another consequence might be multiprocessing. One controller might then coordinate multiple simulations or one transformation module shall transform the output of more than one simulation module. In contrast to cloud value propositions, the traditional approach suggests that one ERP system is connected to just one business simulation game.

Traditional business interfaces are not effective – communication must be redesigned using the cloud-based interfaces. Another important challenge lies in the coordination between the ERP system, the business simulation and the customer during simulation time. How must the message interchange be designed so that simulation can be processed properly? Is it mandatory to define a new XML dialect or simulation game standard?

Today, playing a SaaS-based simulation game would mean paying a fee for the simulation game as well as several ERP system tenants. A special agreement with the ERP system provider is necessary in order to negotiate special scale of prices.

3.4. Suggestions for evaluation

The evaluation of simulations or games is not a trivial process because

- many different (and unknown) factors may influence the learning process,
- evaluation methods are hardly standardised [21:253].

Therefore, Becker and Parker (2012) give some insights how to verify and validate those special software artefacts [2:205-231]. Validation and verification as quality processes support the developer in finding errors or abnormal behaviour in his creation [2:207]. The work of Rodríguez-Hoyos and Gomes (2012) proposes an evaluation framework for the didactic analysis of serious games [24].

As mentioned in Table 1, when dealing with the question of the design evaluation (Hevner's third guideline), a technical layer and methodological layer have to be considered. In current blueprint state of the artefact, we can only offer suggestions. A prototype may serve for system configuration tests. Performance measurements help to score the stability and availability of the system or prototype. This can only be done with previously defined key performance indicators. Other methods for examining the technical verification are code checks [2] and simulation result checks [2] against system model values.

For validation concerns on the conceptual site, the feedback of the participants (for instance in form of a survey) [2; 21:254] or during play testing [2] may be substantial for artefact improvements. Rodríguez-Hoyos and Gomes evaluation framework separate between four dimensions: formal, playful, curricular and ethical. Therefore, this is a suitable approach for a structured didactic evaluation. In order to reduce costs, it is vital to start with evaluation even during the design process.

4. Conclusion

Due to the very different nature of the cloud computing paradigm to traditional software design process, it is not useful to adapt classical software architectures without proper review. Besides the change and standardisation of new interfaces, the architecture as a whole has to provide much more flexibility to fulfil the cloud promise. For instance, the choice of a service model and deployment strategy is not a trivial matter.

Although the Education as a Service (EaaS) approach especially in the cloud-based simulation game context stands for an innovative curriculum concept. Concerning its complexity, a high administrative effort is inevitable in order to provide such a simulation game.

Regarding usage scenarios (ref. to Table 1, fourth guideline), the experiences collected during the build of such a cloud-based simulation game can induce an operations model for application service providers by which they can operate or deploy such games – for instance into an education cloud like Microsoft's *Dreamspark Premium* or the *Steam* gaming platform. Due to the loose coupling of the components, the amount of each component (ERP system, simulation engine, transformer and controller) can be installed dependant on their workload.

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