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THE NEED FOR CLOUD-BASED SIMULATION FROM THE PERSPECTIVE OF SIMULATION PRACTITIONERS

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ABSTRACT

Cloud-based simulation (CBS) is one of the new grand challenges in modelling and simulation (M&S). However, the work on web-enabled M&S is not new. A case in point is web-based simulation (WBS). Given the similarities between WBS and CBS, it is important to learn from WBS. Despite advancements in WBS research, its commercial applicability and adoption by users has not grown to the desired extent. This is partly due to the strong emphasis on WBS as a technological tool instead of a socio-technological tool in which users, their needs and circumstances are considered. To understand the needs and perception from practitioners on CBS, we conducted a survey. The results show that practitioners have a good exposure to cloud applications and mobile gadgets. There also appears to be evidence of a need for CBS that provides fast response time, effective communication tools and functionalities to share, store and retrieve models.

Keywords: Cloud-based simulation, Web-based simulation, simulation project, simulation practice, survey

1 INTRODUCTION

Cloud-Based Modelling and Simulation (CBMS) has been mentioned consistently as one of the grand challenges in *Modelling and Simulation* (M&S) (Taylor et al. 2012, Taylor et al. 2013). CBMS is a term used to capture the intersection between M&S and cloud computing. Although the term "cloud computing" has been with us for some time, it is apparent that there is not a universally accepted definition. One of the most popular definitions is provided by Grance and Mell (2011) on behalf of the US *National Institute of Standards and Technology* (NIST). In their definition, cloud computing is "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models." *ibid*. The five essential characteristics of cloud computing are on-demand self-service (automatic deployment of computing capabilities), broad network access using multiple platforms (such mobile devices, laptops and desktop computers), resource pooling, rapid elasticity (computing capabilities can be scaled up and down to match the fluctuation in demand) and measured service (such as pay-as-you-use model). Cloud computing offers three service models: *Software as a Service* (SaaS), *Platform as a Service* (PaaS) and *Infrastructure as a Service* (IaaS). In SaaS, consumer can run applications using cloud infrastructure while in PaaS, consumers can create applications to be run on cloud infrastructure (hence the consumers have control over their applications). In IaaS, consumers can have control not only over their application but also over the storage and the operating systems. Finally, cloud computing can be deployed in four models: public cloud (infrastructure can be used by public), private cloud (infrastructure can only be used by an individual organisation), community cloud (infrastructure can be used by a community of users with shared missions) and hybrid cloud (the combination of the other three deployment models).

Based on the above definition, we can see the relevance of cloud computing and M&S. As is being explored in the *Cloud-based Simulation for Manufacturing and Engineering* (CloudSME) initiative (www.cloudsme.eu), we can imagine the following cloud-based scenarios.

1. Simulation users can run simulation models on cloud infrastructure (*Simulation as a Service*).
2. Some simulation users (especially simulation modellers) may want to have a control over the models by creating models using simulation development tool hosted on cloud infrastructure (*Modelling as a Service*).
3. Some simulation modellers may want to have a greater control over the simulation development tool itself. Provided that the simulation development tool is reconfigurable or decomposable, we can mix and match the components of the tool (for example, we may use a random number generator from one vendor and choose a simulation optimization tool from another vendor). This is close to the PaaS.
4. Simulation users may want to have control over storage (for example, in data-driven simulation) and the execution platform and middleware (for example, in high performance simulation or distributed simulation). This is similar to the IaaS.

The effort to use the Internet or the Web for M&S is not new. The early efforts in utilising the Web to support model design, model execution and analysis of generated simulation results can be traced back to Fishwick's paper on web-based simulation (WBS) in 1996. There was an explosive growth in the number of publications on WBS between 1996 and 2000. After the peak period between 2000 and 2002, the number of publications dropped off very quickly. Given the similarities between the WBS and cloud-based simulation (CBS), it is important to learn from what has happened to WBS.

First, *CBS must not simply re-implement existing simulation software using cloud computing technologies*. This argument is taken from Kuljis and Paul's critique on WBS (Kuljis and Paul 2003). They argue that the problem with the decline of WBS stems from the fact that there was a mismatch between the main characteristics of the Web and the approach taken by the domain of WBS, which failed to take full advantage of the features of the Web including common standards, interoperability, ease of navigation and use, etc. In other words, the focus of many WBS endeavours was on the re-implementation of existing standalone simulation software.

Second, *CBS should be seen as a socio-technical tool instead of a technological tool*. This comes from our observation that there was a strong emphasis on WBS as a technological tool. This view is also reflected in the literature review done by Byrne et al. (2010). WBS should have adequately addressed what the simulation users really needed from its usage in practice.

In this paper, to try to understand what socio-technical underpinnings might exist for CBS, we present the result of a survey that we sent to simulation practitioners. The objective of the survey is to find out how practitioners carry out their simulation project, their exposure to cloud-enabled applications and mobile gadgets, and their perception on a number of functionalities offered by cloud-based simulation. The remainder of this paper is organised as follows. Section 2 explains the survey design and section 3 presents and discusses the result from the survey. Our conclusions are presented in Section 4.

2 SURVEY DESIGN

To find out more about the interest among simulation practitioners on Cloud-based simulation (CBS), we carried out a survey from January 2013 to the end of February 2013. The questionnaire was sent through various mailing lists and LinkedIn groups related to simulation. We also sent the questionnaire to Simul8's and Lanner's customers (both are discrete-event simulation vendors).

The first part of the questionnaire is to identify the field of industry/expertise of the respondents. This is followed by questions related to simulation projects in which they have been involved (team size, frequency of modelling work and role within a project). These questions should allow us to analyse the next questions on the tools they use for their communication with other team members or clients and how often they use communication tools which include: face-to-face meeting, teleconference (voice only), video conference, on-line messaging/chatting and email (they can also specify other tools). The next question asks about the exposure to a number of cloud-enabled applications and mobile gadgets at work and socially. This question should give us a good idea about the familiarity and appreciation of simulation practitioners on cloud-enabled applications and mobile gadgets whether at work or socially. High usage and appreciation may indicate a positive attitude towards cloud-based applications. The last question asks if they have a stable and fast internet connection, how they would appreciate a number of functionalities offered by cloud-based simulation. This question should provide us with what is considered to be essential by simulation practitioners. The detailed questions asked in the questionnaire are given in the appendix.

3 SURVEY ON SIMULATION MODELLING WORK AND TOOLS

We received 86 responses (35 respondents left their contact detail), of which 23% are academics/researchers and the rest come from industry (Figure 1). Figure 1 shows that we have a good cross-section of sectors represented by respondents. Most of them state that they develop a simulation model regularly (Figure 2).

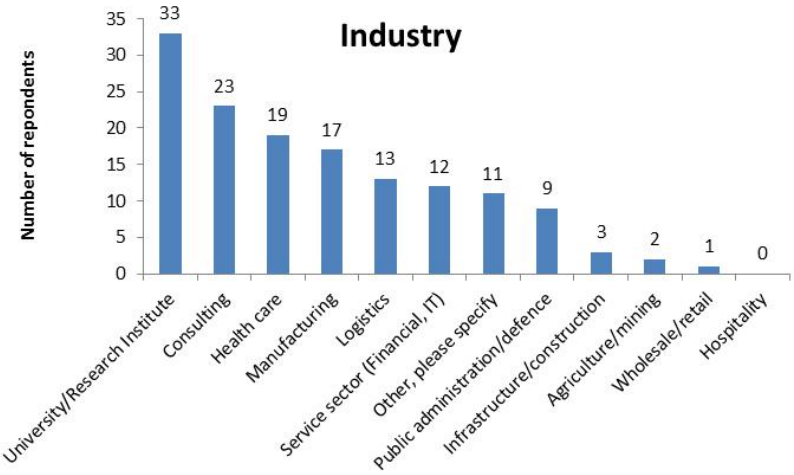

Figure 1 *Sectors represented by respondents*

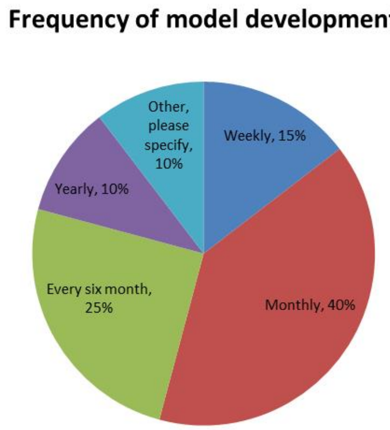

Figure 2 *Frequency of model development*

In the second part of the questionnaire, we tried to find out how in their experience simulation modelling projects had been conducted in practice. Most of them stated that they work in a group and the typical group size is between 3 and 6 (Figure 3). The respondents show that team members in their group have various roles such as simulation modellers, simulation analysts and domain experts (Figure 4). In this survey, we divide the roles into seven categories (the definition of each category is shown in the survey question as shown in appendix). This result confirms that most simulation modelling work requires good communication and collaboration between project team members who may have various roles. The result also shows that face-to-face meetings and emails are the two most common media used for communication between team members (Figure 5). However, the number of respondents who use teleconference and video conference is relatively significant. This may indicate that some team members work from disparate geographical locations. When the communication involves clients who are usually located on a different geographical location, the result shows that email communication is used more than face-to-face meeting (Figure 6). The result also shows a relatively significant number of respondents use teleconference and videoconference facilities to communicate with their clients. However, as one might expect, the majority of interaction is via face-to-face meetings and by email.

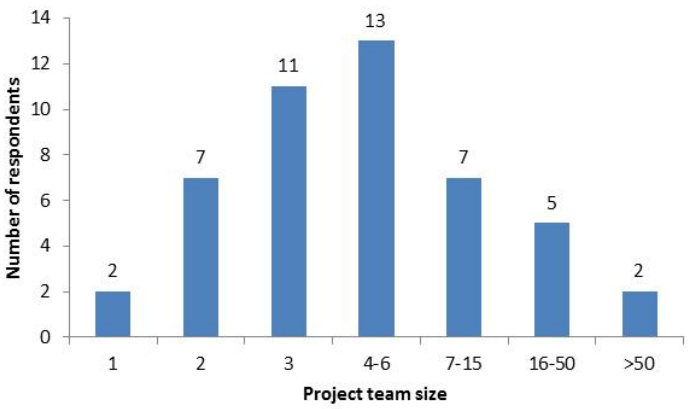

Figure 3 *The typical team size in a simulation project*

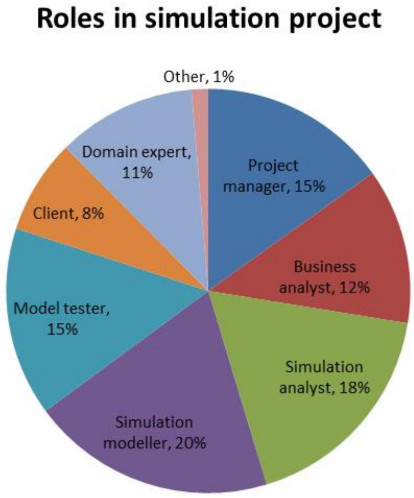

Figure 4 *Roles in simulation project*

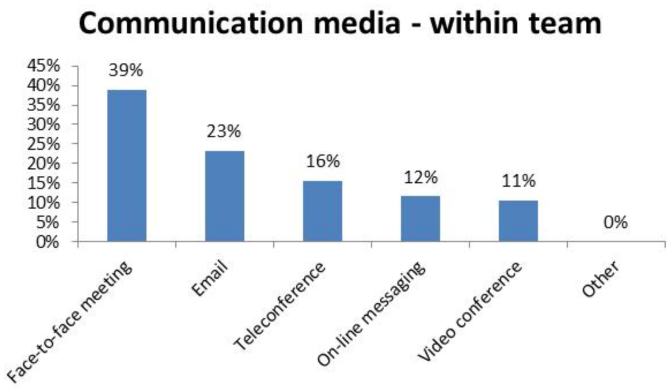

Figure 5 *Communication media used with other team members in a simulation project*

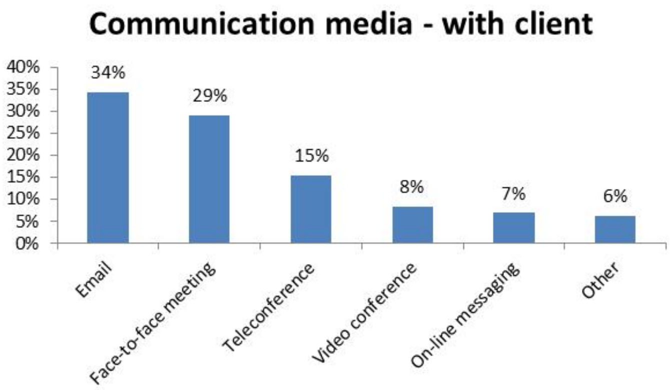

Figure 6 *Communication media used with clients in a simulation project*

The third part of the questionnaire aims to find the exposure of the respondents to popular cloud-enabled/web-enabled applications (such as cloud storage, remote desktop, collaborative writing, social networking and wikis), gadgets (smart phone and tablet), and whether they use the software and the gadgets at work, socially or both. The result is shown in Figure 7. In general, the result shows that the respondents have a good exposure to the tools and gadgets (at work, socially or both). Hence, it implies that many of the respondents have already adopted those technologies. The three most commonly used tools and gadgets at work (including for a simulation project) are remote desktop, cloud storage and a smart phone. This strengthens the previous result that many respondents need to be mobile or to work with people at different physical locations. Other popular tools include collaborative writing (such as Google Docs and Office 365), wikis and blogs. It should also be noted that many respondents have used popular social networking sites (such as LinkedIn and Facebook). It is worth nothing that almost half of those who are using LinkedIn state that they use it for work. Finally, the use of a combination between gadgets (such as smart-phones and tablets) and applications such as cloud storage at work may indicate their readiness to use cloud-enabled applications. In terms of tools specifically used for simulation, it is interesting to note that remote desktop and cloud storage are used the most. Remote desktop allows users to remotely manipulate models between several people. This is highly useful in saving time on projects with avoidable travel.

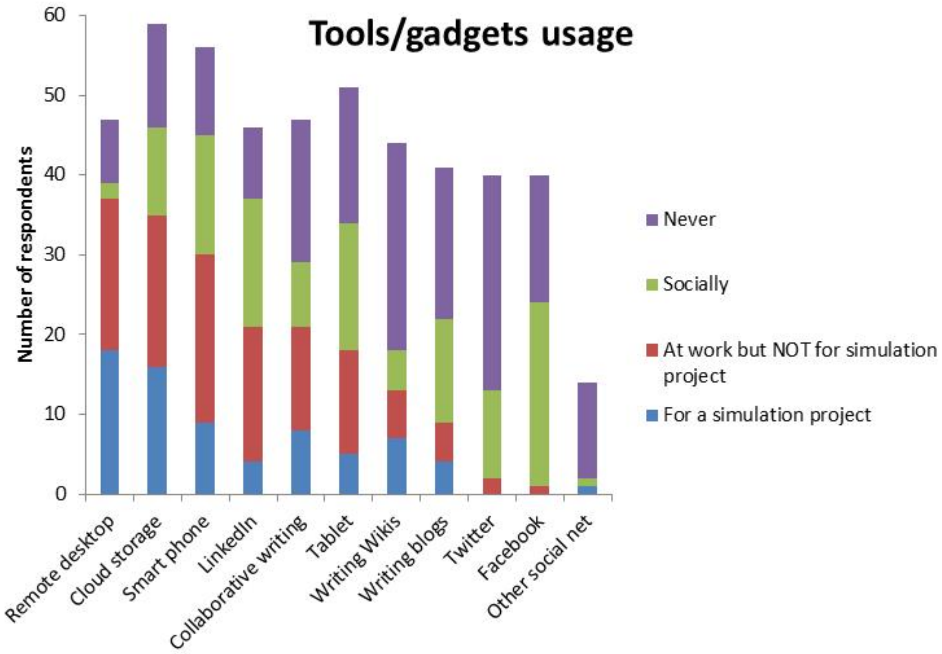

Figure 7 *The exposure and use of tools/gadgets in a simulation project, at work and socially*

The final part of the questionnaire asks the respondents to rate the importance of a number of functionalities offered by cloud technologies to their simulation project, assuming that they have fast and stable internet connection. The result shows that in general most respondents can value the benefit of having those functionalities (Figure 8). It is clear that most respondents value fast response time higher than any functionalities. This is followed by the functionalities that allow other stakeholders in a project team to comment and to run the model using a web browser. This indicates the need of feedback from other stakeholders about the model (from the model developer's side) or giving feedback to those who develop the model. With a web application, it is easier to link a model and the comments on the model and the person who gives the comment may do it at his/her own time from anywhere in the world. Next, the respondents seem to value the functionalities to share, store and retrieve model through a web server or cloud storage relatively highly. The functionalities that are slightly less valued are related to model development process (edit and run models). This is probably due to the familiarity with a desktop tool for model development. This might also be true if we ask whether people who are familiar with writing a document using Microsoft Word (desktop version) to rate the need for the functionality to write a document using Office 365 or Google doc. The need for model repository may be felt more strongly by those who develop model more frequently (60% of respondents who rate this functionality as essential or "good to have" develop model on weekly or monthly basis). Finally, the functionality to allow other stakeholders to edit model is the least valued by most respondents. This may indicate that there is a clear job responsibility in which simulation modellers are the ones who are mostly responsible for model development. Hence, unless there are more than one model developers in a team, this functionality is seen to be the least essential.

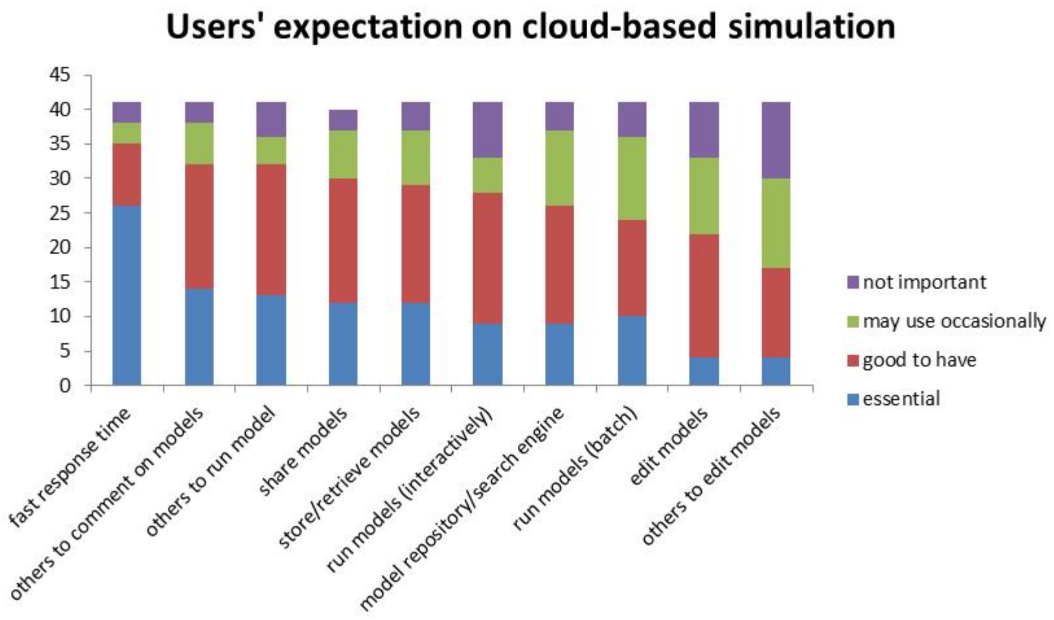

Figure 8 *Users' expectation on cloud-based simulation*

4 CONCLUSION

The findings from this paper contribute to a better understanding of simulation practitioners, their modelling work, their exposure to cloud-enabled applications and mobile gadgets and their appreciation on functionalities that might be offered by cloud-based simulation tools. Given the number of samples, even though it may not represent all simulation practitioners, the findings are considered to be significant. The results confirm that most practitioners work in a team. From the communication tools they use, there is evidence that a significant number of team members work from disparate geographical locations and that most make use of a range of communication technologies to support their work. Simulation practitioners are found to have good exposure to cloud-enabled applications and have used mobile gadgets at work. This shows that they have the potential to be adopters of cloud-based simulation. Simulation practitioners appreciate cloud-based simulation if it can provide fast response time, good communication tools so that feedback from team members/clients can be communicated more effectively and functionalities to share, store and retrieve model through a web server or cloud storage. They seem not to regard functionalities for collaborative model development to be essential although there is evidence of their use. The findings provide us with the foundation to discuss about the roadmap for cloud-based modelling and simulation that is not solely based on technological push but also the real demand from simulation practitioners. This will be addressed in our future work.

A APPENDIX: QUESTIONNAIRE

Q1.1 Please select the most appropriate option(s) which refers to your field of industry/expertise? Agriculture/mining, Consulting, Health care, Hospitality, Infrastructure/construction, Logistics, Manufacturing, Public administration/defence, Service sector (Financial, IT), University/Research Institute, Wholesale/retail, Other, please specify ______________

Please consider a "typical" simulation project that you have been involved in to answer the following questions

Q2.1 What was your project team size (number of people)?

Q2.2 How often do you (or your project teams) create simulation models? Weekly, Monthly, Every six month, Yearly, Other, please specify ________________

Q2.3 What is your main role(s) within a simulation project? Project manager (plan, budget, monitor progress, etc.), Business analyst (interact with clients, understand their needs and translate them into modelling objectives for the simulation analyst), Simulation analyst (analyse simulation input data, simulation output analysis, specify model requirement for simulation modeller), Simulation modeller (develop a model), Model tester (test model and validate model), Domain expert (someone who is an expert on the industry or system being modelled), Client (the beneficiary/user of the model), Other, please specify ____________________

Q2.4 How often did you communicate with other team members using the following media (in percentage)? Face-to-face meeting, Teleconference (voice only), Video conference, On-line messaging/chatting, Email, Other, please specify ____________________

Q2.5 How often did you communicate with your clients (or simulation consultants if you are a client) using the following media (in percentage)? Face-to-face meeting, Teleconference (voice only), Video conference, On-line messaging/chatting, Email, Other, please specify __________________

Q3.1 Do you use the following tools or gadgets?

	For a simulation project	At work but NOT for simulation project	Socially	Never	I don't know
Remote desktop / desktop sharing	❑	❑	❑	❑	❑
Collaborative writing (such as Google Docs and Office 365)	❑	❑	❑	❑	❑
Writing blogs	❑	❑	❑	❑	❑
Writing Wikis	❑	❑	❑	❑	❑
LinkedIn	❑	❑	❑	❑	❑
Facebook	❑	❑	❑	❑	❑
Twitter	❑	❑	❑	❑	❑
Other social networking application, please specify	❑	❑	❑	❑	❑
Cloud storage (such as DropBox, SkyDrive, GoogleDrive)	❑	❑	❑	❑	❑
Tablet (such as iPad, Galaxy Tab and Google Nexus)	❑	❑	❑	❑	❑
Smart phone (such as iPhone, Samsung Galaxy)	❑	❑	❑	❑	❑

Q3.2 If you have fast and stable internet connection, how do you rate the following functionalities in terms of their importance to your simulation project?

	essential	good to have	may use occasionally	not important
store/retrieve models on a web server / cloud	❍	❍	❍	❍
run models and obtain results using a web browser	❍	❍	❍	❍
see the animation of simulation runs using a web browser	❍	❍	❍	❍
edit models using a web browser	❍	❍	❍	❍
share models through a web server / cloud	❍	❍	❍	❍
allow relevant stakeholders to run models using a web-browser	❍	❍	❍	❍
allow relevant stakeholders to edit models using a web browser	❍	❍	❍	❍
allow relevant stakeholders to comment on models using a web-browser	❍	❍	❍	❍
fast response time (animation runs smoothly, produce simulation results without delay, responsive editting, etc.)	❍	❍	❍	❍
allow the creation of a model repository with specialised search engine to find suitable models for reuse	❍	❍	❍	❍

REFERENCES

Byrne J, Heavey C and Byrne P J (2010). A review of Web-based simulation and supporting tools. *Simulation Modelling Practice and Theory* **18**: 253-276.

Fishwick P A (1996). Web-Based Simulation: Some Personal Observations. In: Charnes J M, Morrice D J, Brunner D T and Swain J J (eds). *Proceedings of the 28th Winter Simulation Conference*. IEEE Computer Society: Piscataway, NJ, USA, pp 772–779.

Grance T and Mell P (2011). The NIST Definition of Cloud Computing. NIST [Online]. Available at: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf [Accessed 23/12/12].

Kuljis J and Paul R J (2003). Web-based discrete event simulation models: Current states and possible futures. *Simulation & Gaming* **34(1)**: 39-53.

Taylor S J E, Fishwick P A, Fujimoto R, Page E H, Uhrmacher A M, Wainer G (2012). Panel on Grand Challenges for Modeling and Simulation. In: Laroque C, Himmelspach J, Pasupathy R, Rose O and Uhrmacher A M (eds). *Proceedings of the 2012 Winter Simulation Conference*. IEEE Computer Society: Piscataway, NJ, USA.

Taylor S J E, Khan A, Morse K, Tolk A, Yilmaz L and Zander J (2013). Grand Challenges on the Theory of Modeling and Simulation. In: Proceedings of the Symposium on Theory of Modeling and Simulation, 9 pages.

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