SIMULATION HIGHWAY – DIRECT ACCESS INTELLIGENT CLOUD SIMULATOR

Egils Ginters[(a)], Inita Sakne[(a)], Ieva Lauberte[(a)], Artis Aizstrauts[(a)], Girts Dreija[(a)], Rosa Maria Aguilar Chinea[(b)], Yuri Merkuryev[(c)], Leonid Novitsky[(c)], Janis Grundspenkis[(c)]

[(a)]Sociotechnical Systems Engineering Institute
Vidzeme University of Applied Sciences
Cesu Street 4-2A, Valmiera LV-4200, Latvia
[(b)]Universidad de La Laguna
Pabellón de Gobierno, C/ Molinos de Agua s/n., 38200 La Laguna, Spain
[(c)]Faculty of Computer Science and Information Technology
Riga Technical University
Kalku Street 1, Riga LV-1050

[(a)]egils.ginters@va.lv, [(b)]rosi@isaatc.ull.es, [(c)]merkur@itl.rtu.lv

ABSTRACT

Simulation nowadays plays an increasing role in the assessment of possible solutions and situation analysis. However, the tools used and previously created models are often incompatible and territorially distributed. Domain specialists lack the expertise and specific programming skills to use them effectively. The development of the Future Internet creates new challenges for simulation engineering by offering extended access. However, primarily a conception is needed, which would create unified access to the simulation architecture on the Future Internet. The paper discusses development of a new conceptual approach to simulation engineering, aiming to support domain experts in performing simulation of complicated socio-technical systems on the Cloud.

Keywords: simulation engineering, simulation highway, Future Internet, Cloud simulation

1. INTRODUCTION

The requirements for situations forecasting and transparency of the scenarios in manufacturing and politics before decision making are topical due to high losses of possible faults and impact on the society and environment.

One of the most effective methods to verify possible solutions while saving financial resources and minimizing security risks is simulation. Simulation is a critically vital component of decision making.

The world is varied, as are the methods of specification that correspond to core systems: continuous, discrete, determined, stochastic etc. Formal languages and analytical methods are used to describe these systems. However, the mentioned specifications can be done by an information technology (IT) professional or systems analyst rather than by a domain expert. All of these applied systems can be simulated by using a predefined set of instruments: discrete-event tools (DEVS), system dynamics (SD), an agent-based approach (ABM), multilevel models, micro analytical models etc. Naturally, all of these instruments have corresponding popular and concrete simulation tools which have their own modeling languages, formats and rules. Real socio-technical systems are not homogenous, therefore, to make a decision, multiple distinctive simulation models have to be combined in a unified environment. There are exist distributed communication environments like HLA that provide such functionality, however, that is not possible without significant financial investments, even more each case is a custom engineering solution.

The development of Future Internet, Internet of Things, Service oriented Architecture and Cloud computing creates a new challenge and possibilities for simulation engineering. The aim of this article is to discuss the project findings related to developing the new conceptual approach to simulation engineering on the Future Internet giving various domain experts an immediate possibility to specify different simulation cases as well as translate, distribute and implement these specifications on the Cloud through the Simulation Highway.

2. SIMULATION AND TOOLS

A system is a set of entities, real or abstract, comprising a whole where each component interacts with or is related to at least one other component and they all serve a common objective. In a system we can always find different types of organization in it, and such organization can be described by concepts and principles which are independent from the specific domain at which we are looking. Socio-technical systems are open to, and interact with, their environments, and that they can acquire qualitatively new properties through emergence, resulting in continual evolution (Von Bertalanffy 1976). A system would be defined as group of objects that are joined together in some regular interaction or interdependence

towards the accomplishment of some purpose (Banks 1996). Otherwise, a system can be defined as a collection of interacting components that receives input and provides output for some purpose (Chang 2004).
The socio-technical systems are tended to self-organization, cognition and continual evolution. The systems can be classified as physical and conceptual or abstract systems, open or closed, continuous or discrete systems, static or dynamic systems, linear or non-linear and deterministic or stochastic systems.
A model of the goal systems is an external and explicit representation of part of reality as seen by the people who wish to use that model to understand, to change, to manage and to control that part of reality (Pidd 1996). Model can be defined as a representation of a system for the purpose of studying the system (Banks 1996).

Simulation is the imitation of the operation of a real-world process or system over time (Banks 1998). Simulation modeling and analysis is the process of creating and experimenting with a computerized mathematical model of a physical system (Chang 2004). Simulation is the way how to research the model.

Nowadays different simulation technologies and mostly non-compatible set of simulation software tools are used. For example, some groups can be mentioned (Gilbert and Troitzsch 2006; A.Bruzzone, A.Verbraeck, E.Ginters et. al. 2002): System dynamics and world (large systems) (DYNAMO, VenSim, PowerSim, STELLA, iThink etc.); Queuing models (discrete-event systems) simulation software (DELSI 1.1., OMNET++, QSIM, QPR Process, EXTEND, SIMPLE++, ARENA, SIMUL8, AutoMod, WITNESS, AnyLogic etc.); Micro analytical simulation solutions (MICSIM, UMDBS, STINMOD, DYNAMOD, CORSIM etc.); Multilevel simulation tools (HLM, MIMOSE, MLwiN, aML etc.); Cellular automata CAFUN, LCAU, CASim, Trilife, JCASim, CellLab, CAGE, SITSIM etc.); Agent-based tools (AgentSheet, NetLogo, SWARM, RePast etc.); Learning and evolutionary models simulation tools (Artificial Neural Nets, Evolutionary models, Reinforcement Learning (Research simulators - Stuttgart Neural Network Simulator (SNNS), PDP++, JavaNNS, XNBC and the BNN Toolbox for MATLAB etc.; Data analysis simulators - Alyuda NeuroIntelligence, BrainMaker, EasyNN-plus, MATLAB Neural Network Toolbox, NeuralTools, Netlab, Palisade etc.; Component based development environments - JOONE, Peltarion Synapse and NeuroDimension, NeuroSolutions etc.). The simulation software tools (HLA, DIS etc.) ensure elaboration of distributed models. Sometimes also adjacent approaches like CORBA are applied and new distributed simulation environments are elaborated (Aizstrauts et.al 2010).

Unfortunately approaches are very different and simulation platforms and alphabets do not compatible. Up today selection of the simulation software tools are intuitive. Most part of the simulators cannot be used by domain decision makers in real-time and immediate way due to complexity, heavy architecture and special knowledge on programming and mathematics.

3. COMMUNICATION IN SIMULATION

The development of simulation enables the researchers to explore more sophisticated problems at a more detailed level. At the same time this implies a necessity to use several models, or even different modelling tools. Different modelling approaches (multi agent systems, discrete events simulation, system dynamics, etc.) usually envisage the use of different modelling tools (software). This makes the issue of their mutual communication a central concern to the researcher. In Figure 1 development of simulation tools architecture is shown spreading from stand-alone simulators to Web solutions and homogeneous or heterogeneous distributed simulators.

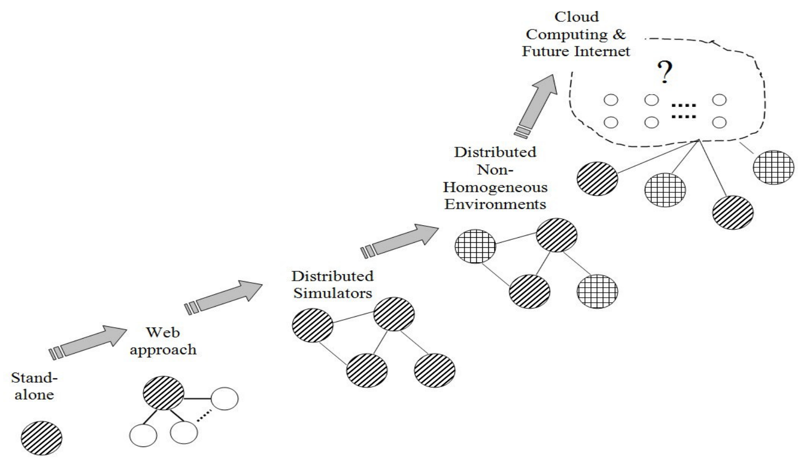

Figure 1: Development of simulation tools architecture

At present, it is very difficult to combine different models made by different simulators because there are no unified descriptions (specifications) for simulation models and a common and well suitable approach for joining simulation tools has not been developed. Therefore, designers cannot co-operate easily when using different simulator models.
Of course, there are several solutions, but they are complicated and not suitable for people without specific knowledge.
This is an important constraint that impedes the development of distributed simulation especially within social and behavioural sciences. These sciences often deal with complicated socio-technical systems that cannot be explored at the sufficient level of quality with one modelling tool.

High Level Architecture (HLA) (Carley 2002) is a concept of the architecture for distributed simulation systems. HLA ensures interoperability and reuses among simulations. It consists of rules that separate parts of distributed simulation model (federates) must follow to achieve proper interaction during a federation execution (see Figure 2); Object Model Template that defines the format for specifying the set of common objects used by a federation (federation object model), their attributes, and relationships among them; Interface Specification, which provides interface to the Run-Time Infrastructure, which can be distributed and ties together federates during model execution.

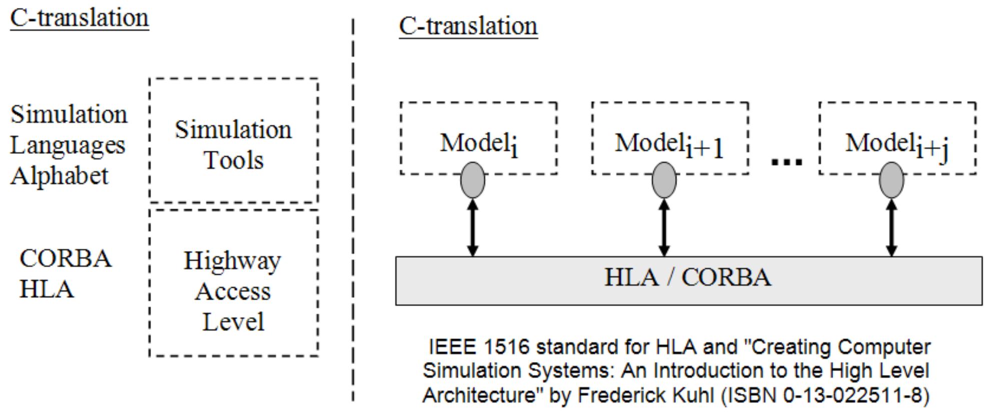

Figure 2: Communication in distributed simulation model

The distributed time management can be done, because all federates' nodes directly undertake synchronization roles. Therefore, the total simulation takes less time and the system is safer, unfortunately, implementation is more complex and laborious.
HLA was created for certain purposes and it was developed according to the needs of industry, where HLA was used. Accordingly innovations of HLA were encapsulated and less attention was paid to the developments within the field of simulations. HLA is a powerful tool for complex simulation systems. But as the technologies develop, the scope and functionality of simulations becomes wider. Inevitably some spheres emerge where HLA does not meet the needs anymore, it is not always convenient. Among one of shortcomings of HLA is its complexity. The wide variety of HLA functionality is rarely needed, besides expenses of HLA and its implementation are rather high (Aizstrauts et.al 2010). Some different protocols and methods (CORBA, HLA, FIPA, ALSP, DIS and other) (Strassburger 2006; Verbraeck 2004; Bolton 2001) exist for elaboration the communication environments, unfortunately any of it has their own disadvantages and right selection is still problematic.

One of the most important problems of the existing communication tools (environments) is compatibility with the architectural solutions of the Future Internet, because environments are non-flexible, and with low adaptability to the requirements of the SoA and the Future Internet of services.

4. THE FUTURE INTERNET AND THE CLOUD

Over the last decade, most Europeans and more than two billion people worldwide have become Internet users. More than 67.6% in the European Union and almost 26% people worldwide use the Internet. In 2010 the number of Internet users in China reached 400 million, which is more than the population of the entire United States (Blackman et.al 2010). With over 1 trillion pages and billions of users the Web is one of the most successful engineering phenomena ever created. At the end of 2009 there were 234 million websites of which 47 million were added in the year. The Web is now a rich media repository, the current upload to Flickr is equivalent to 30 billion new photos per year and YouTube now serves over 1 billion videos per day (Pedrinaci 2010).

The rapid development of mobile technology, providing Internet access to individual remote devices (Internet of Things), has accelerated the pace of development; as a result it is expected that the number of users in 2020 will reach seven billion. The Internet moved from the technical to the social category, where development is more driven by the efforts of interested Internet users than the pressure of technological achievements (Pedrinaci 2010). Some of these users see it as a business environment, others as a provider for social networking opportunities. An inevitable fusion of technology and the social environment can be observed, where the Future Internet is actually a representation of the public, a complex, but integral part of the social system. Future research must conceptualize the Internet as the global social machine. Research shows that (Blackman et.al 2010) technology development is not the key driver of Internet development. The vital part is social factors, which determine that no revolutionary technical changes are possible in the Internet development at the moment. That is why the implementation of new methodologies, algorithms and services gains a special status. They change and improve the Internet step by step by improving the quality of service a user receives i.e. performance, security and intelligence. Simulation is not an exception as it can become one of such services in the Future Internet environment.
Mobile technology has long been offering personal simulation tools such as AgentSheets and others. As a result, it is expected that simulation will become one of the services in the future network Internet of Services, which, in turn, will be promoted by the Internet of Things, which will provide access to remote and mobile equipment.
The Semantic Web is an extension of the current human – readable Web, adding formal knowledge representation so that intelligent software can reason with the information in an automatic and flexible way (Pedrinaci 2010). Semantic Web research has therefore largely focussed on defining languages and tools for representing knowledge in a way that can be shared, reused, combined, and processed over the Web. This research has led to a plethora of standards such as RDF(S), OWL, as well as corresponding tools such as ontology editors, RDF(S) storage and querying systems. The semantic approach can be one of the basic elements in the development of a unified approach for the specification of simulation models and the translation of further constructions to execute them in the Future Internet environment.

It is noted that the human-machine interface plays a special role in the development of the Internet where the emphasis on browser-type access and search-engines gradually moves to Facebook, Twitter and national social network analogues. However, this is just the beginning as 3D immersion and virtual and augmented reality (VR/AR) applications development and introduction (Future Internet 3D) is expected. The development of this direction could have a direct impact on the progress of simulation engineering by providing the visualization of simulation results, which could gradually replace built-in visualization tools, contributing to the unification of a simulation approach.

There are different types and practices of standardization: with ISO-styled standardization, the process may be heavy-handed; or IETF types – global and motivated by desire to keep the internet running effectively, a place where some consensus will be found, and based between ISO and IEEE; or IEEE types of standards – in some ways the opposite of ISO in process and being purely technical; finally we have various Web consortia (e.g. OASIS) becoming even more important since they are high level, including the various open source standards for interfaces and whole applications, which may or may not be normalized (Blackman et.al 2010).

Currently, the most popular methods to describe data and semantic information are considered XML, RDF or OWL, SOAP or REST notations are used for protocol description, but BPEL or BPMN are used to specify orchestration mechanisms. Efforts are being made to make these languages the standard tools for describing Future Internet services, although their possibilities to describe the functioning of a socio-technical system raise serious doubts. At least stochastic process specification could lead to the solving of a series of difficult problems. Opposed to the orchestration approach, the use of choreographies CHOReOS (http://www.choreos.eu) seems more actual and promising, because there is no single monitoring and synchronization service, but all members of the service network work independently and within the extent of their competence to reach the determined goal. Such architecture is more viable, as there are no central administration resources, the disruption of which equals the doom of the service.

To describe the essence of Future Internet, the following concept set is offered: Internet of Contents (IoC), which is provided by the Internet of Services (IoS), while the remote access to specific devices is provided by the Internet of Things (IoT), but it is possible that the user network is part of a larger network, and then it is considered the Internet of Networks (IoN). There is a need for both researchers and practitioners to develop platforms made up of adaptive Future Internet applications. In this sense, the emergence and consolidation of Service-Oriented Architectures (SOA), Cloud Computing and Wireless Sensor Networks (WSN) rise benefits, such as flexibility, scalability, security, interoperability, and adaptability, for building applications.

As one of important parts of the Internet of Services the Cloud computing could be mentioned. Cloud computing ensure scalable storage, computation facilities, application hosting, or even the provisioning of entire applications accessed remotely through the Internet. Some well-known commercial Cloud solutions are for instance Google's AppEngine, Gmail, and Docs, Amazon's Elastic Computing, or Salesforce (Pedrinaci 2010). The European Commission supports approximately 140 Future Internet projects to a greater or lesser extent and some research of them are related with Cloud (http://www.future-internet.eu/activities/fp7-projects.html), for instance, Cloud4SOA (http://www.cloud4soa.eu/) focuses on the semantic interoperability and on introducing a user-centric approach for applications which are built upon and deployed using Cloud resources; Cloud-TM (http://www.cloudtm.eu/) working on the development and administration of Cloud applications; CONTRAIL (http://contrail-project.eu/) designs an open source system for integration of heterogeneous resources into a single homogeneous Federated Cloud; CumuloNimbo (http://www.cumulonimbo.eu/) provides consistency, availability, and simpler programming abstractions, such as transactions; Morfeo 4CaaST (http://4caast.morfeo-project.org/) - platform for elastic hosting of Internet-scale multi-tier applications; mOSAIC (http://www.mosaic-cloud.eu/) develops an platform allowing to the users to tune Cloud services; OPTIMIS (http://www.optimis-project.eu) establishes an open Cloud Service Ecosystem for adaptable and reliable IT resources support; VISION Cloud (http://www.visioncloud.eu/) introduces an infrastructure for reliable delivery of data-intensive storage services and many other projects launched during previous calls.

Cloud-based services because are expected to become one of the main IT market niches and as a consequence many large companies are working on the creation of their own solution to retain a competitive position (The Economist 2009). Due to the reason mentioned above it would be rational to provide Cloud-based simulation service as integral component of the Internet of Services.

5. SIMULATION LAYOUT DESIGN AND VISUALIZATION OF THE RESULTS

One of the essential actualities is the display of simulation results in a form that is understandable to domain specialists and as close as possible to the specifics of the business sector.

Currently, built-in tools with limited functionality are used to display simulation results. Furthermore, it is not clear how to visualize the results of a non-homogenous and distributed simulation.

There are several different definitions for Virtual Reality (VR), but one of the formulations determines that it is the simulation of the goal system using computer graphics and providing the user with the ability to interact with the researchable system by using three and more levels of freedom (Burdea 2003). It all depends on the research object. If reality is the object of research, the virtual constructions complement the visible object. In the present case, there is talk of an Augmented Reality (AR) solution. If the research object is a virtual object, where a real life existing installation or component is added, then it can be considered an Augmented Virtuality (AV) situation. Currently, virtual reality questions relate to a scientific sub-sector, which combines various fields such as computers, robotics, graphics, engineering and cognition. VR worlds are 3D environments, created by computer graphics techniques, where one or more users are immersed totally or partially to interact with virtual elements. Mainly, special devices stimulate the sight, hearing and touch. Higher immersion level can be achieved with output devices, which are mainly directed to humans visual sense, for example, head mounted displays (HMD), stereoscopic monitors, special glasses, projection walls, CAVE systems, etc. Multiple sound sources positioned provides 3D sound, and touch can be simulated by the use of haptic devices (Moraos and Machado 2009).

The basic element of a VR system is the authoring platform which provides the import of models from other 3D graphics tools (AutoCAD, Maya, 3D Max etc.), the generating and rendering of scenes, and the building and operation of scenarios. Although the construction of VR/AR systems is still expensive and time consuming, which is caused by the incompatibility of hardware and authoring platforms, gradual development is taking place (Ginters et.al 2007). At least VRLM supports most authoring platforms. In recent years VR platform providers (Bluemel 2011) have been working on the creation of tools for simulation layout planning. Initially, VR/AR might be a good supplement to any of the simulation environments to improve the clearness of simulation, but in the near future the agreement between simulation and VR professionals could lead to the development of a unified VR-simulation interface concept. Another useful VR application could be the visualization of simulation results by adapting them to the perception and industry specifics of domains experts. In any case, it is clear that the fusion of VR with simulation environments and tools is a matter of the nearest future.

There are more than twenty EC FP7 projects, which currently do research in the field of virtual reality, however, there are few with a connection to the development of Future Internet, for instance, IRMOS (http://www.irmosproject.eu) will design, develop, integrate and validate a Service Oriented Infrastructure that enables a broad range of interactive real-time applications. It will support the development and deployment of real time applications in a distributed way. The infrastructure will be demonstrated by focusing on virtual and augmented reality; VirtualLife (http://www.ict-virtuallife.eu) aims to combine a high quality immersive 3D virtual experience with the trustworthiness of a secure communication infrastructure, focusing on the creation of secure and ruled places within the virtual world where important transactions can occur; 2020 3D Media

(www.20203dmedia.eu) is aimed to the development of new technologies to support the acquisition, coding, editing, networked distribution, and display of stereoscopic and immersive audiovisual media, capable of providing novel and more compelling forms of entertainment both for home and for public grounds. The users of the resulting technologies will be both media industry professionals across the current film, TV and 'new media' sectors producing programme material as well as the general public.
For the time being, virtual reality experts are busy with their internal problems and, it seems, are not ready to deploy and adapt their systems for the Future Internet environment. A close cooperation between Future Internet architects and VR/AR ideologists has not been formed because both sides are not ready for serious negotiations, although opinions can be heard, that Web 3.0 will be in 3D. However, it is clear that sooner or later it will happen, and simulation experts should participate in the development of this unified concept.

6. SIMULATION HIGHWAY – THE CONCEPT

Simulation Highway - common approach and rules to deploy, access, join and exploit the different and heterogeneous simulation models in distributed environment on the Future Internet and Cloud.

The Simulation Highway (Ginters and Vorslovs 2008; Ginters and Aquilar 2008) ensures translation and distribution the simulation requests in the Cloud. These simulation requests address a set of simulation cells organizing implementation highway during the simulation session of defined task.

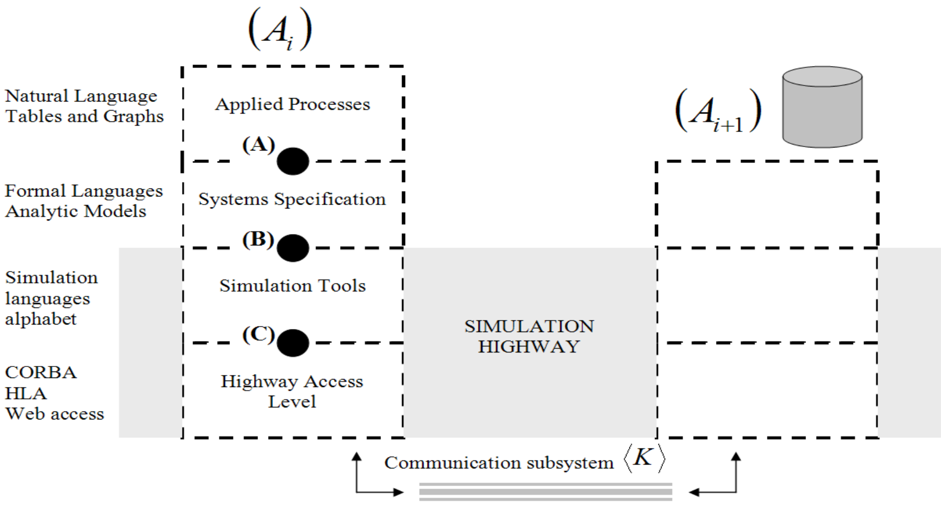

Figure 3: Multilevel Requests Translation and Distribution on Future Internet (Ginters and Aquilar 2008)

Each simulation cell serves as a server and simultaneously as a switch so that various and previously existing simulation models that are registered to the cell and participates in the decision making task in real-time can be connected to the simulation highway of the task (see Figure 4). Cognition is integral attribute of each simulation cell.

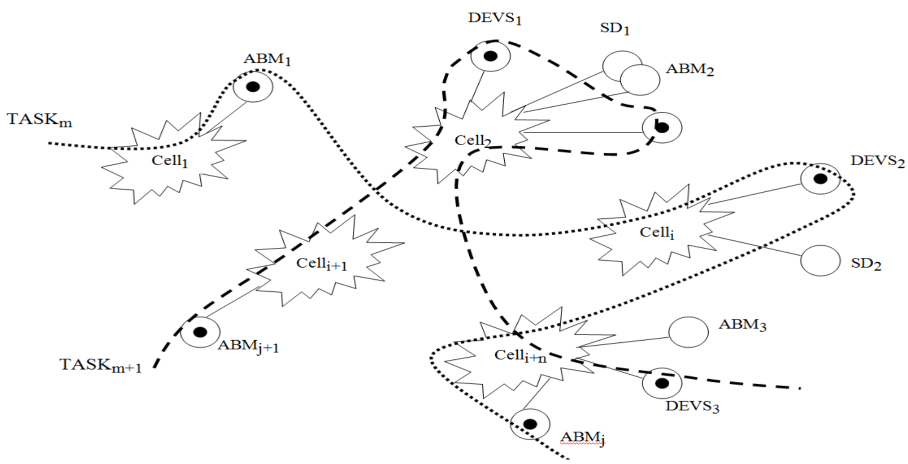

Figure 4: Simulation Highway – Distributed Multiple Access Simulation Environment

To each cell different models: discrete-event (DEVS), system dynamics (SD), agent-based (ABM) can be registered. Each task, formulated by the domain expert, generates a heterogeneous chain of interacting models, or highway. The results are visualized in a manner that is understandable and demonstrative to the client using VR facilities provided by the Future Internet 3D.

The important problem for distributed simulation is placidity of the Cloud platforms. For example, Amazon's EC2 supports the Message Passing Interface (MPI), the message-based communications protocol used by parallel programs that run on clusters (Fujimoto et.al 2010). This provides theoretically a variant to making parallel and distributed simulations.

Nevertheless this approach is too general to be successfully used in such a specific field as simulation, because Cloud platforms are better oriented at providing high bandwidth communications among applications for longer sessions than to interchange of many small messages requiring quick delivery. Theoretically it is possible that simulation societies would arrange common Cloud platform suitable for implementation of the simulation tasks, but such approach would be the step away from the aim, because the benefit is use of the common Cloud solutions by all the tasks. Therefore, selection of the right Cloud platform would be the challenging task.

7. ONTOLOGY BASED ADAPTABLE UNIVERSAL SIMULATION SPECIFICATION LANGUAGE

One of the major problems is a different process specification and the performance of further transmissions, ensuring cooperation with the Simulation Highway.

Existing simulation languages are different and problem-oriented; the abstraction level is low enough. On the other hand, the languages used by software engineers are not suitable to describe real and complex processes. There have been several attempts to achieve universal solutions (see Figure 5).

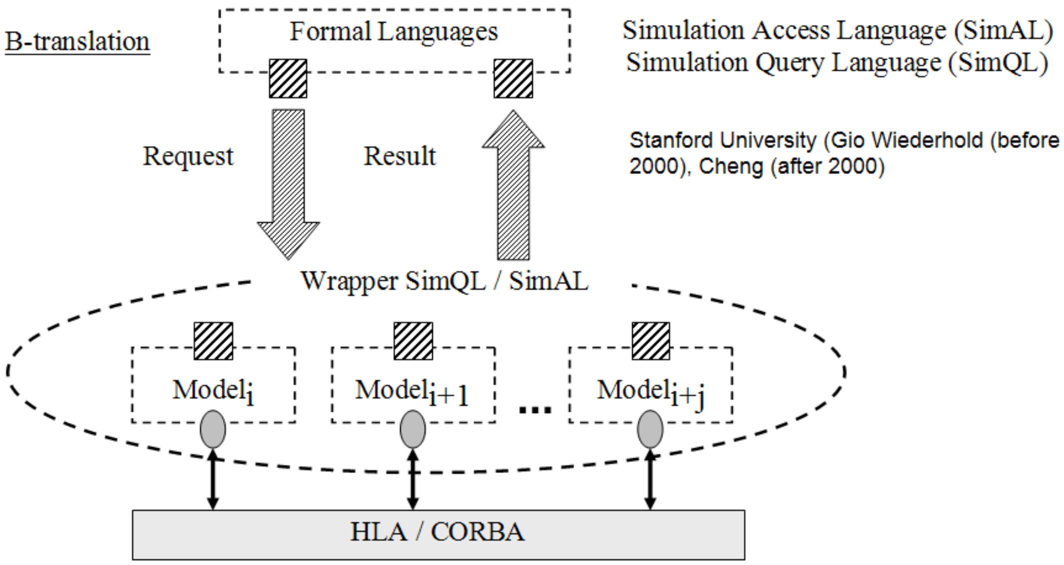

Figure 5: Client-Server Access Model SimAL/SimQL

In the beginning of the 21st century client-server access was offered for simulation models by integrating SQL query analogues, but the proposed solution did not gain wide acceptance, because it was not enough, i.e. access to the simulation environment did not improved for domain experts, because the query still had to be made in what a person without programming skills would consider an unfriendly language.

Ontologies provide formal methods for describing the concepts, categories, and relationships within a domain. Domain ontologies may be particularly helpful to simulation modellers since they can be used to communicate domain information to simulation and modelling tools with limited human intervention.

Ontology driven simulation (ODS) takes advantage of this feature by using software tools to align knowledge resident in domain ontologies with knowledge resident in a modelling ontology in order to facilitate the creation of simulation models. In ODS, a tool is used to map concepts from domain ontologies to concepts in a modelling ontology and then create instances of modelling ontology classes to represent a model.

Ontology driven simulation uses ontologies to drive the creation of simulation models and in doing so makes use of an agreed upon set of terms and relationships that are shared by domain experts, modelers, and model development tools. These terms and relationships provide a semantic grounding and structure for the executable model. The domain ontology exists for a specific application area, and its classes and instances determine the types of components that will make up the model.

The modeling ontology is developed independently of any specific domain ontology but may rely on general upper ontologies. Modellers receive the benefit of having a stable set of terms for the domain available through the design tools that they are using.

Domain experts and others who make use of the simulation models benefit by having simulations use a common set of terms with which they are familiar.

Under the framework of the Simulation Highway project is intended to create Ontology Based Adaptable Universal Simulation Specification Language based on a knowledgeable, ontological and semantic approach that would give various domain experts an immediate possibility to specify different simulation cases as well as translate, distribute and implement these specifications in the Cloud through the Simulation Highway.

The language would be based on UML and its followers BPMN and BPEL, and supplemented with the possibilities to describe stochastic and heterogeneous processes, as well as additions that would provide domain experts with more friendly access. The use of BPMN and BPEL would facilitate the introduction of the new simulation specification language in the Future Internet environment.

8. SIMULATION HIGHWAY AND VISUALIZATION OF THE RESULTS

It is clear that the presentation form of the simulation results should be demonstrative and close to the perceptual characteristics of domain experts. The higher is the level of immersion, the better the quality of the gained knowledge.

The important reason for VR/AR use is the requirements for the quality and the performance of simulation layout design. Of course, in industrial tasks it does not a critical factor like military applications (Smith 2010), but in any case intelligent application of VR facilities would substantially reduce the potential errors and time for the layout design.

The development of virtual and augmented reality (VR/AR) solutions and evolution of simulation environments creates a convergence of both sides where VR/AR will become an integral part of simulation tools. However, the next step is the demand for universalism and sufficiently open access, which could be provided by the Future Internet of Services and Cloud facilities.

This means, that requirements have to be defined and developed for an interface between the Simulation Highway and the set of virtualization tools on the Future Internet 3D (see Figure 6).

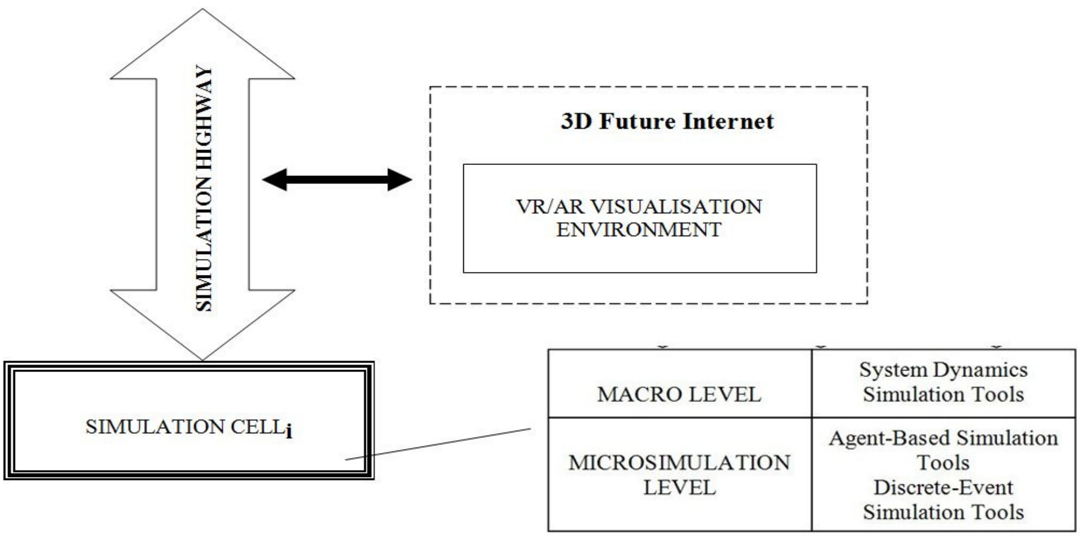

Figure 6: Simulation Highway - part of the Internet of Networks

The Future Internet of Devices (Things) ensuring access to the net for the mobile users dramatically increases the number of potential modellers. However, in the case of simulation, it must be remembered that the resource capacity of mobile devices (screen, memory, battery) is limited and cannot be compared to stationary users.

9. CONCLUSIONS

Simulation, in its half a century long existence, has achieved structurally diverse and heterogeneous solutions. New possibilities have emerged, which are analogous to software design, such as prototyping, automated model generation and others, and that is why simulation can be defined as simulation engineering.

The diversity and time consuming creation of models claim for requirements by unification and standardization. This can slow down the development of simulation technologies while expanding its scope of application, which could create the possibility of convenient decision making for domain experts.

Unification is doubtful without the creation of a unified approach to the distributed simulation and Ontology Based Adaptable Universal Simulation Specification Language based on a knowledgeable, ontological and semantic approach, which should preferably be based on habitual, well supported and with the Future Internet key persons understandings compatible constructions such as UML, BPEL, BPMN, etc.

The development of the Future Internet solutions is one of the priorities of European research. Therefore, service providers, including simulation professionals, should appropriately focus on solution development for the Future Internet of Services on the Cloud. A major advantage of simulation in the Cloud is that it is scalable. As the number of modellers increases, simulation servers can be added to increase the computational and storage capacity. Serious challenge is selection of the right platform for the Cloud due to real-time requirements of simulation.

The visualization of simulation results has to be done in an understandable and acceptable form, which VR/AR solutions can provide. These have to be integrated into the Future Internet 3D, but the Simulation Highway, as a part of Internet of Networks, has to ensure an interface between VR/AR and simulation models.

The proposed Simulation Highway solution is an attempt to unify the access to heterogeneous simulation models, to provide domain experts with the immediate specification possibilities and to ensure the economy of computer resources by deploying the simulation on the Future Internet of Services. The solution promotes the development tendencies of the Internet of Things, because it intends to deploy simulation tools to mobile communication devices.

Project partners will realize a demonstration tasks which will relate to a decision making simulation on port logistics and policy modeling. Expected results would allow for the consolidation of varied and different previously developed simulation models into a unified environment and ensure their direct usage by miscellaneous industry domain experts and specialists.

ACKNOWLEDGMENTS

The current article was prepared in the framework of ERAF project No.2DP/2.1.1.2.0/10/APIA/VIAA/001 “Support for preparation of IST FP7 STREP project “Simulation Highway””.

REFERENCES

Von Bertalanffy, Ludwig, 1976. General System Theory: Foundations, Development, Applications, Rev. ed., ISBN-978-0807604533.

Banks, J., Carson, S. II, and Nelson, B.L., 1996. Discrete-Event System Simulation, 2nd ed., Prentice Hall, Upper Saddle River, N.J.

Chang, Chris, 2004. Simulation modeling handbook: a practical approach, CRC Press LLC, ISBN 0-8493-1241-8.

Pidd, Michael, 1996. Tools for Thinking: Modelling in Management Science, ISBN 978-0471964551, 1996, 360p.

Banks, Jerry, 1998. Handbook of simulation, John Wiley & Sons, ISBN 0-471-13403-1.

Gilbert, Nigel, and Troitzsch, Klaus G., 2006. Simulation for the Social Scientist. Second Edition. ISBN 139780335221493, Open University Press.

Bruzzone, A., Verbraeck, A., Ginters, E., et. al., 2002. Logistics Information Systems, Part 1-2, Jumi, ISBN 9984-30-021-8, Riga, 2002, 682 p.

Carley, K.M., 2002. Computational organizational science and organizational engineering, Simulation Modelling Practice and Theory 10 (2002) 253–269.

Aizstrauts, A., Ginters, E., Aizstrauta, D., 2010. Step by Step to Easy Communication Environment for Distributed Simulation. //In: *Annual Proceedings of Vidzeme University College „ICTE in Regional Development”*, ISBN ISBN 978-9984-633-20-6, Valmiera: Vidzeme University of Applied Sciences, Sociotechnical systems engineering institute, 2010, pp.11-13.

Silins, A., Ginters, E., Aizstrauta, D., 2010. Easy Communication Environment for Distributed Simulation. //In: *World Scientific Proceedings Series on Computer Engineering and Information Science 3 “Computational Intelligence in Business and Economics”*/ Proceedings of the MS’10 International Conference, Barcelona, Spain, July 15-17, 2010, ISBN 978-981-4324-43-4, pp.91-98

Strassburger, S., 2006. The road to COTS-interoperability: from generic HLA-interfaces towards plug-and-play capabilities, in *Proceedings of the 37th conference on Winter simulation*, December 03-06, 2006, Monterey, California.

Verbraeck, A., 2004. Component-based Distributed Simulations. The Way Forward?, in *Proceedings 18th Workshop on Parallel and Distributed Computer Simulation*. (Kufstein, Austria, 16-19

May 2004), IEEE Computer Society Press, Los Alamitos, CA, 2004. pp. 141-148.
Bolton, F., 2001. *Pure CORBA*, Sams, ISBN 978-0672318122, 2001, P. 944.
Blackman, C., Brown, I., Cave, J., Forge, S., Guevara, K., Srivastava, L., Tsuchiya, M., Popper, R., 2010. Towards a Future Internet. Interrelation between Technological, Social and Economic Trends. Final Report for DG Information Society and Media, European Commission DG INFSO, Project SMART, 2008/0049 November 2010
Pedrinaci, C., and Domingue, J., 2010. Toward the Next Wave of Services: Linked Services for the Web of Data, Journal of Universal Computer Science.
The Economist. 2009. Clash of the clouds. The Economist. 392, 80-82, 2009
Burdea, G., Coiffet, P., 2003. Virtual Reality Technology. 2nd ed., Wiley Interscience, 2003.
Marcos de Morales, R., Dos Santos Machado, L., 2009. Online Training Evaluation in Virtual Reality Simulators Using Possibilistic Networks.//In: Proceedings SHEWC 2009 Safety, Health and Environmental World Congress, July 26 - 29, 2009, Mongaguá, Brazil.
Ginters, E., Vorslovs, I., 2008. Simulation Highway for Food Quality Management. *Proceedings of the International Scientific Conference „Aplied Information and Communication Technologies"*, Latvia University of Agriculture, Jelgava, Latvia, April 10-12, ISBN 978-9984-784-68-7, 2008, pp.86-95.
Ginters, E., Aguilar Chinea, M. R., 2008. Simulation Highway for Applied Systems Management. *Proceedings of the 7th WSEAS Int. Conf. on CIRCUITS, SYSTEMS, ELECTRONICS, CONTROL & SIGNAL PROCESSING (CSECS '08)*, Puerto de La Cruz, Tenerife, Spain, December 15-17, 2008, ISBN 978-960-474-035-2, 2008, pp.180-186
Towards a Future Internet, 2010. Interrelation between Technological, Social and Economic Trends. *Final Report for DG Information Society and Media. European Commission DG INFSO Project SMART 2008/0049*, November 2010, Available from: http://www.internetfutures.eu/wp-content/uploads/2010/11/TAFI-Final-Report.pdf, [accessed 01.04.2011]
Fujimoto, R.M, Malik, A.W., Park, A.J., 2010. Parallel and Distributed Simulation in the Cloud, SCS M&S Magazine – 2010 / n3
Smith, R., 2010. Simulation in the Cloud, ITEC 2010, London, 18-20 May.

AUTHORS BIOGRAPHY

Egils GINTERS is director of Socio-technical Systems Engineering Institute. He is full time Professor of Information Technologies in the Systems Modelling Department at the Vidzeme University of Applied Sciences. He is a member of the Institute of Electrical and Electronics Engineers (IEEE), European Social Simulation Association (ESSA) and Latvian Simulation Society. He participated and/or coordinated some of EC funded research and academic projects: FP7 FUPOL project No. 287119 (2011-2014), FP7-ICT-2009-5 CHOREOS project No. 257178 (2010-2013), e-LOGMAR-M No.511285 (2004-2006), SocSimNet LV/B/F/PP-172.000 (2004-2006), LOGIS MOBILE LV/B/F/PP-172.001 (2004-2006), IST BALTPORTS-IT (2000-2003), LOGIS LV-PP-138.003 (2000-2002), European INCO Copernicus DAMAC-HPPL976012 (1998-2000), INCO Copernicus Project AMCAI 0312 (1994-1997). His main field of interests involves: systems simulation, logistics information systems and technology acceptance and sustainability assessment.

Yuri MERKURYEV is Professor and Head of the Department of Modelling and Simulation at Riga Technical University in Riga, Latvia. His professional interests include methodology of discrete-event simulation, supply chain simulation and management, as well as education in the areas of simulation and logistics management. Prof. Merkuryev is a corresponding member of the Latvian Academy of Sciences, President of Latvian Simulation Society, Board Member of the Federation of European Simulation Societies (EUROSIM), SCS Senior Member and Director of the Latvian Center of the McLeod Institute of Simulation Sciences, and Chartered IT Professional Fellow of the British Computer Society. He authors about 300 scientific publications, including 6 books, and is a co-editor (with Galina Merkuryeva, Miquel Angel Piera and Antoni Guasch) of a recently published by Springer-Verlag book "Simulation-Based Case Studies in Logistics: Education and Applied Research". He is editorial board member of several journals, including "Simulation: Transactions of the Society for Modeling and Simulation International," and "International Journal of Simulation and Process Modelling". Prof. Merkuryev regularly participates in organising international conferences in the area of modelling and simulation. In particular, he has served as General Chair of the International Conference "European Conference on Modelling and Simulation", ECMS'2005. He is permanently involved into organising of the HMS (The International Conference on Harbour, Maritime & Multimodal Logistics Modelling and Simulation) series of conferences within the annual International Mediterranean and Latin American Modelling Multiconference, I3M.

Rosa Maria AQUILAR CHINEA is Professor and Vice-Rector at Universidad de la Laguna in Santa Cruz de Tenerife, Spain. His professional interests include ontologies of discrete-event simulation environments. Prof. Aquilar Chinea regularly participates in organising international conferences in the area of modelling and simulation. In particular, he has served as Chair of the International Mediterranean Modelling Multiconferences EMSS 2006 and other.