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ICT Evolution: from Single Computational Tasks to Modeling of Life

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Abstract. The paper discusses the model of ITC evolution from viewpoint of the ratio of the number of devices and served users. The current stage of such an evolution is considered as wearable and modeling one. Special attention is paid to modeling and simulation (M&S) as an important trend in education/training for the business and industry. The new approach in its use in context of cloud-based technologies is proposed: Modeling and Simulation as a Service (MSaaS). The general architecture is proposed for consideration.

Keywords: ICT, aviation safety, astrophysics, database.

1 Introduction

As experts noted in 2017, "As we embark on the Fourth Industrial Revolution, it is clear that technology will play a central role in almost every aspect of our lives. Research by the World Economic Forum has estimated that 65% of primary school children will find themselves in professions that are not there today. By 2020, it is estimated that there will be 1.5 million new digitized jobs worldwide. At the same time, 90% of organizations now have a lack of IT skills, while 75% of teachers and students feel that there is a gap in their ability to meet the skills requirements of the IT workforce "[1]. The Davos' World Economic Forum in January 2020 raised the question of the School of the Future: what it would be, in particular, the need to identify new models of education for the fourth industrial revolution [2], as the development and fulfillment of trends in the current stage of educational informatization [3] in the digital transformation of the learning environment [4].

It is clear that the solution of this problem requires certain resources, in the information age - digital [5], taking into account age-specific features of cognitive abilities at micro-age intervals [6], use of adequate methodological (first of all, mathematical) apparatus [7] for forecasting and appropriate choice optimal tools and adaptation of educational resources to the individual capabilities of the education seeker [8]. Appropriateness of the tools used can be estimated using substantiated criteria [9] and techniques [10].

According to the experts, “Higher human-machine interaction with new technologies will increase productivity but require different, often higher skills, new technological interfaces, different pay patterns in some cases, and different types of business and employee investment skills ” [11, p.7]. Appropriate changes meet business requirements and need to be applied in education process effecting adaptive learning systems [12] and optimizing individual mental efforts [13].

Purpose. To develop the model of the ICT transformation from shared access computers to e-learning tools and technologies.

2 Methodology

The model of transformation of the digital education can be presented as evolutional stages with corresponding types of digital tools and directions of support for the education process (Fig.1).

Fig.1 Evolutional stages with corresponding types of digital tools and directions of support for the education process

If the first stage can be described as “one shared access computer for many users” working off-line. The next stage had a new feature: possibility for a user to work on-line (mini-computers). The next stage of ICT evolution dealt with personal computers that became later smaller and mobile.

Networks provided users with extended possibilities, unlimited from point of view an access to different resources. Their development was a transformation into cloud-based resources, friendlier end extended for users’ needs.

The last stage, that we live on, can be characterized as much more flexible and person-oriented. The appropriate tools provide a user with opportunity to live and to act in the synthetic environment (virtual, augmented, mixed etc.), as well as provide opportunity for adaptive learning and construction of the personal trajectory of teaching [14]. Teaching is transforming from obtaining a set of facts or prescribed knowledge into the search of knowledge needed for the learner and synthesis of such knowledge by the learner himself/herself by using wide spectrum of tools. Because the amount of facts and knowledge becomes crucial every day, the search as such became not enough. Modeling and simulation give new opportunity to explore the world [15].

3 Results and Discussion

It is known that data interpolation for use in predictive models of object description and extrapolation have significant differences in the application of models to humans, not technical products, because humans have significant psychophysiological, psy-

chological, educational and other differences, because reliability and robustness of models to the effect of "noise" becomes of particular importance: their application to objects whose parameters are significantly different from those included in the training sample of the model under which the model is built. As a result, the question arises as to the optimality of the models by the criteria of prediction accuracy, reliability and robustness.

"It must be understood that not only new means and opportunities arise, but a digital transformation of the human life and human activity that was actively discussed at the Davos Forum in 2019. First of all, it concerns new technologies that accompany us in all areas of our lives and activities - information and communication technologies (ICTs) - and also directly affect not only our present, but also the future" [16].

In recent years, the use of cloud-based modeling and technology and service-oriented architecture has been increasingly widespread in the world, offering greater use of modeling and simulation (M&S) capabilities to meet critical societal needs [17].

Modeling and simulation is the use of models (such as a physical, mathematical or logical representation of a system, entity, phenomenon, or process) as a basis for modeling to analyze data used to make managerial or technical decisions. In a computer application, M&S is used to build a mathematical model that contains the key parameters of a physical or societal model. The mathematical model represents the physical model in virtual form and the conditions that set up an interesting experiment are applied. Mathematics as a general language to describe the Universe provides learners with understanding in what way the world is united. Simulation means that the computer calculates the results of these conditions on a mathematical model - and outputs the results in a format that is read by machine or person, depending on the implementation. Simulation is increasingly used in the sense of "simulation". To some extend, it is "game", a cognitive task that can be a part of the general education process [18].

M&S as a Service (MSaaS) is a new concept that includes a focus on servicing and delivering M&S applications through a cloud computing model as a service to provide more simulation environments that can be deployed and executed at the user's request. The MSaaS paradigm supports offline use as well as the integration of multiple simulated and real systems into a single cloud simulation environment when needed.

The MSaaS concept has to be tested at the national level in different educational scientific and practical structures in various experiments. As it was noted, the results of the experiments and the initial operational programs in military area (includeing training and practical use) demonstrated that "MSaaS was capable of realizing that products, data and processes are conveniently accessible to a large number of users when and where required" [17, p. 21]. As researcher highlighted, "M&S products are highly valuable resources and it is essential that M&S products, data and processes

are conveniently accessible to a large number of users as often as possible. However, achieving interoperability between simulation systems and ensuring credibility of results currently requires large efforts with regards to time, personnel and budget" [17, p. 15].

For educational tasks, this concept can become one of the main areas in students' cognitive activity, provided that the methodological, technical, organizational and content issues are reasonably developed.

M&S as a Service (MSaaS) can be realized as both the national and an educational institution level approach for discovery, composition, execution and management of M&S services.

Realization of this concept needs to solve three groups of problems: the MSaaS Operational Concept, the MSaaS Technical Reference Architecture, and the MSaaS Governance Policies.

The general architecture of the learning process with MSaaS can be represented as the administration of the M&S cloud(s) exchanging by metadata with customers (teacher and students) of the education institution (Fig.2).

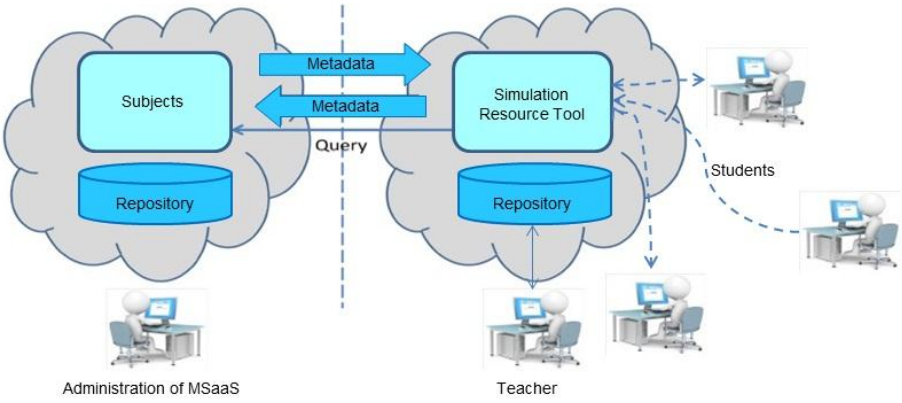

Fig. 2. Example of the administration of the M&S clouds exchanging by metadata

Repository on the administration side contains all available modeling areas that can be specified and adjusted to the needs of the particular education institution and/or subject area.

These results correspond the current needs to change digital transformation of education to prepare professionals for new and future jobs such as big-data, data scientist, data analytics etc.

3.1 Simulation as a tool to create new knowledge on the base of collected data and data mining for science and edu

The Education Community Framework for M&S as a Service enables:

- The community of users to discover new opportunities to teach/learn/train and to work together.
- Users to enhance their operational performance and optimizing effort in the process.
- M&S aims to provide the user with discoverable services that are readily available on-demand and deliver a choice of applications in a flexible and adaptive manner.

The MSaaS concept is illustrated in Figure 3. MSaaS is an enterprise-level approach for discovery, composition, execution and management of M&S services. MSaaS provides the linking element between M&S services that are provided by a community of stakeholders and the users that are actually utilizing these capabilities for their individual and organizational needs.

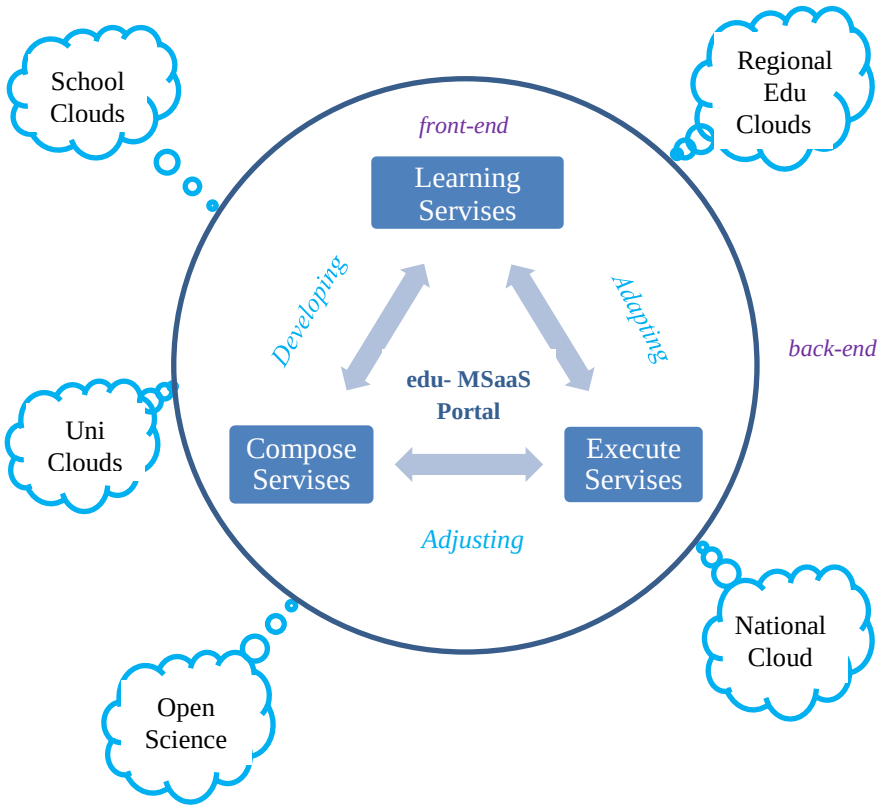

Fig. 3. The edu-MSaaS concept

Using proposals of authors for M&S Service in military field [19], application to the Education Community Framework for MSaaS defines user-facing capabilities (front-end) and underlying technical infrastructure (back-end), as it is shown in Fig.3 with development and adapration to the specific typeof activity as the education. The front-end can be called the edu-MSaaS Portal. It provides access to a large variety of M&S capabilities from which the users are able to select the services that best suit their requirements, and track the experiences and lessons learned of users. The users can discover, compose and execute M&S services through the front-end, which is the central access point that guides them through the process:

Discover Services (a mechanism for users to search and discover M&S services and assets: data, knowledge, services, models, and scenarios):

- Specify and discover scenario.
- Define simulation requirements and discover services.
- Define types and levels of game-based learning.

*Compose Services (*The ability to compose discovered services to perform a given simulation use case. It is envisaged that simulation services will be composed through existing simulation architectures and protocols and can be readily executed on-demand. Simulation technology will enabling further automation of discovery, composition and execution):

- Design simulation environment.
- Compose services.

*Execute Services (*The ability to deploy the composed services automatically on a cloud-based or local computing infrastructure):

- Deploy and execute a composition of services.
- Collect and analyze data.
- Save simulation environment for reuse.
- Provide cybersecurity support for users.

A further description of the process and associated activities prescribed for a user is assumed that the following supporting services and infrastructure are available:

- Availability of a registry with information about available M&S services and capabilities.
- Availability of a repository with access to the actual M&S services and capabilities.
- Availability of an MSaaS Portal as a central Front-end providing discovery, composition and execution services.
- Availability of networking and hardware infrastructure (Cloud provider, local hardware, network) on which to execute the simulation services.

Such proposals can be especially useful if expanding M&S service to AR/VR environment [20], lifelong learning paradigm [21] as well as trends and ooportunities of larning in social networks [22].

4 Concluding Remarks and Future Work

The model proposed allows representing ITC evolution from viewpoint of the ratio of the number of devices and served users. The current stage of such an evolution is considered as wearable and modeling one, flexible and person-oriented. Special attention is paid to modeling and simulation (M&S) as an important trend in education/training for the business and industry. The new approach in its use in context of cloud-based technologies is proposed: Modeling and Simulation as a Service (MSaaS). The general architecture is proposed for consideration.

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