Cloud based Simulation Platform for Circuits and Systems Design

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Abstacts: **This paper provides a roadmap of development of the Engineering Design Platform, based on service-oriented computing (SOC) and intended, in particular, for EDA (Electronic Design Automation) domain which migration to cloud computing remains slow. Under SOC the entire simulation process is broken down into a set of loosely-coupled interacting cloud services (specific software components with unified interfaces) that can be performed at different Cloud sites and can be dynamically orchestrated to execute the simulation workflows composed by the users of the web-based environment.**
The Engineering Design Platform will support end users in developing customized simulation applications in the form of Software-as-a-Service (SaaS) based provision. Moreover, simulation software service providers and consulting companies will have access to a Platform-as-a-Service (PaaS) solution that enables them to quickly assemble custom simulation solutions in the cloud for their clients. The Engineering Design Platform may be built on existing and proven technologies that will enable the project to deliver its results quickly.

Key-words: **Service-oriented computing (SOC), Web-services, Cloud Computing, Services Repository, Software-as-a-Service (SaaS**)

I. INTRODUCTION

Under pressure of the market the complexity of developed applications is rapidly growing. Modern applications are no more holistic units, as they were in the past. They are not monolithic kernels working on a single computer platform, but rather a set of dynamically changing modules. Service-oriented architecture concept was developed together with development of the Web. This modular approach to software development is based on the use of distributed loosely coupled replaceable components with standardized interfaces for communication via standardized protocols.
Applications are created by several teams of developers using different programming languages, using the set of data that can come "on-line" from several, usually geographically distributed sources. As a result, there is a need for a new style of application development, based on a software services (program services) [1-5].This style allows programmers not to start work from scratch, and create new applications using ready-made service available on the network. Modern engineering applications are built as a complex network of services offered by different providers, based on heterogeneous resources of different organizational structures. Together, these services form a powerful and versatile tool for the modern e-science: if cloud enables large-scale computation, figuratively speaking, shall make available scientific superpower "virtual supercomputer", the workflow system (workflow management system) can help develop a plan composed of computational procedures, dynamically adjust it to suit the purposes of the simulation and its interim results, monitor the progress of the whole complex computational process.

So any user community, regardless of its discipline, should be supplied with the technological approach to build their own distributed compute-intensive multi-disciplinary applications rapidly. This paper contains the roadmap of development of the Engineering Design Platform, based on Service-oriented computing (SOC) and intended, in particular, for modeling and optimization of Nonlinear Dynamic Microsystems, being consisted of components of different physical nature and being widely spread in different scientific and engineering fields.
Service-oriented architecture is used, where the entire simulation process is broken down into a set of loosely-coupled interacting cloud services (specific software components with unified interfaces) that can be performed at different Cloud sites. Web services are representing the basic building blocks of simulation system's functionality: input data preprocessing; mathematical model development and its dimension reduction; DC, AC, TR, STA, FOUR and sensitivities analysis; parametrical optimization, tolerances assignment; statistical analysis and yield maximization; results processing etc. [6-8]. Beside EDA the simulation, analysis and design can be done for different control systems and dynamic systems composed of electronic, hydraulic, pneumatic, mechanical, electrical, electromagnetic, and other physical phenomena elements. Complex non-linear systems of this type are widely used in modern aerospace, robotics, NC machine tools, and test equipment, highway engineering, agricultural and other applications.
The rest of this paper is organized as follows: Section 2

presents SOC in Engineering Design and innovative features of our proposal. Section 3 describes the impact and exploitation plan and Section 4 concludes this paper.

II. DESCRIPTION OF A PROBLEM SOLUTION

Our proposal has the following innovative features:
• Implementation of novel service-oriented design paradigm in Engineering according to which all levels of design are divided into separate loosely coupled stages and procedures for their subsequent transfer to the form of standardized web-services.
• Creation of the repository of design web-services which will contain components developed by different producers that support collective design work and globalization of R&D activities in Europe, either for free or with certain fee.
• Personalization and customization of Design in Engineering because users can build and adjust their design scenario and workflow by selecting the necessary web-services (as calculation procedures) to be executed on cloud resources.
• Modernization of existing SPICE-like simulation software by introducing new customers' component models and their parameters and adding additional unique design web services (multi-criterion optimization, optimal tolerances assignment, yield maximization, etc.).

The main objective of the proposal in hands is the service-oriented highly advanced Optimal Engineering Design Platform. The main objective is divided into quantifiable sub-objectives:
• Implementation of the emerging distributed design paradigms in Engineering, which can be executed in cloud environments.
• Development of tools which enable users to build and adjust scenarios and workflows of their design procedures or mathematical experiments via the Internet by selecting the necessary web-services (as calculation procedures) to be executed on cloud resources, including automatic creation of equations of the object mathematical model (a circuit or a system) based on a description of its structure and properties of the used components in the form of differential-algebraic or differential equations reduced to the form, which is acceptable for solving by other software subsystems.
• Improvement of mathematical background of web-services which cover novel types of analyses and solutions of these equations (Multi-task Optimization, Tolerance Assignment, etc.).
• Development of a structure and component interfaces of the specialised Optimal Engineering Design software, based on the orchestration of web services in service-oriented, distributed computational cloud infrastructure.
• Leveraging cloud computing and parallel computing to overcome resource shortage problem when solving engineering design problems of high complexity and with required accuracy in a reasonable time.
• Development of a set of flexible tools for solving interdisciplinary problems of Optimal Engineering Design, supporting remote collective work. Although there are many existing tools that can be useful in some selected cases (including user portals providing user interface for grid/cloud applications and sharing resources etc.) there is no single complex solution that sufficiently meets all of requirements with respect to Optimization and Simulation of Complex Non-Linear Engineering Systems in Cloud. Proposed approach, been based on service-oriented computing, is completely different from present attempts to migrate monolithic large CAE/CAD software systems into the cloud infrastructure as it is done in *TINACloud, PartSim, RT-LAB, FineSim Pro* [9-12].

The delivery of software as a set of distributed services can help to solve problems like software reuse, deployment and evolution. The "software as a service model" will open the way to the rapid creation of new value-added composite services based on existing ones. Although service-oriented computing in cloud computing environments presents a new set of research challenges, their combination provides potentially transformative opportunities. The service-oriented Engineering Design Platform may be developed on a base of the proposed architecture. Service-oriented computing and Cloud computing have a reciprocal relationship — one provides the computing of services, and the other provides the services of computing. Service-oriented computing in cloud computing environments presents a new set of research challenges [13,14].
Actually service-oriented software developers are divided into three independent but cooperative groups: Application builders (or services clients), service brokers and service providers. Service providers' task is to provide independent and loosely coupled services. Service brokers' duty is service introduction and marketing. Application builders find their required services for constructing their applications via service brokers. Development is divided between a service provider and an application builder. A service provider writes and exclusively owns the code of the offered services, whereas an application builder develops client applications that make use of the offered services (Fig.1).
Usually the Services Repository is created which contains as ***Platform Environment Supporting Services,*** so ***Application supporting services***), from which a user will be able to composite his own design route in the particular engineering field. The Environment Supporting Services offer the standard operations for service management and hosting (e.g. cloud hosting, event processing and management, mediation and data services, services composition and workflow, security, connectivity, messaging, storage etc.).
The Application support services are created by investigating the generalized research or engineering design process and selecting its loosely coupled stages and procedures for subsequent their transferring to the forms of standardized Web services. It is possible also to analyse the existing scientific software for the possible re-use of the best algorithms and design procedures implementations in the creating the repository of Application support services.
The computer simulation is the universal approach in

research methodologies of different science branches where very similar processes' or objects' models and algorithms of models analysis in time and frequency domains are used. This promotes building multidisciplinary Application support services for the Repository of services. This Repository can be used through the pan-European e- infrastructure and composed applications can be executed in pan-European HPC infrastructure. It is worth to mention that these Applications will have dynamic architecture during their running because of changing executing nodes and changing assess to the distributed Repository of services. Web services, used by end-users, are autonomous, self-describing, and platform-independent computational elements. For the purpose of developing massively distributed interoperable applications, Web services are described, published, discovered, composed, and programmed, using a standard set of programming languages and protocols, by many partners from public and private sectors.

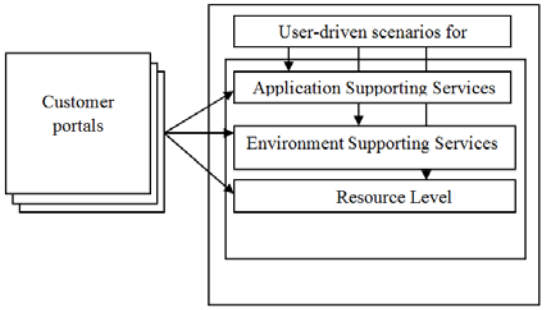

Figure1. An Engineering Design Platform general structure

The project in hands supports custom user analysis scenario development and execution functionality is accessible with lightweight web interface. It hides the complexity of web-service interaction from user with abstract workflow concept and simple graphical workflow editor.

III. THE IMPACT AND EXPLOITATION PLAN

Based on SOC facilities, the Institute of Applied System Analysis (IASA) of NTUU "Igor Sikorsky Kiev Polytechnic Institute" (Ukraine) has developed the user case WebALLTED as the web-enabled Engineering Design Platform, intended, in particular, for modelling and optimization of Nonlinear Dynamic Systems, which consist of components of different physical nature and which are widely spread in different scientific and engineering fields. It is the cross-disciplinary application for distributed computing in the form of a network of collaborative components functioning within or across organization borders which support the general methodology of design. The abbreviation ALLTED means **ALL TE**gnologies **D**esigner [15,16]. It seems to be very useful for people who have needs to use applications composed by SOC, as well as for the people who can design sophisticated applications using services.

Dissemination and exploitation plan will support selection of interested stakeholders and establishing relations with potential users from industries/SMEs. For this it will be elaborated a series of training courses (for end-users, as well as for distributed CAD applications and services developers). This activity is thus very strongly focused on enhancing the potential end-user to be prepared to access to the proposed services and understand the developing concept.

Main areas of commercialization and self-supporting are:

- Provide a fee to access the functionality of individual components of Cloud-based Engineering Design Platform for use by developers as part of their products).
- Fee for performing full ordered customer's design by Ukrainian partner (through the cloud accounting system).
- Establishing a special body for providing consulting services, including developing libraries of Mechatronic System components.
- Helping in implementing design web-service repository and effective instrument for customer workflow execution for improvement operation of national e-infrastructures.

IY. CONCLUSION

Service-oriented applications governance involves knowledge about services, providers and users. Development is divided between a service provider and an application builder. This separation enables application builders to focus on business logic of his application while leaving the technical details to service providers. If a large multidisciplinary and multinational Repository of Application supporting services is created, the end-users can tailor the services to their own personal requirements and expectations by incorporating functionalities of available services into large-scale Internet-based distributed application software.

Resulting in an application design becomes personalized and customized because users can build and adjust their design scenario and workflow by selecting the necessary Web services (as computing procedures) to be executed on Cloud resources and users themselves are transferred from software users to software developers.

The prototype of the service-oriented Engineering Design Platform was developed on a base of the proposed architecture for Electronic Design Automation domain. Beside EDA the simulation, analysis and design can be done using WebALLTED for different control systems and dynamic systems composed of electronic, hydraulic, pneumatic, mechanical, electrical, electromagnetic, and other physical phenomena elements. Complex non-linear systems of this type are widely used in modern test equipment, aerospace, robotics, NC machine tools, highway engineering, agricultural and other applications. Of course, if provided set of Web services will not be fully comprehensive, the interested users will be able to develop and add additional own Web services as well as to incorporate Web services of other providers into their own complex applications and the Repository of services.

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