A Generic Reference Architecture for Collaboratory Scientific Virtual Laboratory

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ABSTRACT

The paper presents a generic reference architecture framework for collaboratory experiment virtual laboratory. The model presented is open source driven, flexible and based on modern tools and technologies. This in effect will allow geographically remote scientists with limited internal laboratory resources, access to wealth of experimental datasets, computing facilities, and distributed hard-to-duplicate laboratory devices. The key issues discussed are architectural design and choice of technology used for creating virtual laboratory. This architecture offers great levels of flexibility, simplicity, and interoperability that are needed to allow integration between heterogeneous distributed grid resources and its clients and executors. The framework, besides theoretical modelling, will provide a road map for future research and open questions.

Keywords: Architecture, Collaboratory, Grid Technology, Virtual Laboratory, Web Services

1. INTRODUCTION

Virtual laboratory is a heterogeneous, distributed environment, which allows scientists across geographical locations to work on a common project. This environment creates a favourable and conducive atmosphere for scientists to conduct experiments with the usage of physical laboratory devices, perform simulations using computational resources, and initiates communication among scientists working on similar group of projects over a distributed network environment. Technically, we could also refer to this as a group of integrated components that forms an advanced environment, which could be used to plan and perform complex scientific experiments (Krakow, 2009). Experiments in this context are processes that combine available applications, services, devices and data into sequence of ordered activities and perform

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computer simulation in order to obtain new knowledge.

The main reason for building such open, flexible, scalable and configurable system is to allow remote access to various scientific equipments, to facilitate and accelerate research process, share knowledge among research groups and also to manage experimental data and results. However, the system provides multidisciplinary functionalities, which seems attractive especially to the experimental scientists, technologists and engineers (Lawenda et al., 2004; Khetty & Xian-He, 2000). Although, executing such project is quite capital intensive, the concept of the virtual laboratory remains the long-awaited solution of the future for research environments with limited equipment resources.

The virtual laboratory promises to offer and provide means that will widely open the field of science for societal demands in education and professional specialization in new technologies. The realization of the proposed virtual laboratory environment will allow scientists and engineers to work on their projects via remote events simulation, interpretation of experimental data and, in some cases, run real experiments in a customized laboratory.

The remainder of the paper is organized as follows. In Section 2, a survey of related work and state of the overview on virtual laboratory is presented. The proposed system architecture and model is described in Section 3, and in Section 4, an in-depth description of the proposed system service rendering, system key players and operational environment are covered. Finally, Section 5 offers concluding remarks and future direction on the work.

2. RELATED WORKS

The first work on virtual laboratory comprised solely of texts and images of instruments, experiments, concepts, sites and people linked to experimentalization of life (“Dierig, Schmidgen & Dierig.”). Then it was also seen as a platform for discussing experimentation in the areas of life sciences, art and technology. In recent times, two main purpose of virtual laboratory development have been identified and pursued to date. These two areas are education and research. The examples of educational functions of virtual laboratories are (“ Handschuh.”):

1. Learning and teaching of chemistry by presenting simulations of experiments.
2. Physics presentations, such as structures and properties of molecules.
3. Familiarizing with science, including genomics and techniques applied in biology and medicine, example. DNA microarray technology.
4. Demonstration of statistic concepts and methods.

In science, virtual laboratories are becoming more popular, facilitating large-scale bioinformatics studies (“GenGrid.”; Susumu et al., 2005) and computational tasks, for example, drug discovery (Buyya, 2003), virology (“ViroLab.”), proteomics and mass spectrometry (“PubMed,”) and other disciplines. They also enable collaboration between real laboratories and companies (“PSNC VLAB.; AlmaGrid.”). Nowadays, due to technological breakthrough and automation of experimental procedures, virtual laboratories may not only collect, store and process data, but also perform some steps of experiments, providing access to expensive and specialized instruments (Afsarmanesh et al., 2000; Belloum et al., 2003; Hey & Trefethen, 2002). Such approach was applied to establish virtual laboratories connected with radio-telescope and NMR spectroscope (“PNSC-NMR.”).

To construct and implement virtual laboratories the grid architecture is used (see Section 2.2). Grid computing allows for increase of the computational power due to the combination of multiple resources and implementation of any application. Connecting even geographically distributed experimental component resources in a functional network simplifies complex data processing and management. Virtual laboratories belong to a specific representation of grid application often referred to as Remote Instrumentation Systems (Handschu et al., 2009). They cooperate with other grid systems such
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