Web Services and Semantic Web in Remote Control of Laboratory-scale and Matlab Simulation Models

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ABSTRACT: *Internet control of laboratory experiments has lately become a new phenomenon in university education. It brings effective use of the laboratory equipment and comfort to students in performing their laboratory experiments from anywhere. Since a solution for the control-engineering laboratory of the CTU was designed in the framework of a diploma thesis, obtained experience and necessity of establishing a common access to software models especially those created in Matlab/Simulink are the main reasons why a new development has been considered. New features and advantages provided by web services and semantic web are described and discussed both for existing remote laboratory control and planned introduction of the Matlab/Simulink based simulators into various types of educational courses.*

1. INTRODUCTION

Web services are becoming a standard in application-to-application communication (Haas, 2002). While they bring long awaited unification of the programmatic interface between programs on different platforms, they also help programs to spread to new areas of use, thus bringing many new opportunities. They allow previously unthinkable solutions to emerge. However, they also bring many new challenges.

2. WEB SERVICES IN GENERAL

Web services (previously also known as application services) are services (usually including some combination of programming and data, and possibly including human resources as well) that are made available from a provider's web server for web users or other web-connected programs (TechTarget, 2002). Major advantages of web services are standardized protocols (TCP/IP and HTTP) and data formats (XML), which allow otherwise incompatible programs and platforms to communicate with one another.

The goal of web services is to provide services to other programs or individuals. These services can range from booking a hotel or renting a car to providing the current value of a requested stock quote or forecasting weather for a given area.

2.1 A closer look at web services architecture

In order for the remote party to be able to access the data and understand it correctly, some rules need to be defined describing the format and meaning of data and a way of accessing it. The format for web services data has been set to be Extensible Markup Language (XML). XML is similar to HTML as it uses tags to describe data. Unlike HTML, XML does not have a predefined set of usable tags. Therefore the developer of a web service can define his/her own tags that will be used to describe the data.

Knowing how to access the data provided by the web services is just as important as being able to understand this data. Accessing web service functions is described using Web Services Description Language (WSDL). WSDL is an XML-based language used to describe the services one offers and to provide a way for a remote party to access those services electronically. (TechTarget, 2002)

If one wants to access a certain web service, he/she must know who provides such a service. Information about available web services and the functions that these services provide are contained in the UDDI registries. A UDDI (Universal Description, Discovery and Integration) initiative can be thought
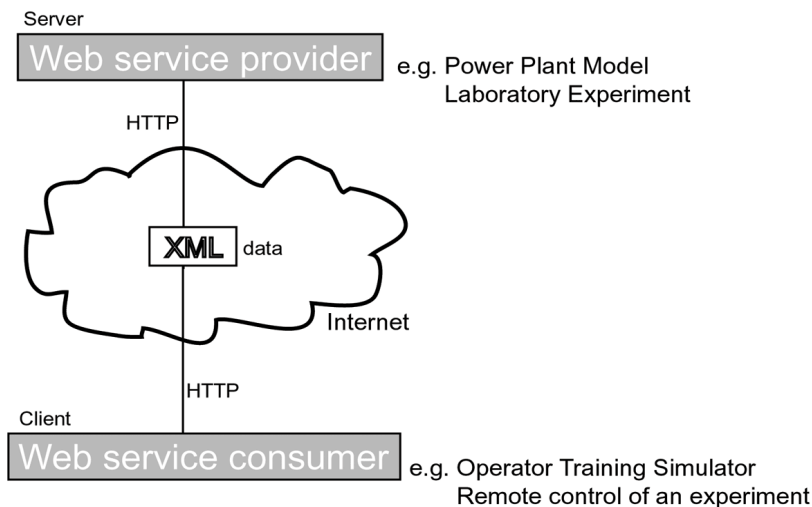
Web Services Architecture

Figure 1 - Scheme of a web services architecture

of as the yellow pages of web services. They include lists of registered web services. The services are described using WSDL.

2.2 Advantages of web services over proprietary implementation of remote control

The following are the main advantages of the use of web services:

- Unified cross-platform interface – based on TCP/IP, HTTP, XML and WSDL standards, this solution can be implemented on a variety of platforms

- Scalability - changes to the experiment (server side) can be made without having to change the client software

- Passes through most firewalls – HTTP protocol is used, therefore no changes need to be implemented in the setup of most firewalls, as HTTP traffic is allowed on most networks

- Allows cooperation between on-line users – connection of several users to the experiment at one time is allowed and better management of access rights is provided.

2.3 Matlab approach to remote access

Being a great tool for laboratory experiments as well as system modelling, Matlab software and its remote access capabilities are at the center of attention while developing web service based experiments and models. Recent versions of Matlab software include a web server that allows HTML pages to be generated from within Matlab and served to the clients connecting the Matlab remotely. This approach combines both application server (server generating the data) and web server (server taking care of delivering the generated data to the clients). Recent trends in this area however seem to rather separate these two functions than combine them. This is to allow each server to concentrate on its work and do so more effectively. Further testing is planned to examine the abilities of Matlab web server to withstand heavy load, especially under conditions of simultaneous work of several users.

3. POWER PLANT SIMULATORS AND THE WEB

In recent years, coal-fired power plant simulators of various kinds and for various uses have been developed at the Institute of Instrumentation and Control Engineering in co-operation with Energy Training Centre in Tušimice, Czech Republic. (Neuman P. et al, 2000, Jan, J. A., Šulc B., 2001, 2002).

The last development was on an operator-training simulator using Matlab/Simulink as a tool for simulation and Wonderware InTouch as a tool for visualization and manipulation. These purely software realizations are supplemented in the industrial version, by an operator panel. Although the educational version lacks the feeling of working in an operator room, (and this is the specific advantage of the industrial simulator, where the operator uses the real control panels in his/her operator room), it offers a broader range of activities to be performed. Besides providing acquaintance with the work of an operator, this solution allows students to test advanced control algorithms, perform identification experiments and other control engineering tasks otherwise hardly performable in a real environment. In normal operator simulators these functions are not available, as they go beyond the responsibility of the operator. The scope of these tasks cannot be fully estimated in advance and so a well designed interface between the student and the simulator is necessary. Web services will play a key role in the design of such solutions as they provide optimal support for this task. The design of this interface is forming part of a dissertation work currently being undertaken at Czech Technical University.

4. SEMANTIC WEB APPROACH

Web services are a good solution to the problem of system interconnection by defining both the transport protocols as well as data formats. However, in the more general case of sharing data accross heterogenous networks, third fundamental problem must be addressed: the semantics of the data. In this connection, the current focus of the World Wide Web Consortium (W3C, 2001) in this area is on the development of standards that will provide the necessary mechanisms for a universal description of shared data. This effort is being addressed with the Resource Description Framework initiative (RDF) governed by the W3C. At the present time, the Learning Object Metadata (LOMv1.0) Base Schema is already aproved as the IEEE Standard 1484.12.1 paving the way for the first implementations. This standard defines entities of a learning object such as Interactivity type, Semantic Density, Intended End User Role, Typical Age Range, Typical Learning Time and many others. This standard has been created "so that a metadata instance for a learning object can be used by a learning technology system to manage, locate, evaluate or exchange learning objects" (IEEE, 2002).

The activites carried out currently at the Instrumentation and Control Engineering Department are focused on the development of a pilot system based on the use of the web services and semantic web principles.

5. CONCLUSIONS

Web services approach and semantic web prinsiples seem to be suitable for remote access to both laboratory experiments as well as to simulation models. However, only after pilot project testing with the focus on the system load and compatibility, a final judgement will be possible. Based on the knowledge gained during the recent Advances in Control Education Symposium held in Oulu, Finland, questions arise as to what will be the effect of a significant simultaneous activity of a larger number of students. Focus is also put on the improvement of the models themselves, especially on the promising development of more precise modelling in the area of non-linear systems.

6. ACKNOWLEDGEMENT

REFERENCES

HAAS, H. 2003: *Web Services Activity*. www.w3.org/2002/ws.

HRDLIČKA, P., NEUMAN P. & B. ŠULC. (2002): *Process Instrumentation Modular Models of Thermal Power Plant for Operator Training Simulators*. 15th IFAC World Congress on Automatic Control, Barcelona, Spain.

IEEE. 2002. *Draft Standard for Learning Object Metadata*. Learning Technology Standards Committee of the IEEE, IEEE 1484.12.1-2002

JAN, J. A. & B. ŠULC. 2001: *Object Oriented Own-Built Model Library of Non-linear Thermo-Fluid*. Matlab 2001 Conference Proceedings, VŠCHT Praha

JAN, J. A. 2002: *Soft Computing in Object Oriented Nonlinear Modelling and Control of Thermo-Fluid Dynamic Systems*. PhD Thesis. Czech Technical University in Prague.

NEUMAN, P., B. ŠULC & T. DLOUHÝ. 2000: *Nonlinear Model of a Coal Fired Boiler Applied to an Engineering Simulator*. Preprints IFAC Symposium on Power Plants and Power Systems Control 2000, Brussels.

NEUMAN, P. & B. ŠULC 2000: *Engineering Models of a Coal Fired Steam Boiler in Teaching, Training and Research Applications*. 5th IFAC Symposium on Advances in Control Education, Gold Coast, Australia.

SÁNCHEZ, J., F. MORILLA, S. DORMIDO, J. ARANDA & P. RUIPÉREZ. 2000: *Conceptual Learning of Control by Java-based Simulations*. 5th IFAC Symposium on Advances in Control Education, Gold Coast, Australia.

TAMÁŠ, J., ŠULC, B. 2003: *Using Web Services in Remote Control of a Laboratory Experiment and a Power Plant Simulator.* 6th IFAC Symposium on Advances in Control Education, Oulu, Finland 2003

TAMÁŠ, J., KLIMÁNEK, D., ŠULC, B. 2003: *Internet Based HMI in Low-cost Simulators.* XXVIII. Instruments and Control Seminar ASŘ 2003 Proceedings, TU Ostrava

TAMÁŠ, J. 2001: *Performing Laboratory Experiments in Control Engineering via Internet.* Diploma thesis (in Czech). Czech Technical University in Prague.

TECHTARGET. 2002: *IT-specific Encyclopedia*. www.whatis.com.

ŠULC B., J. A. JAN. 2001. *User Friendly Simulink Thermal Power Plant Modelling using Object Oriented Non-linear Dynamic Model Library*. 5th IASTED International Conference Power and Energy Systems (PES 2001) Tampa, Florida, USA, pp. 253-256, ISBN: 0-88986-317-2.

WORLD WIDE WEB CONSORTIUM. 2001. *Semantic Web Activity Statement.* www.w3.org/2001/sw/Activity