Remote Educational Laboratory System Based on Web Services Standards

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Our Lab-on-Web project, which is dedicated to remote, educational experimentation on electronic devices and circuits, has evolved over several years and different system solutions have been tested [1]. Here, we report on the recent adaptation of the Web Services standards to Lab-on-Web, implemented by means of the .NET framework by Microsoft. This framework allows for a strong integration between backbone programs and web applications and services, including modern Learning Management Systems (LMS).

The new Web Services interface is language and platform independent, making Lab-on-Web accessible for further development from external, trusted platforms. This enables educators at other locations to adapt versions of our experimental package to their specific needs, without the cost of maintenance and hosting. Another benefit is that educators can select experiments from different hosting locations from within our eMerge collaboration [2], using a "Universal Description, Discovery and Integration" (UDDI) directory to compile a course content according to their special requirements.

Presently, our Lab-on-Web .NET application incorporates Web Services interfaces and a UDDI hosted by a Windows 2003 server. Access check is included with the implementation of the .NET framework role security model. A Component Object Model with extensions (COM+) object is designed to take care of instrument connection and Local Area Network (LAN) access. Concurrent users of the system are queued into a standard Microsoft Message Queue (MSMQ), a standard feature of Windows operating systems. The instruments used in the laboratory are all very fast, allowing experiment requests to be handled with little waiting time at moderate server loads.

With different levels of trust, the lab can be accessed at different levels. A non-trusted operator is able to perform experiments with high-level procedures, which protect the equipment from misuse. A trusted operator is able to use low-level access routines and design special user interfaces of the instrument set-up, which may vary from the standard experiment set-ups available from the hosting organization [3].

[1] T. A. Fjeldly and M. S. Shur, "Electronics Laboratory Experiments Accessible via Internet" in *LAB on the WEB, Running Real Electronics Experiments via the Internet*, T. A. Fjeldly and M. S. Shur, editors, John Wiley & Sons, New York, NY (2003).

[2] eMerge: a European Community project within the Socrates/Minerva program, see J. MARTINEZ, et al., "eMerge, a European Educational Network for Dissemination of Online Laboratory Experiments", *Int. Conf. on Engineering Education (ICEE 2003)*, Valencia, Spain, July 2003, paper no. 3171.

[3] S. Kolberg and T. A. Fjeldly, "Internet Laboratory with Web Services Accessibility", *Advances in Technology-Based Education: Towards a Knowledge-Based Society, Proc. 2nd Int. Conf. on Multimedia ICTs in Education (m-ICTE2003)*, Badajoz, Spain, Dec. 2003), A. M. Vilas, J. A. M. Gonzalez, and J. M. Gonzalez, Editors, Vol. 3, pp. 1700-1704.