Chapter 4.22
Web Service Enabled Online Laboratory

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ABSTRACT

Online experimentation allows students from anywhere to operate remote instruments at any time. The current techniques constrain users to bind to products from one company and install client side software. We use Web services and Service Oriented Architecture to improve the interoperability and usability of the remote instruments. Under a service oriented architecture for online experiment system, a generic methodology to wrap commercial instruments using IVI and VISA standard as Web services is developed. We enhance the instrument Web services into stateful services so that they can manage user booking and persist experiment results. We also benchmark the performance of this system when SOAP is used as the wire format for communication and propose solutions to optimize performance. In order to avoid any installation at the client side, the authors develop Web 2.0 based techniques to display the virtual instrument panel and real time signals with just a standard Web browser. The technique developed in this article can be widely used for different real laboratories, such as microelectronics, chemical engineering, polymer crystallization, structural engineering, and signal processing.

INTRODUCTION

In science and engineering education, experimentation plays a crucial role. The classic university science course entails lecture and lab: students' active participation in experiments enhances their understanding of the principles described in the lectures. However, not every educational institution can afford all the experimental equipment it would like. Moreover, colleges and universities increasingly offer distance-learning programs, allowing students to attend lectures and seminars and complete coursework using the Internet. In situations such as these, access to online laboratories or experiment systems can greatly enhance student learning - increasing the range of experiments available at an institution and giving the distance learners hands-on, real-time experience. Online laboratories, however, are not as mature as online courses. There is no matured software system to support online experimentation. Experimentation is also an important approach for scientific discovery. Sharing expensive equipment is a common practice in the scientific community. Some research facilities, e.g. synchrotrons and accelerators, are very expensive that a country normally invests to build one of the kind. These facilities are shared by the scientific community national wide and/or international wide. Currently, the scientists need to reserve a time slot in these facilitates and travel to the site to conduct the experiments. With the capacity of online experimentation, traveling cost can be saved. More importantly, online experimentation can allow the users to reserve shorter time slots, because the users do not need to finish an experiment during their travel. Therefore, the resource sharing can be more efficient.

Current online experiment systems fall into two categories (Naef, 2006): *virtual laboratories* provide a simulation environment in which students conduct experiments; and *remote laboratories*, with real instruments and equipments at the remote sites. The later is the scope of our research. The ultimate goal of our research is to provide IT techniques for remote experimentation over Internet. Our focus in this article is to let students use a Graphic User Interface (GUI) to operate actual instruments via remote control.

The difficulty with creating an effective laboratory operated by remote control is making scattered computational resources and instruments operable across platforms. Existing online experiment systems commonly use a classic client-sever architecture and off-the-shelf middleware for communication (Hardison, *et al.* 2005, Auer and Gallent, 2000, Latchman, *et al.* 1999). Normally, to ensure interoperability, these systems rely on instruments from a single company—such as National Instruments or Agilent—and Microsoft Windows as the common operating system. Users must then install additional software to operate the remote instruments. For a student using an old laptop or the computer at a public library, this could be difficult. So, online labs configured this way can't achieve the ultimate goals of sharing heterogeneous resources among online laboratories and easy access via the Web. Our solution to these shortcomings is to base online experiment systems on Web services, which are designed to support interoperable, machine to-machine interaction over a network and can also integrate heterogeneous resources. We have devised a service-oriented architecture for online experiment systems, enabled by Web service protocols, and a methodology for wrapping the operations of the instruments into Web services. Although these methods probably aren't suitable for time-critical missions or applications that need real-time control, such as robot operation, they do work for controlling standard commercial instruments over low-speed or unreliable communication networks—the types of networks available to many college students. Using this framework, we can create an online experiment system for students—or an online research lab for scientists—that incorporates a great variety of instruments and that users can access without installing special software.