

Putting Labs Online with Web Services

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In science and engineering education, experimentation plays a crucial role. Colleges and universities increasingly offer distance-learning programs, allowing students to attend lectures and seminars and complete coursework using the Internet. Access to online laboratories or experiment systems can greatly enhance student learning. Online laboratories, however, are not as mature as online courses. Existing online experiment systems commonly use a classic client-server architecture and off-the-shelf middleware for communication. These systems rely on instruments from a single company—such as National Instruments® or Agilent® to ensure interoperability. Users must then install the proper software to operate the remote instruments. This promising e-learning application is well positioned to use Web Services to conduct online experiment systems due to its interoperability and Internet compliance. 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. Our methodology works for controlling standard commercial instruments compliant with IVI (Interoperable Virtual Instrument) standards over low-speed or unreliable communication networks—the types of networks available to many college students. We propose that the instrument Web Services should be stateful services and we present a framework to manage the states of the instrument web services. We benchmark the latency of this system when using SOAP as the wire format for communication with Agilent 33220A waveform generator and propose solutions to optimize performance.