Chapter 5.9
Stanford CyberLab:
Internet Assisted Laboratories

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ABSTRACT

Cyberlab is a fully automated, Internet accessible laboratory for use in research and teaching, developed at Stanford University since 1996. Cyberlab is a completely self-contained system including a web-based scheduler, analysis tools, a data acquisition system, a digital notebook, extensive collaboration tools including simultaneous access to the equipment by multiple students, extensive security features, including firewall compliance without the need for IT intervention. The system is easily scalable and can be integrated with other distance learning programs.

INTRODUCTION

The World Wide Web has revolutionized information dissemination. From commerce to entertainment, and how the physical world can be experienced, the Internet has profoundly affected operations. Education, too, has undergone significant changes caused by Internet technology, just as over 20 years ago when Stanford University introduced the use of video for distribution and broadcast of classroom lectures (Gibbons, 1997). Broadcasting technology allowed students at first in Silicon Valley companies, and later nationwide, to participate in Stanford classes at remote locations. In the last few years, video broadcasting and the Internet have merged, providing students with opportunities to attend classroom lectures anywhere, at a time of their choosing. Education has been globalized and individualized.

Previous broadcasting technologies were not capable of providing truly interactive communication. Students often felt isolated from both the teacher and their classmates. The Internet has opened the opportunity to create remote communities. Instantaneous messaging, email, and live video technologies provide remote students with means to reduce the feeling of isolation. Internet technology also has the ability to access remote instrumentation. A time-honored tradition in physics, biology, chemistry and engineering has been to augment classroom lectures with laboratory courses and live demonstrations. Traditional broadcasting technologies are one-directional and unsuited for remote control and operation. Internet technology is bidirectional and has the opportunity to provide remote education that is as rich and all encompassing as a classroom lecture combined with experimentation.

In principle, Internet technology allows physical experiments to be carried out remotely, fully integrated with video and communication media for worldwide delivery at a time of the students choosing. Real experimentation can also be efficiently combined with numerical simulations. Simulations could be used to quickly explore various experimental configurations and as a means to augment and to prepare for carrying out real experiments. The Internet allows separation between student and equipment, while still maintaining close connectivity and efficient means for communication. This approach supplements current trends in laboratory experimentation, where many experiments are already computer controlled. The Internet now provides the means for overcoming geographical separation and the ability to practice advanced laboratory techniques from remote locations. Using Internet technologies, experiments can be brought into the classroom conveniently and more cheaply to provide enrichment of the traditional educational experience.

Remote control of experiments over the Internet requires careful design and consideration of the complete system with regard to functionality, cost and ease of implementation and use. A great number of general-purpose communication technologies are available, ranging from email, to chat and broadcasting tools, as well as standard protocols for transporting data. Additionally, control of instrumentation requires security measures as machines potentially could inflict harm caused by faulty command transmissions or by instruction sets which are compromised by third parties. Naturally, the first lines of defense are firewalls surrounding the equipment, rendering the equipment invisible from the outside world and thus defeating universal access. Finally, the system solution should create an environment in which multiple users can collaborate in a manner akin to being physically next to the equipment, while teachers and students can reside at disparate locations.

Software systems satisfying all these demands did not exist when we started our research in 1996. We began with designing a new system from the ground up with the vision of using standard protocols for data transport and communication, and off-the-shelf technology whenever possible. We tried to implement an approach in which the barrier to entry would be low for both teachers and students and low in cost to promote widespread acceptance and implementation. During the design phase, we realized a few important lessons, the most significant one being that the physical human-instrument interface was no

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