The Reality of Collaboratories

D. A. Agarwal, S. R. Sachs, and W. E. Johnston [1]

Ernest Orlando Lawrence Berkeley National Laboratory
Berkeley, CA 94720 USA

Advances in data acquisition and dissemination technologies along with several other computer science technologies provide an opportunity to define new environments for remote access to scientific instruments and collaboration between researchers at remote sites. These environments, called "collaboratories"[1], provide complete location-independent collaborative access to instruments, data acquisition and analysis resources, as well as to collaborating researchers.

Over the past two years we have built a prototype collaboratory at the Spectro-Microscopy Facility of the Advanced Light Source (ALS) Beamline 7.0 at Lawrence Berkeley National Laboratory. The scientists who use the beamline are based at different cities around the world. Before the introduction of the collaboratory, an experiment at the beamline required that multiple researchers travel to Berkeley, CA. With the collaboratory, scientists can now discuss experiments with other scientists around the world and at the beamline, "walk" around the beamline using remotely controlled cameras, access data as it is taken, monitor instrument parameters, and do limited control of the experiment from their offices.

This paper presents the design of the prototype Spectro-Microscopy Collaboratory, and the lessons learned in providing remote access to the facility. It also presents the software architecture and components that are being developed to provide a toolkit for bringing future experimental equipment on-line.

Key words: collaboratory; remote access; spectro-microscopy; telepresence; electronic notebooks; experiments on-line

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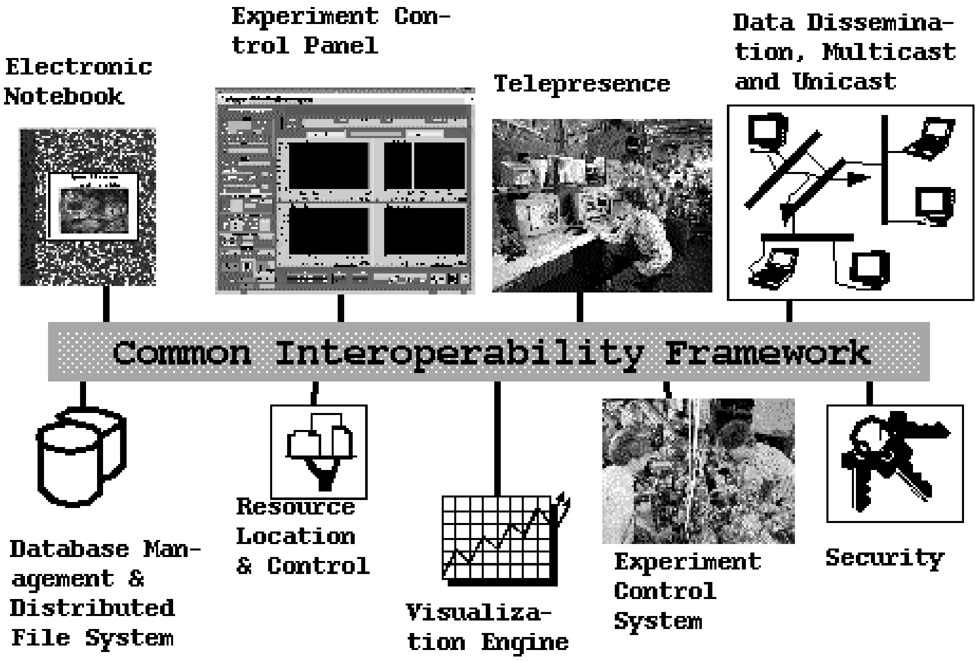

Fig. 1. The components of the collaboratory environment.

1 Discussion

The Distributed, Collaboratory Experiment Environments (DCEE) Program sponsored by the US Department of Energy (DOE) consists of four projects to build prototype remote experiment and collaborative environments. The prototypes are providing remote access to expensive, hard-to-duplicate, DOE scientific facilities, including electron microscopes, high resolution NMR and spectro-microscopy instruments, and a tokamak fusion reactor. Other collaboratory development efforts include: a research database called the Worm Community System [5], and efforts to build remote access to instruments and collaboration capabilities in the electron microscopy community [4] and upper atmospheric research community [2] to name a few. An excellent discussion of collaboratories in general may be found in [3].

There are many software components required to make collaboratories a reality. Figure 1 illustrates these components. The traditional tools utilized by researchers include paper notebooks for recording experiment data, turn-key experiment control systems, and security accomplished through isolation, obscurity, or lock and key. The tools required to make collaboratories a reality include electronic notebooks, on-line instruments, telepresence facilities, security, data dissemination mechanisms, resource location and coordination facilities, a common software infrastructure and distributed file systems.

The work of making collaboratories a reality in scientific environments includes the research and development of the mechanisms and infrastructure that support them. Some of these mechanisms such as experiment monitoring have already been developed. Other mechanisms, such as data dissemination, resource management for the sharing of experiment control, safety and security, electronic notebooks, elements of telepresence, and integrated user interfaces are current topics of research and development.

2 Component Descriptions

The first step in building the collaboratory was to provide remote scientists with a connection to the facility. Traditional videoconferencing tools do not provide enough feedback to a remote researcher who needs the ability to "walk" around the experiment site and interact with people. Telepresence facilities include videoconferencing capabilities, remotely controllable pan/tilt/zoom/focus cameras, wireless audio, and tools for rendezvous and launch of sessions. To avoid the need for researchers at the ALS to "babysit" the videoconferencing session, a conference control tool has been developed to allow remote lauching and control of the videoconferencing sessions.

The experiment control software, which is traditionally a turn-key closed system, has been reconfigured and extended to allow monitoring and control of the experiment over the network. Initially we reconfigured the existing control software to run either remote or local using status update message to maintain synchronization. However, it soon became apparent that the interface developed for local control of the beamline experiments was too complicated and difficult to use for a remote user. In the current system, we have built a simpler remote user interface with limited control functionality. This interface allows access to most of the functions relevant to the control of instruments and to data collection during an experiment.

The Electronic Notebook (EN) allows storage and retrieval of information generated as collaborating physicists run and analyze experiments. The electronic notebook thus provides an interface for organizing, archiving and searching all the information developed during a collaboration. The notebook is based on the integration of an electronic notebook engine with the OPM database management system [http://gizmo.lbl.gov/opm.html] developed at LBNL. The electronic notebook engine has been designed to communicate with the experiment control software and with all other collaboratory components in order to automatically acquire experiment and collaboration information. More information about this project is available at http://www-itg.lbl.gov/Notebook.

The underlying infrastructure of the collaboratory environment is a common framework that supports the interoperability of the various components. This framework provides a single integrated environment that is easily extensible and scalable. Each software component can be built as a plug-in module that interoperates with other modules through a common interface, common security, and common communication mechanisms. New software tools are plugged into the framework and register with the resource manager. Other tools contact the resource manager and request use of resources as needed. The user is presented with a single login to the collaboratory environment and all credentials for the use of the various tools are obtained based on a single login. An element of this framework is data dissemination which provides high performance, efficient, and reliable dissemination of experiment information to collaborators through unicast and multicast based communication mechanisms. Security is achieved through application of a public key infrastructure.

The collaboratory environment is composed of many different software and hardware components. One of the challenges in building collaboratories is to provide a single integrated view of the environment to the users. Additional concerns addressed in the design of the collaboratory software include scalability to large numbers of remote users, maintenance of remote sites, hardware platform and operating system portability, software licensing restrictions and cost of commercial software.

3 Conclusion

A collaboratory prototype at Beamline 7.0 is now largely complete. The remote researchers are able to monitor experiments, use limited remote control, “walk” around the ALS with remote control cameras, and interact with the researchers at the ALS. We are currently adding an electronic notebook and reliable multicast to the environment. There are still many components under development, but the ability to remotely access the experiments is already providing significant benefits to the researchers at the ALS in terms of their ability to interact with remote sites during an experiment.

For further information about the Spectro-Microscopy Collaboratory or the DCEE program see http://www-itg.lbl.gov/ BL7Collab or http://www-itg.lbl.gov/DCEE respectively.

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