6.152J students receive instruction on fabrication processes in EML.

EDUCATIONAL ACTIVITIES

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MIT Device Simulation Weblab: An Online Simulator For Microelectronics Education

A. Solis, J.A. del Alamo
Sponsorship: Microsoft Corporation

In the field of microelectronics, a device simulator is an important engineering tool with enormous educational value. With a simulator, a student can examine the characteristics of a microelectronic device described by a particular model. This ability makes it easier to develop intuition for the general behavior of that device and to

examine the impact of particular device parameters on device characteristics. In this project, we designed and implemented the MIT Device Simulation WebLab (WeblabSim), an online simulator for exploring the behavior of microelectronic devices [1]. WeblabSim makes a device simulator readily available to users on the web anywhere, at any time.

The WeblabSim system uses a three-tier design based on the iLab Shared Architecture (Figure 1). It consists of a client applet that lets users configure simulations, a laboratory server that runs them, and a generic service broker that mediates between the two through SOAP-based web services. We have implemented a graphical Java client applet, based on the client used by the MIT Microelectronics WebLab [2]. Our laboratory server has a distributed, modular design consisting of a data store, several worker servers that run simulations, and a master server that acts as a coordinator. On this system, we have successfully deployed WinSpice, a circuit simulator based on Berkeley Spice3F4.

Our initial experiences with WeblabSim indicate that it is feature-complete, reliable, and efficient. At this point, it is ready for beta deployment in a classroom setting, which we hope to carry out in the Fall of 2005.

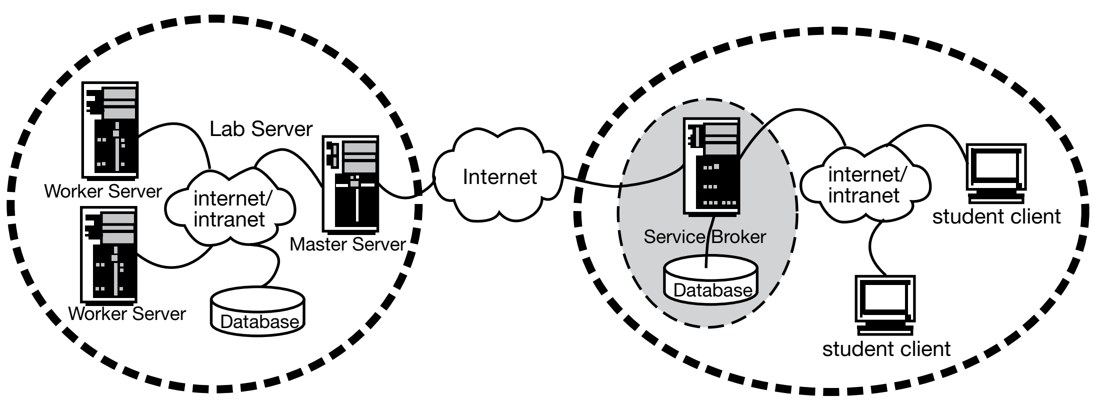

Figure 1: Topology of the MIT Device Simulation WebLab.

REFERENCES:

[1] Solis, A., “MIT Device Simulation WebLab: An Online Simulator for Microelectronic Devices.” MIT EECS MEng Thesis, September 2004.

[2] del Alamo, J. A., V. Chang, J. Hardison, D. Zych, L. Hui, “An Online Microelectronics Device Characterization Laboratory with a Circuit-like User Interface.” International Conference on Engineering Education 2002, Valencia (Spain) 2003.

The Microelectronics WebLab 6.0: An Implementation Using Web Services and the iLab Shared Architecture

J. Hardison, D. Zych, J.A. del Alamo, V.J. Harward, S.R. Lerman, S.M. Wang, K. Yehia, C. Varadharajan
Sponsorship: Microsoft Corporation

A new version of the MIT Microelectronics WebLab, an online semiconductor characterization laboratory, has recently been deployed. While WebLab is primarily of interest in microelectronics education, it also represents a testbed for new pedagogical and technological concepts associated with online laboratories.

WebLab 6.0, our latest release, is constructed around the newly developed iLab Shared Architecture – a three-tier framework designed at MIT to expedite the development and simplify the management of online laboratories [1]. The iLab Shared Architecture introduces a piece of middleware (termed the "Service Broker") between the Client application and the Lab Server. This Service Broker uses Web Services to provide functionality, such as user authentication and data storage, that is generic and common to all labs as well as to facilitate lab-specific communication between a given Client – Lab Server pair. WebLab 6.0 is the first lab deployed using this architecture [2].

The WebLab 6.0 Client is implemented using Java technology. It features a more polished User Interface and has been designed to be more modular and extensible than previous versions. The WebLab 6.0 Lab Server was completely redesigned as a highly modular, data-driven web application that is an improvement both in terms of performance and reliability. Additionally, the basic design of the Lab Server, as well as certain implemented components, can be reused to develop new online labs.

WebLab 6.0 was deployed and successfully tested during the Spring 2004 semester in an undergraduate microelectronics course at MIT involving over 100 students. Since then, several undergraduate and graduate courses, both at MIT and other institutions, have made use of WebLab 6.0 for lab assignments. Additionally, the WebLab 6.0 source has been released as an exemplar as it is the first online laboratory implemented using the iLab Shared Architecture [3]. WebLab 6.0 can be accessed at http://openilabs.mit.edu.

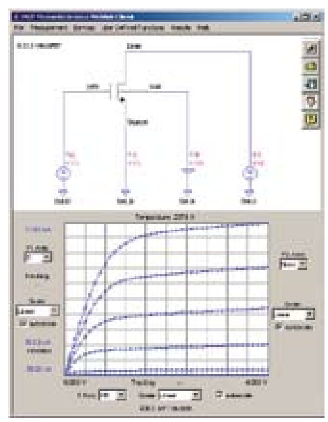

Figure 1: The Microelectronics WebLab 6.0 Client Interface.

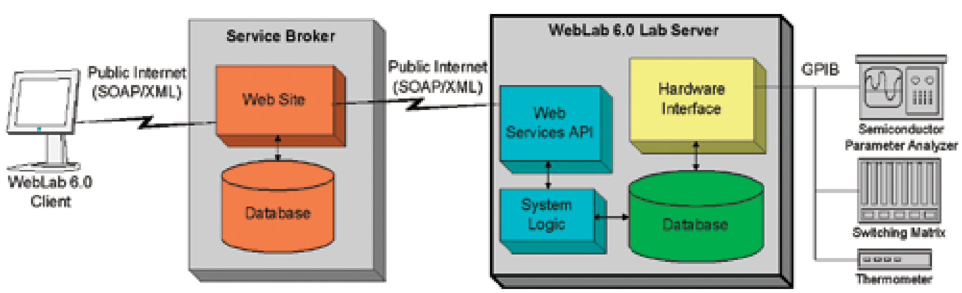

Figure 2: Schematic diagram of the Microelectronics WebLab 6.0 as implemented using the iLab Shared Architecture. The Service Broker performs generic lab functionality.

REFERENCES:

[1] Harward, V.J., J. A. del Alamo, V. S. Choudhary, K. deLong, J. L. Hardison *et al.*, "iLab: A Scalable Architecture for Sharing Online Experiments", ICEE, Gainesville, Florida (USA), 2004

[2] Hardison, J., D. Zych, J. A. del Alamo, V. J. Harward, S. R. Lerman, *et al.*, "The Microelectronics WebLab 6.0 – An Implementation Using Web Services and the iLab Shared Architecture", ICEER, Tainan, Taiwan, 2005

[3] MIT iCampus: iLabs website, http://icampus.mit.edu/ilabs.

Realizing the Potential of Online Laboratories in Developing Countries

J.A. del Alamo
Sponsorship: Carnegie Corporation of New York

We are about to launch an educational outreach program to realize the potential of online laboratories (iLabs) in Sub-Sahara Africa. iLabs constitute a new educational resource that allows students to carry out real experiments through the Internet. iLabs offer the potential of enriching science and engineering education around the world by bringing educationally meaningful laboratory experiences to students wherever an Internet connection is available. This "universality" of iLabs is seriously challenged in locations where access to the global Internet is limited by narrow bandwidths and high connection costs, or where students have restricted access to computers. Such conditions are pervasive in the developing world and are particularly dire in sub-Sahara Africa.

Through our new program, we will create an educational partnership among Makerere University (Kampala, Uganda), University of Dar Es Salaam (Dar es Salaam, Tanzania), Obafemi Awolowo University (Ile-Ife, Nigeria), and MIT to identify a scalable model to exploit the potential of iLabs in Sub-Sahara Africa. Our program will contain three main components: *teaching*, *lab dissemination*, and *student/staff exchanges*. Our *teaching* module aims to insert and utilize MIT's existing iLabs in the curriculum of partner institutions through the direct collaboration of the educators involved. We will share educational content, adapt manuals and tutorial materials, and develop new content and materials in a collaborative manner. Through our *lab dissemination* module, MIT will assist the partner institutions in the development of new iLabs in Africa that are uniquely designed to address local curricular needs and constraints. These iLabs will be constructed using MIT's iLab Shared Architecture (Figure 1) and will be shared among all partners. The *student/staff exchange* component will bring African graduate students and staff to MIT to be part of the group designing and implementing iLab technology and new educational content. It will also send MIT undergraduate students to the three partner universities in Africa to strengthen iLab-related efforts.

For more information, go to:
http://web.mit.edu/newsoffice/2005/africa.html

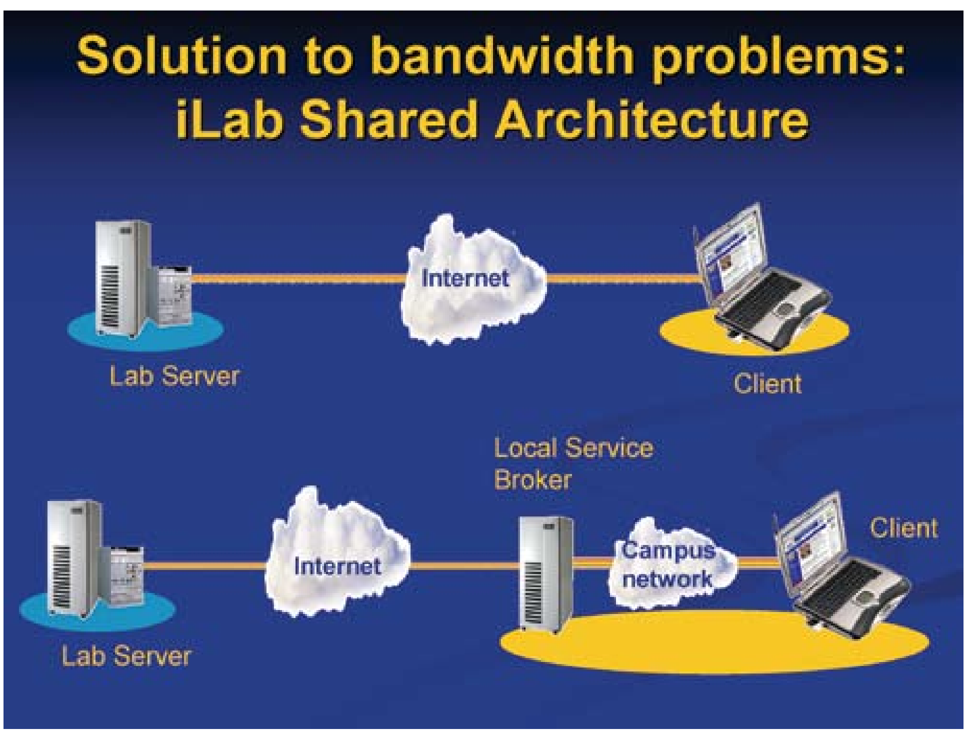

Figure 1: The MIT iLab Shared Architecture for implementing online laboratories helps alleviate the dearth of bandwidth in developing countries by placing a Service Broker in the intranet of the client campus.

A Microfluidics Teaching Laboratory

A.J. Aranyosi, A. Siddiqui, N.I Reyes-Gonzalez, E.J Lim, S. Desai, D.M. Freeman
Sponsorship: VaNTH-ERC, MIT SoE

Microfluidics holds promise for revolutionizing the design of systems for chemical and biological analysis. To introduce students to this important topic, we have developed a teaching laboratory that provides hands-on experience with microfluidic devices. Chambers are built, using soft lithography techniques, and mounted on glass to allow microscopic observation. Figure 1 illustrates a laminar flow chamber in which two fluids mix by diffusion. Students characterize the diffusion constant of a dye by measuring both spatial gradients in brightness across the channel at several locations and the velocity of the fluid along the channel. Measurements were made using custom software (Figure 2) that enabled both qualitative and quantitative analysis of microscope images.

The laboratory has been used successfully in two MIT courses. In 6.021J (Quantitative Physiology: Cells and Tissues), student teams propose and carry out a project to investigate a particular aspect of diffusion, such as determining if the diffusion constant varies with dye concentration. They present their results as a technical paper, which is critiqued by staff, writing experts, and fellow students. This process gives them an introduction to microfluidics, experience with technical writing, a better understanding of the course material, and a keen sense of the challenge of making experimental measurements. In 6.152J (Micro/Nano Processing Technology), students design and fabricate their own laminar flow chambers. They use the laboratory system to characterize these chambers by determining the diffusion constant of a dye. These measurements provide valuable feedback to help students improve their design process. In addition to these courses, the laboratory is scheduled for use in several other courses at MIT and Yale University. By adopting the laboratory, these courses are helping to train a new generation of students to have both conceptual knowledge and practical experience with microfluidics systems.

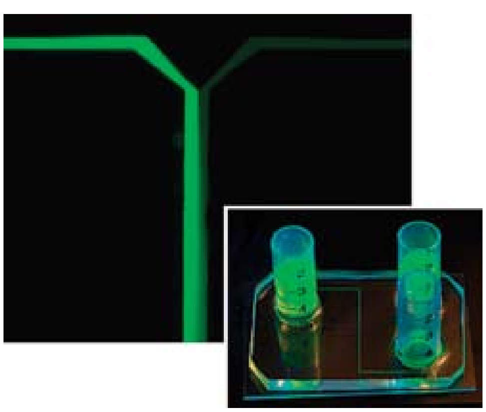

Figure 1: (Lower right) A laminar flow chamber. Fluids flow from the top two reservoirs combine and mix by diffusion as they flow along the center channel. (Upper left) Magnified view showing diffusion where the two fluids meet.

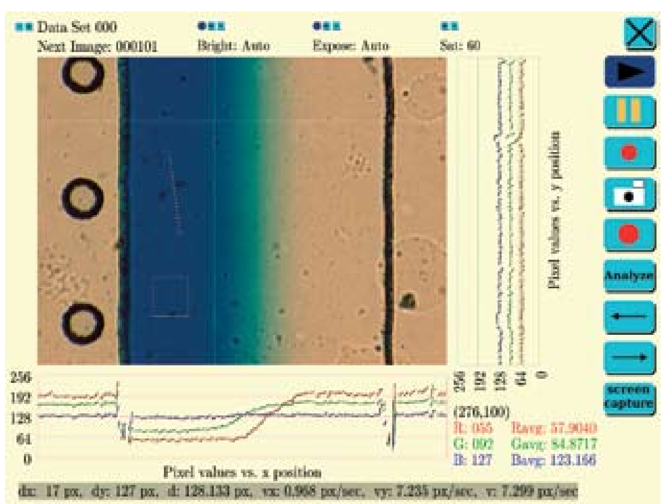

Figure 2: The software interface for the lab. The central image shows the microfluidic channel, with two fluids mixing by diffusion. The plots below and to the right of the image allow quantitative measurements to be made from the images.

Microfabrication Project Laboratory (6.151)

Technical Instructor, L. Wang

This laboratory course is offered in the spring semester for students that have already completed 6.152J. The course is designed to teach experimental microfabrication process design. The students of this subject are given a broad process goal, namely to build a device, and they are challenged to design and develop a process sequence. Typically, the entire class (4-6 students) works on one device, and they partition the integrated process into a set of unit process sequences. Work proceeds first, on the development of the unit processes, and then, on the integrated process. In recent years, the students have succeeded in microfabricating micromachined contactors for integrated circuit testing, flexible electrode arrays for retinal implants, and microcantilevers for AFM applications.

Micro/Nano Processing Technology (3.155J/6.152J)

Technical Instructor, L. Wang

This combination laboratory and lecture course is offered and taught jointly by the Department of Electrical Engineering and Computer Science and the Materials Science and Engineering Department. The course includes weekly lectures on all aspects of micro/nano processing technology with design problems to teach process design. Additionally, the course includes weekly laboratory sessions conducted in the MTL. During these sessions, each student fabricates a wafer of poly-silicon gate MOS devices, silicon nitride nano-mechanical devices, and a plastic microfluidic mixer. All the devices and structures are tested and laboratory reports correlating the test results with theoretical expectations culminates the education experience. The course is offered every semester, and a laboratory-only version of the course is offered 3-4 times/year.