MIT iLabs:
Towards a Community of Internet Accessible Laboratories

Phillip D. Long, Ph.D.
MIT

Mark Schulz, Ph.D.
University of Queensland

Open Educational Resources for Network-enabled education
August 18-19, 2006, Hotel Taj Ambassador, New Delhi
Sponsored by: National Knowledge Commission
Contents

- iCampus - context
- Motivation
- iLabs at MIT
- The iLab Architecture
- Unique issues for iLabs in the developing world
- iLabs at UQ
- Opportunities for partnership
What is iCampus?

- iCampus is an MIT research program to enhance university education through information technology
  - Established in 1999 with funding from Microsoft Research
- 2000 – 2004: Focus on impact at MIT
  - Sponsored projects involving over 400 MIT faculty, staff, and researchers
  - Has affected nearly 100 subjects with a combined enrollment of over 5,000 students per year
- 2004-2006: Focus on global dissemination
Remote access to laboratory equipment (iLabs)
On-line lectures and exercises in computer science (xTutor)
Technology enabled active learning (TEAL)
Web-administered writing examinations (iMOAT)
xMAS - Cross Media Annotation System
Sketch for Understanding
Motivation to iLabs

- There is enormous educational value in hands-on laboratory experiences

- But, conventional labs...
  - ... are expensive and have complex logistics
  - ... can’t easily be shared

- iLabs: real laboratories that are accessed through the Internet from anywhere at any time potentially by large numbers of students
Goals of iLab project at MIT

- To leverage the pedagogical potential of iLabs in science & engineering education

- To develop a scalable framework to:
  - Ease the development of new iLabs
  - Facilitate iLab management
  - Enable worldwide sharing of iLabs
iLabs at MIT

Dynamic signal analyzer (EECS, deployed 2004)

Polymer crystallization (Chem. E., deployed 2003)

Shake table (Civil Eng., deployed 2004)

Microelectronics device characterization (EECS, deployed 1998)

Heat exchanger (Chem. E., deployed 2001)
Microelectronics Device Characterization

Semiconductor Parameter Analyzer, Switching Matrix (donation of Agilent Technologies)

Device under test

Device test fixtures (donation of Agilent Technologies)

W2000 server (software donation of Microsoft)
Lab Capacity

- When do students carry out assignment?
- What is the lab system capacity?

Oct. 13-20, 2000

2PM: 6.012 exercise due
4PM: 6.720J/3.43J exercise due

2PM: 6.012 exercise out
4PM: 6.720J/3.43J exercise out

(75 students)
(25 students)
Lab Capacity

System capacity: > 2,000 users/week, > 15,000 jobs/week

[Oct. 13-20, 2000]

2PM: 6.012 exercise out (75 students)

4PM: 6.720J/3.43J exercise out (25 students)

2PM: 6.012 exercise due 4PM: 6.720J/3.43J exercise due
Typical Assignment: Microelectronic Device Characterization Project

Four step process:

Using iLab GUI:
- Measure DC I-V device characteristics
- Graph results

Download data to student’s computer

Using MATLAB or EXCEL:
- Extract device parameters
- Construct model based on theory presented in class
- Compare with measurements, discuss

Freely explore other modes of operation…
Formal Assessment

◆ Assessment performed in 6.012 in:
  - Spring 2005 (90 students)
  - Fall 2005 (65 students)

◆ Assessment through:
  - Individual student interviews (~20 students)
  - Quantitative surveys (~30-40 students)
What we’ve learned from µE ilab

- iLab experiences can significantly enhance learning

- For iLab educational experiences to be effective:
  - system has to work well, specially under peak load conditions!
  - system must allow free exploration and making many mistakes
  - clear documentation and tutorials are essential

- Several small assignments more effective than few large projects

- Students find difficulty in handling real-world data
  - offline, post-measurement portion of assignment critical to learning experience
Lab Use

over 3600 student users (for credit) since 1998
The MIT iLab Architecture

- Client
- Campus network
- Service Broker
- University Databases
- Internet
- Lab Server
Unique Issues for iLabs in developing countries

- **Opportunities:**
  - Paucity of labs
  - Lots of young enthusiastic people
  - Great need for engineers

- **Challenges:**
  - Limited access to networked computers
  - Limited computer literacy
  - Severe bandwidth limitations
Bandwidth limitations
(example: Makerere University, Kampala)

- Campus wide single-mode optical fiber (2 Gb/s)
- Satellite gateway to Internet (total bandwidth of Uganda=25 Mb/s)
- Metropolitan network (total campus bandwidth=2.5 Mb/s)
- Academic buildings networked at 10/100 Mb/s

Figures for Spring 2004
Consequences for iLabs (and other rich educational resources)

- Need to deploy educational resources locally
- Solutions engineered in the developed world not necessarily effective in developing countries
- Pedagogy likely to be different in bandwidth starved situations
- Ultimate goal: “native” iLabs. How do we support this?
An example: iLab-Africa project

**Goals:**

- To deploy MIT's iLabs throughout curriculum in Africa
- To support new iLab development in Africa
- To create opportunities for internships for MIT and African students
- To create a scalable iLab research network in Africa
iLabs in Africa: challenges and solutions

- client GUI’s are “fat”
- require complex plug-ins
- demanding on local resources
Partial Solution: “thin” clients

v. 6.1 graphical applet
- 169 kbytes
- <download time> from OAU=79”

v. 6.1 classic applet
- 94 kbytes
- <download time> from OAU=63”
iLabs in Africa: challenges

client served from half a world away at MIT
Solution: local Service Broker
Installed SBs at OAU, MUK and UDSM

<download time> at OAU: 22” (graphical), 17” (classic)
iLabs in Africa: challenges

- Professional lab hardware prohibitively expensive

Diagram:
- Client
- Campus network
- Service Broker
- University Databases
- Internet
- Lab Server
Solution: inexpensive hardware

- Agilent 4155
  - ~$50K

- NI Elvis
  - ~$2K

- iLab Mini
  - ~$40
iLabs in Australia
Consequences for iLabs (and other rich educational resources)

• Need to deploy educational resources locally
• Solutions engineered in the developed world not necessarily effective in developing countries
• Pedagogy likely to be different in bandwidth starved situations
• Ultimate goal: “native” iLabs. How do we support this?
iLab: the Opportunities

- Order of magnitude more laboratories available to our students

- Unique labs:
  - Unusual locations, expensive equipment, rare materials

- Rich pedagogical experiences:
  - More lab time to students
  - GUI to lab integrating graphing, simulation, collaboration, tutoring

- Worldwide communities of scholars created around labs sharing content
iLab: the Challenges

◆ Developing an iLab from scratch is a lot of work!
   ➢ Great attention needed to user scalability
   ➢ Needs to be done by domain specialist

◆ Managing a broadly shared iLab is also a lot of work!
  ➢ Disincentive for owner to share lab

◆ Key challenge: iLab Scalability
Conclusions

- iLabs can enhance science and engineering education in India as well as the rest of the world
- iLabs and their educational content can be broadly shared within India and around the world
- iLabs provide a path for the developed world to support education in the developing world
- iLabs Architecture is a scalable framework to support iLab dissemination around the world
“If You Can’t Come to the Lab… the Lab Will Come to You!”

(Earth at 89 GHz; courtesy of J. Grahn, Chalmers U.)

longpd@mit.edu