MIT iLabs: Laboratories Without Frontiers

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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





Dynamic signal analyzer (EECS, deployed 2004)



Microelectronics device characterization (EECS, deployed 1998)

iLabs at MIT





ELVIS (EECS, deployed 2006)

Polymer crystallization (Chem. E., deployed 2003)



Shake table (Civil Eng., deployed 2004)



Heat exchanger (Chem. E., deployed 2001)

Microelectronics Device Characterization iLab



👙 View Data

👙 SMU1 Configuration

X

Typical Assignment

Transistor characterization project:

- Measure transistor characteristics
- Extract transistor parameters
- Compare measurements with class models



Also, do whatever else you want with the transistor...

iLab Capacity



iLab Capacity



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



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 available 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

The MIT iLab Architecture



Three tier architecture:

- Lab Server: brings experimental setup online
- Client: GUI to lab
- Service Broker:
 - Serves GUI, mediates between Client and Lab Server
 - Performs generic functions (user management, data storage)

The MIT iLab Architecture



Development responsibilities:

- * Lab Server, Client:
 - Educator heavily involved in development
 - Registered with Service Brokers around World
- Service Broker:
 - Developed by MIT, open source
 - > Has well defined software interfaces

The MIT iLab Architecture



Management responsibilities:

- Lab management (i.e. lab policy):
 - performed by lab provider
- Service Broker:
 - > User registration, authentication
 - User data storage and archiving
 - Responsibility of user's institution

Unique Issues for iLabs in developing countries

Opportunities:

- Paucity of labs
- Great need for engineers

Challenges:

- Limited access to networked computers and educational software tools
- Limited appreciation of versatility of computer
- Severe bandwidth limitations

Bandwidth limitations

(example: Makerere University, Kampala)





satellite gateway to Internet



academic buildings networked at 10/100 Mb/s

For comparison, MIT's bandwidth is 8 Gb/s (all data for Nov. 2006)

World Submarine Optical Fiber Systems



- Limited reach of optical fiber systems
- Limited national networks
- Similar problems in other regions in the World

Consequences for iLabs (and other rich educational resources)

- Need to deploy educational resources locally
- Solutions engineered in the developed world not necessarily effective across digital divide
 - → need to engage developing countries in educational technology innovation
- Pedagogy likely to be different in bandwidth starved situations
 - \rightarrow need to be ready to experiment and modify



Average Applet download time at OAU reduced from 79" to 22"



iLab development in Africa



Kayode Ayodele (OAU, Nigeria)



OAU Opamp iLab



Sustainability-The iLab Consortium

Need for an iLab Consortium:

- to create an efficient market place for sharing and trading access to iLabs
- to support communities of scholars created around iLabs
- to lead evolution of iLab Architecture



Foundation, Non-Profit & Government

Conclusions



- iLabs will enhance science and engineering education
- iLabs and their educational content will be broadly shared around the world
- iLabs can provide a path for the developed world to support education in the developing world
- iLab Architecture: 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.)