iLabs:
Performing Laboratory Experiments Across Continents

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Statement of the Problem

- There is enormous educational value in hands-on laboratory experiences, but…

- … conventional laboratories are expensive and have complex logistics:
  - Scheduling, equipment cost, lab space, lab staffing, training, safety

- … conventional labs don’t scale well and can’t easily be shared
  - All institutions must own all labs
Solution: Online Laboratories

- **Online laboratory** ("iLab" or "WebLab"): a real laboratory that is accessed through the Internet from anywhere at any time
  - Not a "virtual laboratory" (simulations)
  - Not a "canned experiment" (a "one-click" lab)

- Online laboratories can deliver many of the educational benefits of hands-on experimentation
iLabs at MIT

Flagpole (Civil Eng., deployed 2000, inactive)

Microelectronics device characterization (EECS, deployed 1998)

Polymer crystallization (Chem. E., deployed 2003)

Heat exchanger (Chem. E., deployed 2001)

Shake table (Civil Eng., to be deployed early 2004)
MIT graduate and undergraduate courses since Fall 1998
NUS (Singapore, 11 time zones), Fall 2000-03 (20-30 st/yr)
Chalmers U. (Sweden, 6 time zones), Spring 2003-04 (250 st/yr)
Over 1900 student users since 1998 (for credit)
Uniqueness of iLabs

- Pedagogy
  - iLabs create laboratory experiences in subjects that didn’t have them before.
  - iLabs enable laboratory experiments at most opportune moment in curriculum.
  - iLabs allow students to perform experiments in pleasant environments at times of their choice
  - iLabs minimize frustrations with hardware
  - iLabs allow students to work in a “stop-and-go” mode
Uniqueness of iLabs

- **Logistics**
  - iLabs can be located in places inaccessible to students
  - iLabs hold unique scaling characteristics:
    - round the clock usage
    - from anywhere in the world

- **Economics**
  - iLabs can be broadly shared $\rightarrow$ fundamental change in economics of the lab experience
Revolutionary consequences

- Order-of-magnitude more laboratory experiences available to students
- Can afford sophisticated labs involving:
  - advanced instrumentation
  - rare materials
  - unreachable locations
- iLabs embedded inside rich educational platforms containing:
  - visualization tools, simulations, data processing
  - remote collaboration and tutoring.
iLabs will spawn communities of learners to share:

- hardware
- and educational content

Institutions in the *developed* world can support educational needs of the *developing* world.
Feasibility study for iLabs in sub-Saharan Africa

Carnegie Corporation of New York

Goals:

- To assess the potential of iLabs to enrich university education in developing countries.
- To identify the barriers that prevent the realization of the potential of iLabs in developing countries.

Obafemi Awolowo University
MIT’s iLabs involved:

- Microelectronics WebLab (EE)
- Heat exchanger (Chem E)

Process:

- Establish linkages
- Study ICT infrastructure
- Connect with faculty
- Carry out experiments

At University of Dar es Salaam (Feb. ’04)

At Makerere University, Kampala (Feb. ’04)
Preliminary findings

- Good match in curriculum and paucity of labs, but...
- Limited access to networked computers
  - Limited hours in institutional computer clusters
  - Negligible student ownership of PC’s
  - No networked computers in student residences
- Limited computer literacy on part of students:
  - Computer not seen as versatile engineering tool
  - Computer phobia on the part of many engineering students
- 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, $28,000/mo)
- academic buildings networked at 10/100 Mb/s (but not student residences)
No optical fiber links to East Africa:

- each country is an island in the global Internet
- cannot have *regional* center to disseminate educational resources
No optical fiber links across country:

- each city is an island in the global Internet
- cannot have *national* center to disseminate educational resources
### Bandwidth: MUK vs. MIT

<table>
<thead>
<tr>
<th></th>
<th>MUK</th>
<th>MIT</th>
<th>MUK/MIT ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>campus gateway (Mb/s)</td>
<td>2.5</td>
<td>~2,300</td>
<td>~10^{-3}</td>
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<tr>
<td>gateway cost ($ per month)</td>
<td>$28K</td>
<td>~$80K</td>
<td>~1/3</td>
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<tr>
<td>GDP per capita</td>
<td>$1.2K</td>
<td>$36K</td>
<td>~0.03</td>
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**bandwidth cost relative to per capita GDP** ~10^4

- Technological solutions developed at MIT might not be a good match for developing countries
- Pedagogy likely to be different in bandwidth starved situations
- Need to deploy educational resources *locally*
iLab Shared Architecture*

*purposed under iCampus at MIT
Conclusions

- iLabs will enhance science and engineering education
- iLabs and their educational content will be broadly shared around the world
- iLabs provide a path for the developed world to support the educational objectives of the developing world
- Unique challenges to iLab technology and pedagogy in developing world
- iLabs Shared Architecture: scalable framework for iLabs, well suited to needs of developing world
“If You Can’t Come to the Lab… the Lab Will Come to You!”