iLabs:

Performing Laboratory Experiments Across Continents

MIT

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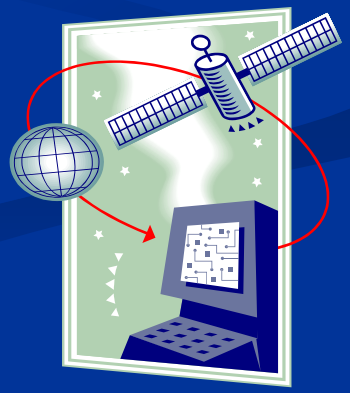
Statement of the Problem

- 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

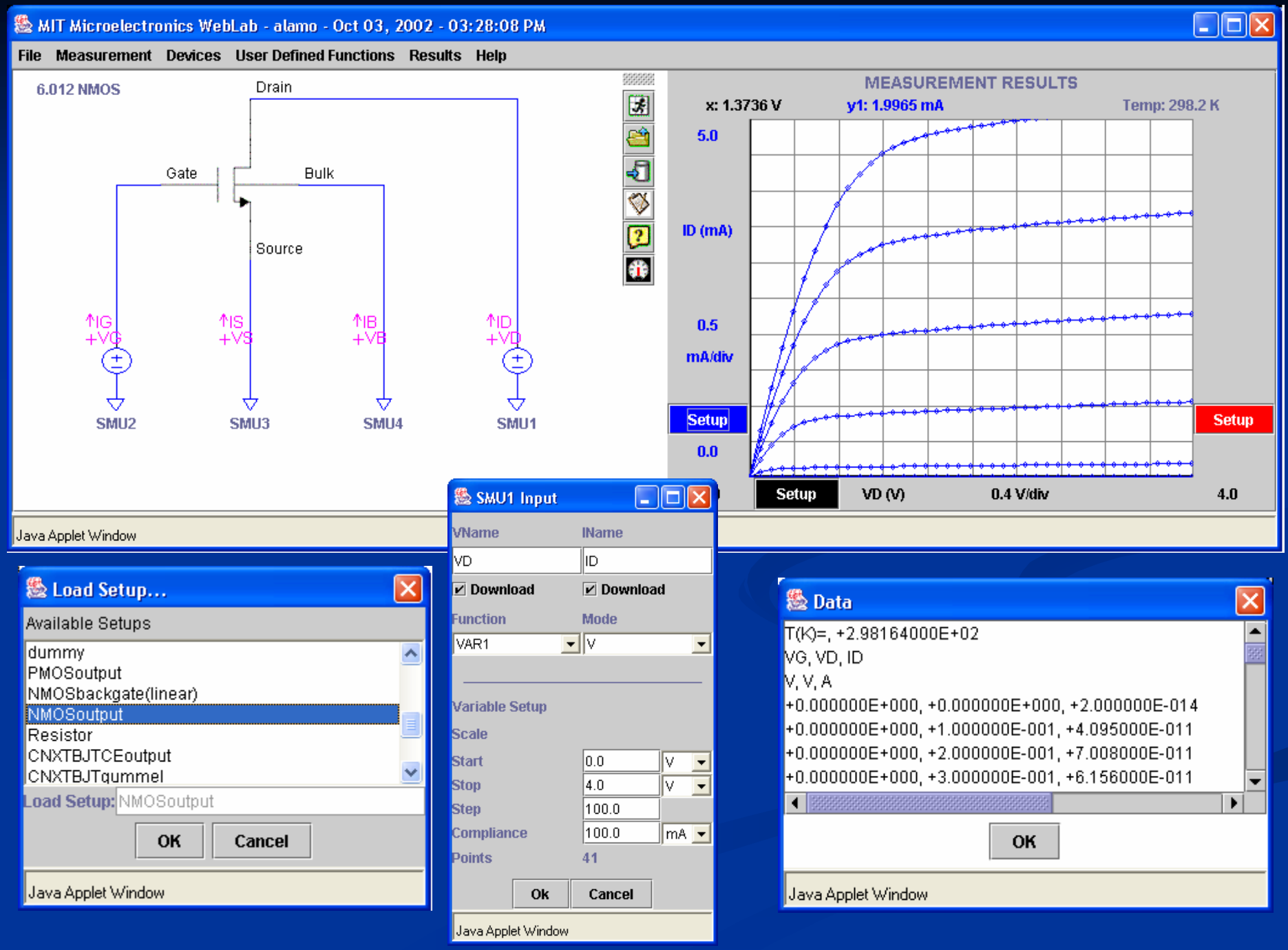
Flagpole *(Civil Eng., deployed 2000, inactive)*

Polymer crystallization *(Chem. E., deployed 2003)*

Shake table *(Civil Eng., to be deployed early 2004)*

Microelectronics device characterization *(EECS, deployed 1998)*

Heat exchanger *(Chem. E., deployed 2001)*


MIT Microelectronics WebLab - alamo - Oct 03, 2002 - 03:28:08 PM
File Measurement Devices User Defined Functions Results Help
6.012 NMOS
Drain
Gate
Bulk
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↑IG +VG
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↑IB +VB
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SMU2
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MEASUREMENT RESULTS
x: 1.3736 V
y1: 1.9965 mA
Temp: 298.2 K
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ID (mA)
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Java Applet Window
Load Setup...
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dummy
PMOSoutput
NMOSbackgate(linear)
NMOSoutput
Resistor
CNXTBJTCEoutput
CNXTBJTgummel
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Java Applet Window

Educational Experiments

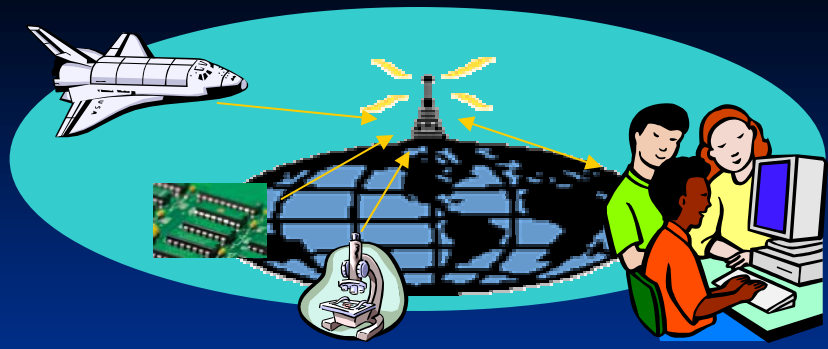
MIT graduate and undergraduate courses since Fall 1998

NUS (Singapore, 11 time zones), Fall 2000-03 (20-30 st/yr)

Chalmers U. (Sweden, 6 time zones), Spring 2003-04 (250 st/yr)

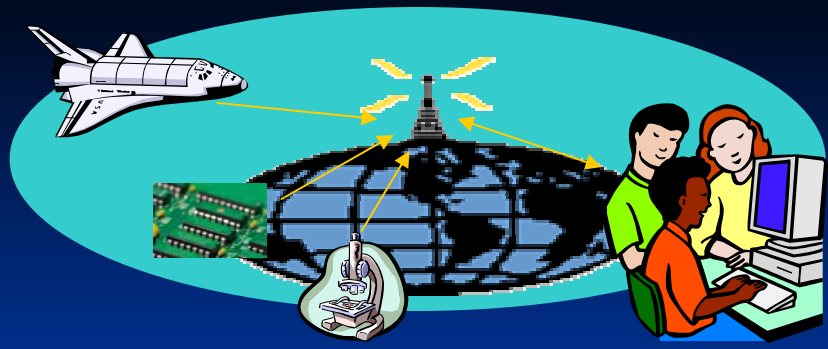
Over 1900 student users since 1998 (for credit)

Uniqueness of iLabs



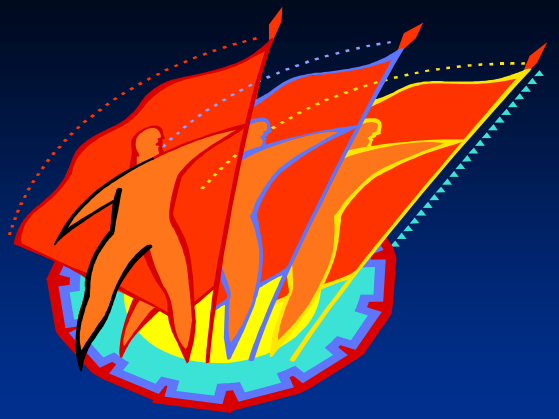
- Pedagogy
  - iLabs create laboratory experiences in subjects that didn't have them before.
  - iLabs enable laboratory experiments at most opportune moment in curriculum.
  - iLabs allow students to perform experiments in pleasant environments at times of their choice
  - iLabs minimize frustrations 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 → 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.

Revolutionary consequences

- 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-Sahara Africa

Carnegie Corporation of New York

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

University of Dar es Salaam

MAKERERE UNIVERSITY

Obafemi Awolowo University

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.

- 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)

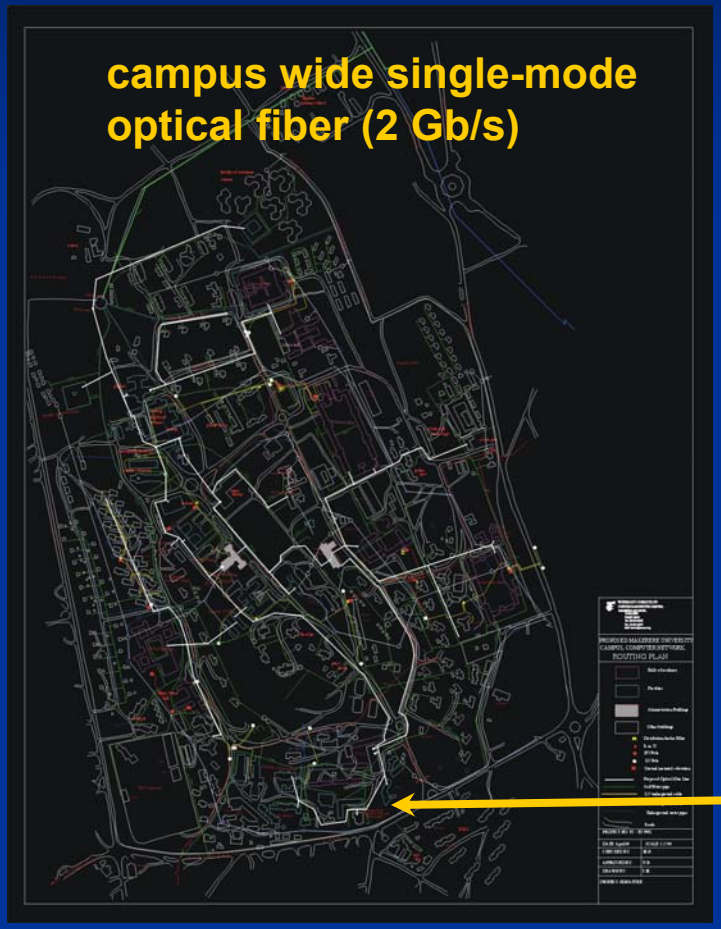
At Makerere University, Kampala (Feb. '04)

Preliminary findings

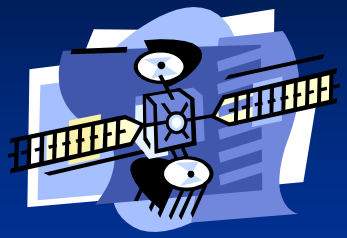
- Good match in curriculum and paucity of labs, but…
- Limited access to networked computers
  - Limited hours in institutional computer clusters
  - Negligible student ownership of PC's
  - No networked computers in student residences
- Limited computer literacy on part of students:
  - computer not seen as versatile engineering tool
  - *computer phobia* on the part of many engineering students
- Severe bandwidth limitations

Bandwidth limitations

(example: Makerere University, Kampala)

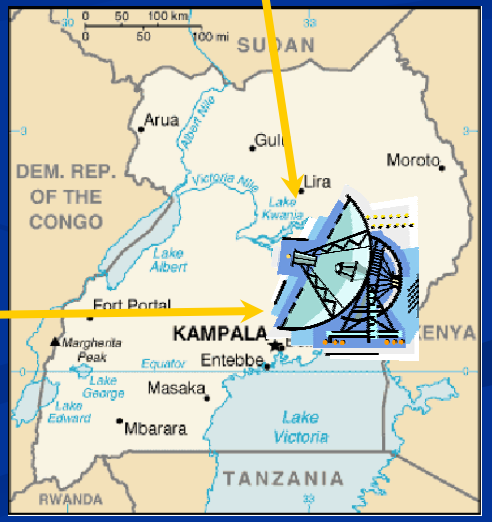


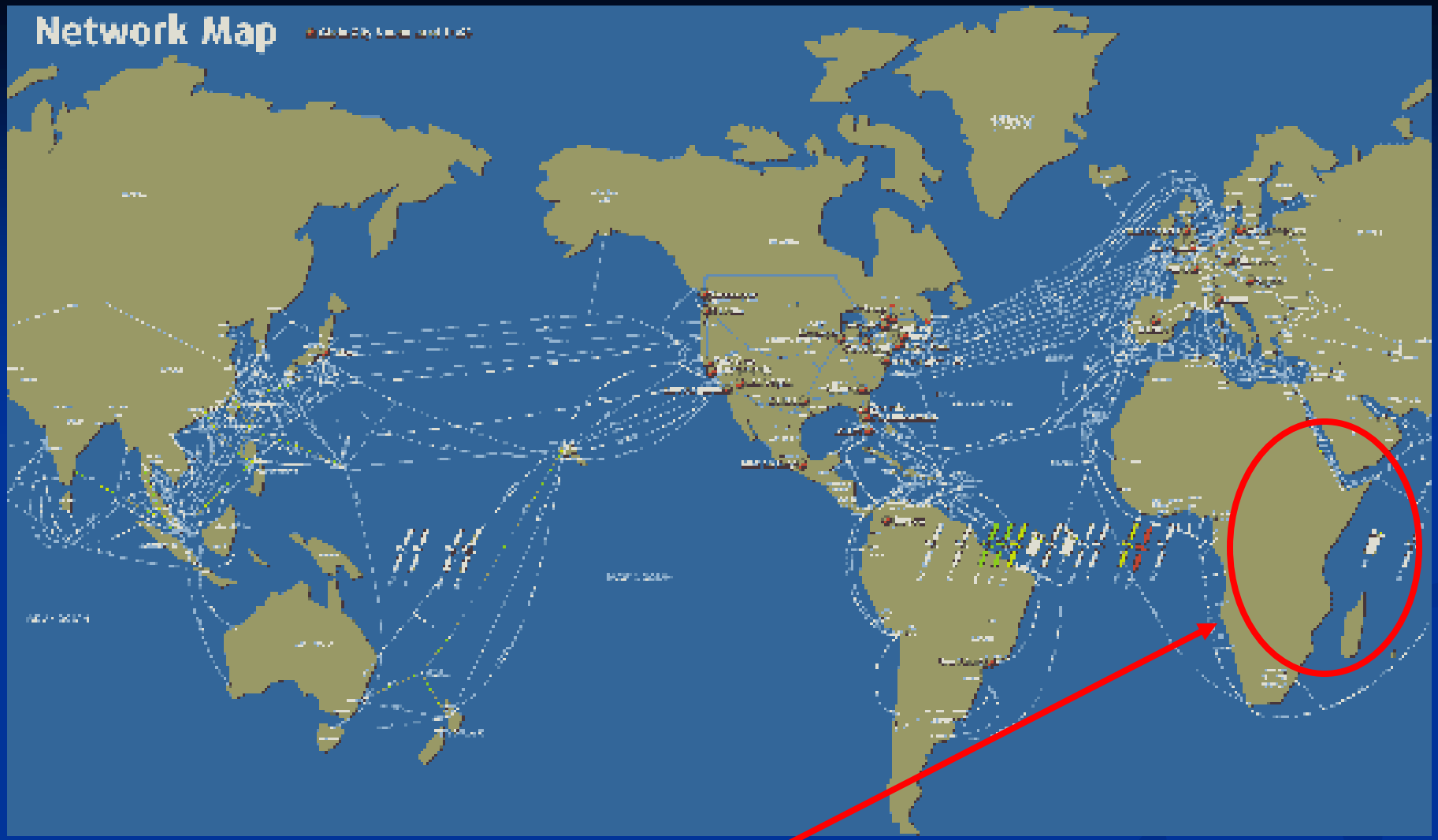
academic buildings networked at 10/100 Mb/s (but not student residences)



satellite gateway to Internet (total bandwidth of Uganda=25 Mb/s)

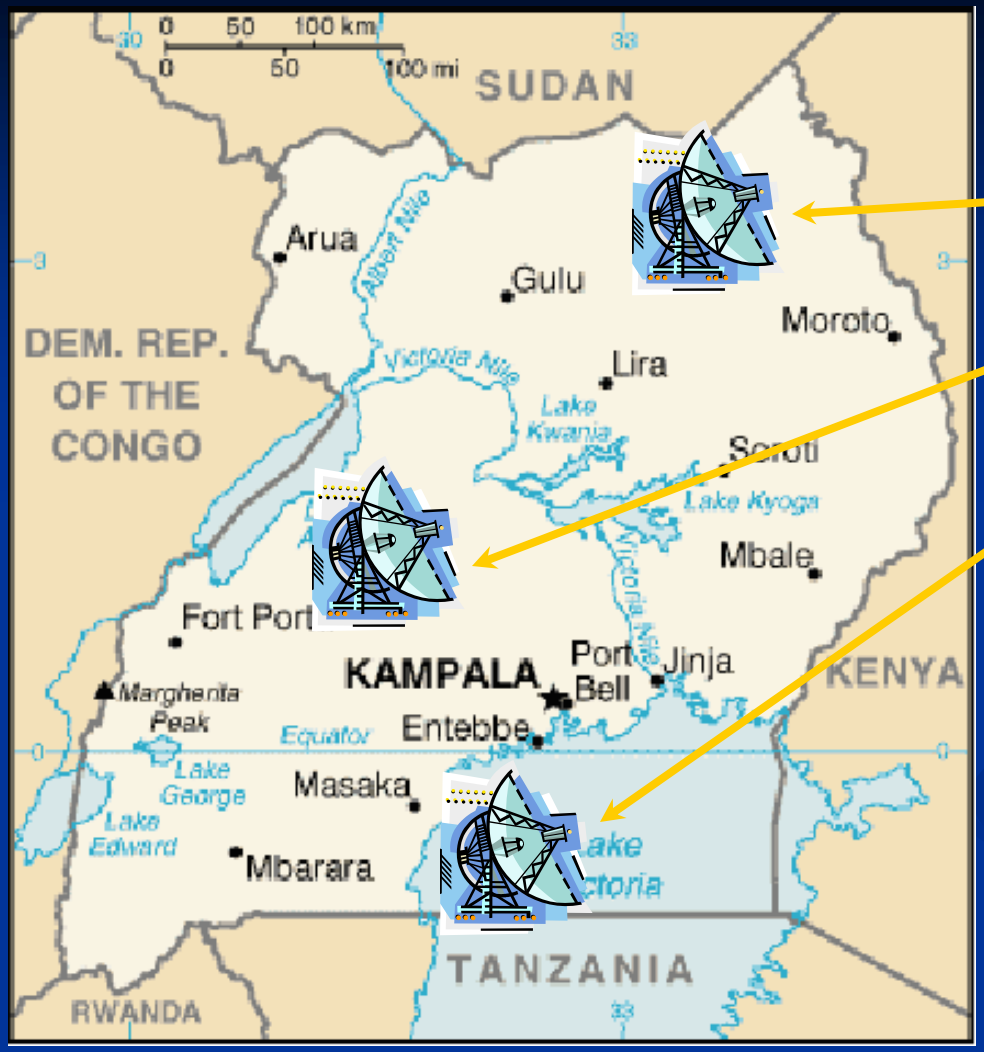
metropolitan network (total campus bandwidth=2.5 Mb/s, $28,000/mo)

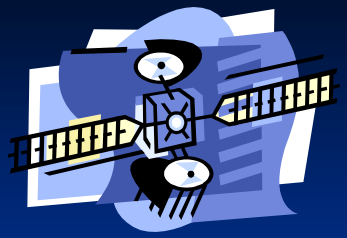




No optical fiber links to East Africa:

- each country is an island in the global Internet
- cannot have *regional* center to disseminate educational resources





No optical fiber links across country:

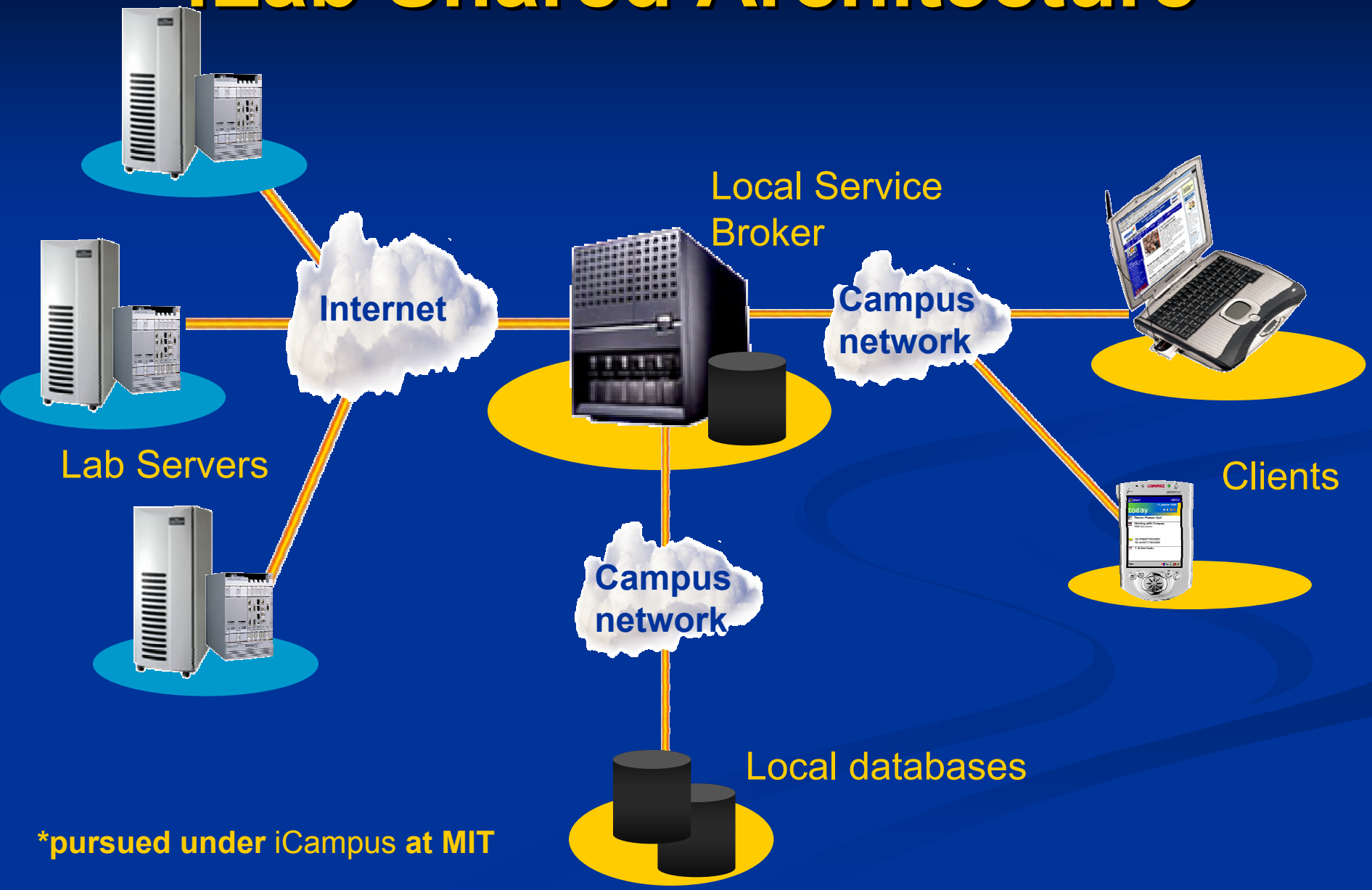
- each city is an island in the global Internet
- cannot have *national* center to disseminate educational resources

Bandwidth: MUK vs. MIT

	MUK	MIT	MUK/MIT ratio
campus gateway (Mb/s)	2.5	~2,300	$\sim 10^{-3}$
gateway cost ($ per month)	$28K	~$80K	~1/3
GDP per capita	$1.2K	$36K	~0.03
bandwidth cost relative to per capita GDP			**$\sim 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*



*pursued 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!”

MIT