iLabs:

Performing Laboratory Experiments Across Continents

MIT

Jesús del Alamo and Steven R. Lerman
MIT

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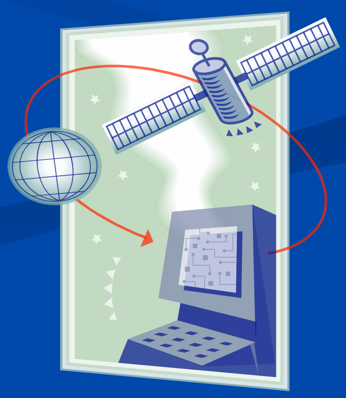
Statement of the Problem

- 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

Online Laboratories

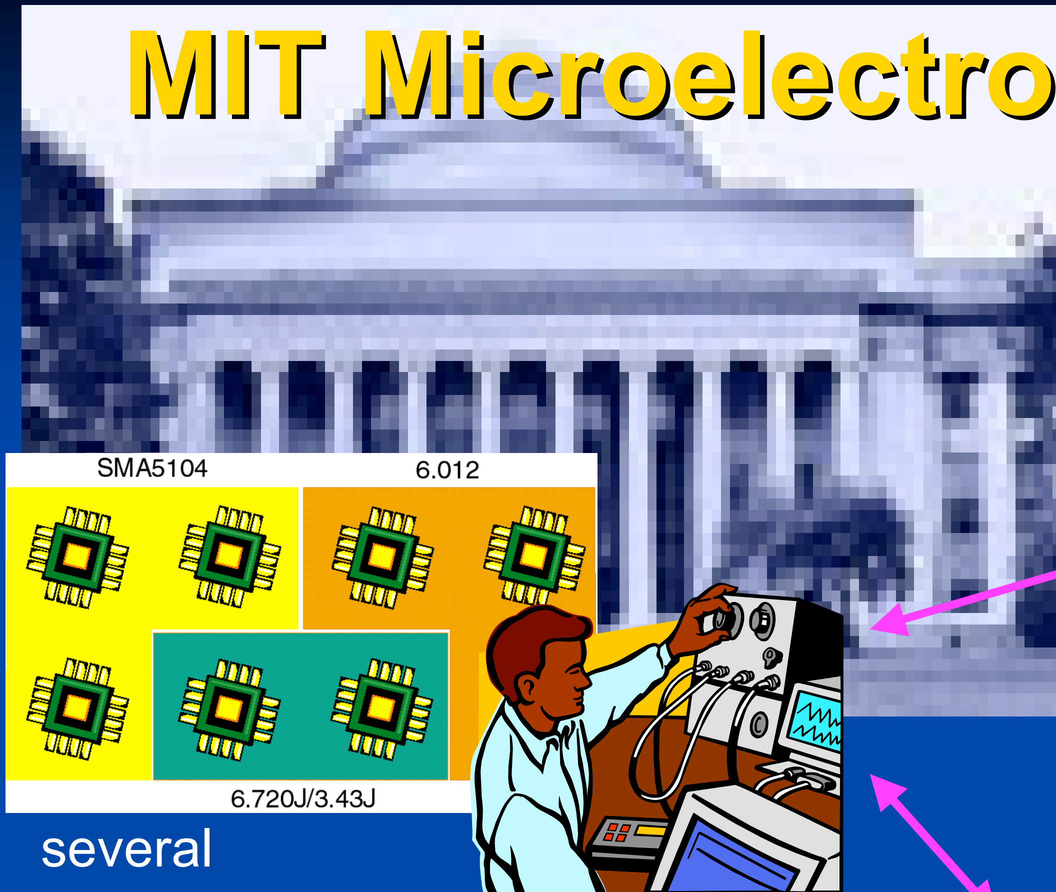
- ***Online laboratory* *("iLab" or "WebLab")*:** a real laboratory that is accessed through the Internet from anywhere at any time
  - Not a "virtual laboratory" (simulations)
  - Not a "canned experiment" (a "one-click" lab)

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



MIT Microelectronics WebLab

(since 1998)



several transistors available

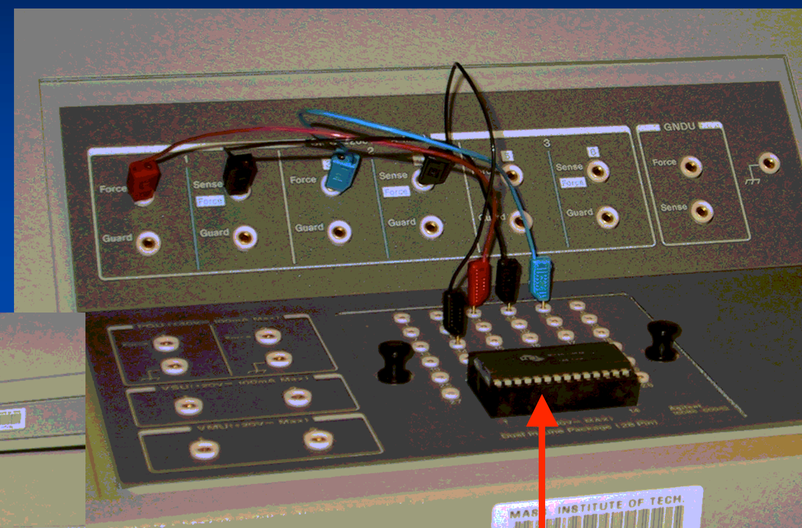
current-voltage characteristics of transistors

accessible through conventional web browser

queuing system allows multiple users simultaneously

MIT Microelectronics WebLab

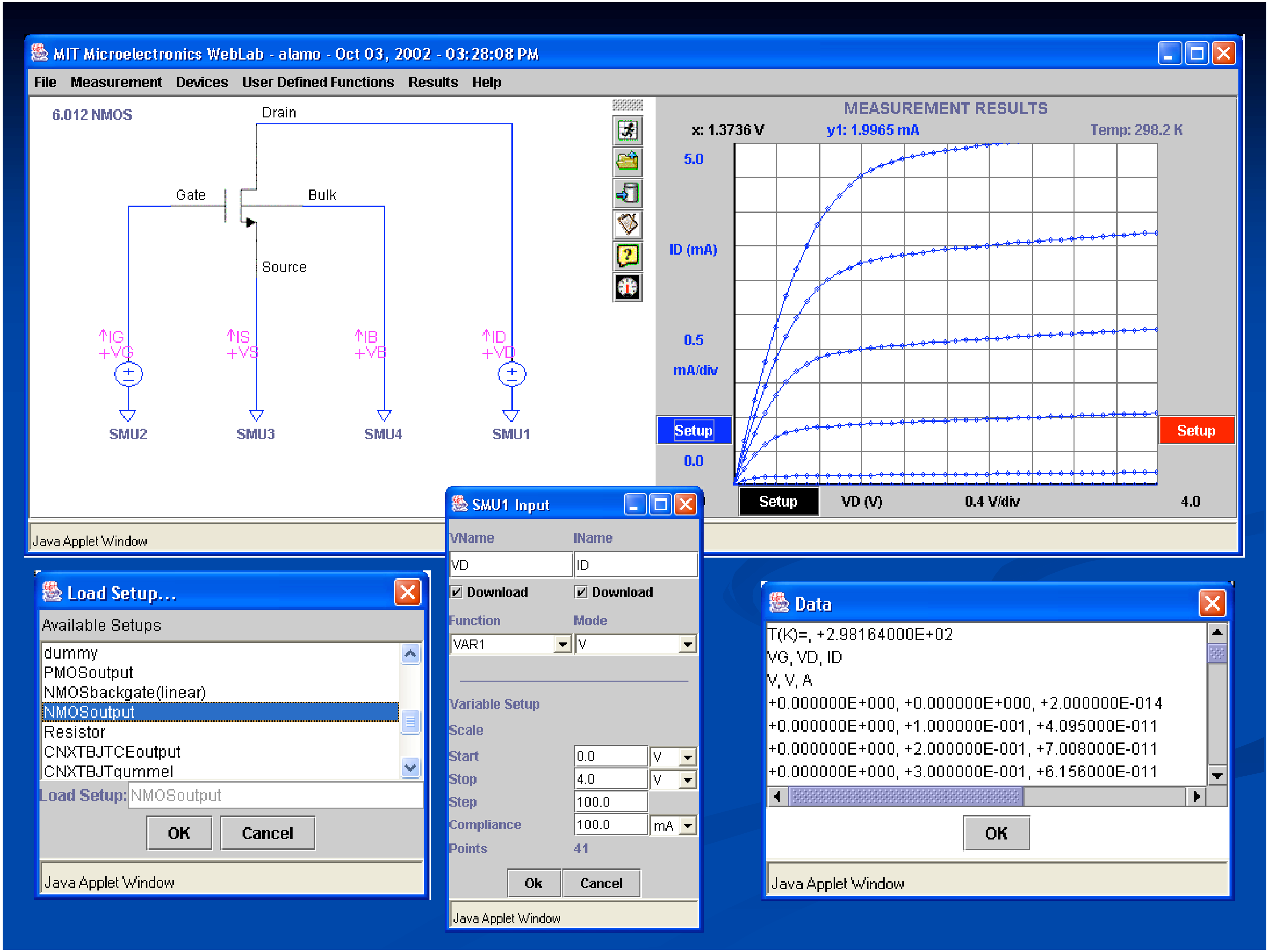
Semiconductor Parameter Analyzer, Switching Matrix (donation of Agilent Technologies)



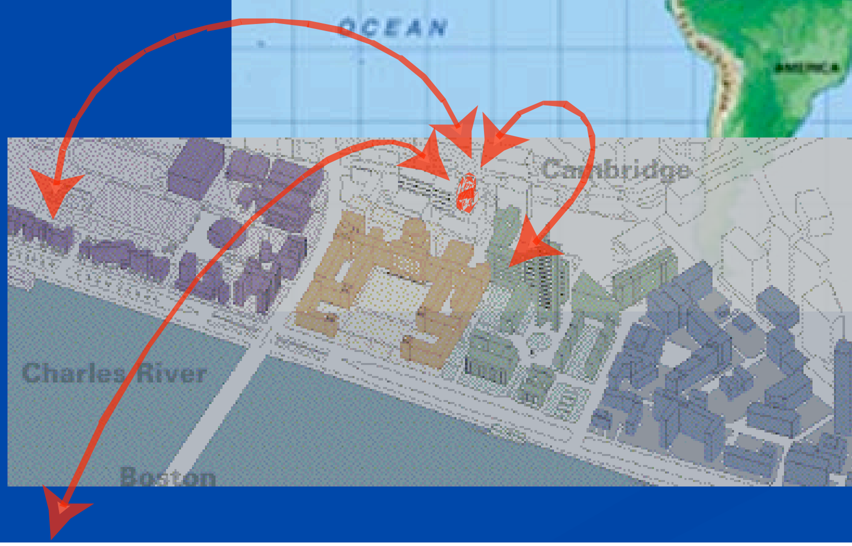
Device under test

Device test fixtures (donation of Agilent Technologies)

W2000 server


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
Source
IG +VG
IS +VS
IB +VB
ID +VD
SMU2
SMU3
SMU4
SMU1
MEASUREMENT RESULTS
x: 1.3736 V
y1: 1.9965 mA
Temp: 298.2 K
5.0
ID (mA)
0.5
mA/div
Setup
0.0
Setup
Setup
VD (V)
0.4 V/div
4.0
Java Applet Window
SMU1 Input
VName
IName
VD
ID
Download
Download
Function
Mode
VAR1
V
Variable Setup
Scale
Start
0.0
V
Stop
4.0
V
Step
100.0
Compliance
100.0
mA
Points
41
Ok
Cancel
Java Applet Window
Load Setup...
Available Setups
dummy
PMOSoutput
NMOSbackgate(linear)
NMOSoutput
Resistor
CNXTBJTCEoutput
CNXTBJTgummel
Load Setup: NMOSoutput
OK
Cancel
Java Applet Window
Data
T(K)=, +2.98164000E+02
VG, VD, ID
V, V, A
+0.000000E+000, +0.000000E+000, +2.000000E-014
+0.000000E+000, +1.000000E-001, +4.095000E-011
+0.000000E+000, +2.000000E-001, +7.008000E-011
+0.000000E+000, +3.000000E-001, +6.156000E-011
OK
Java Applet Window

Educational Experiments

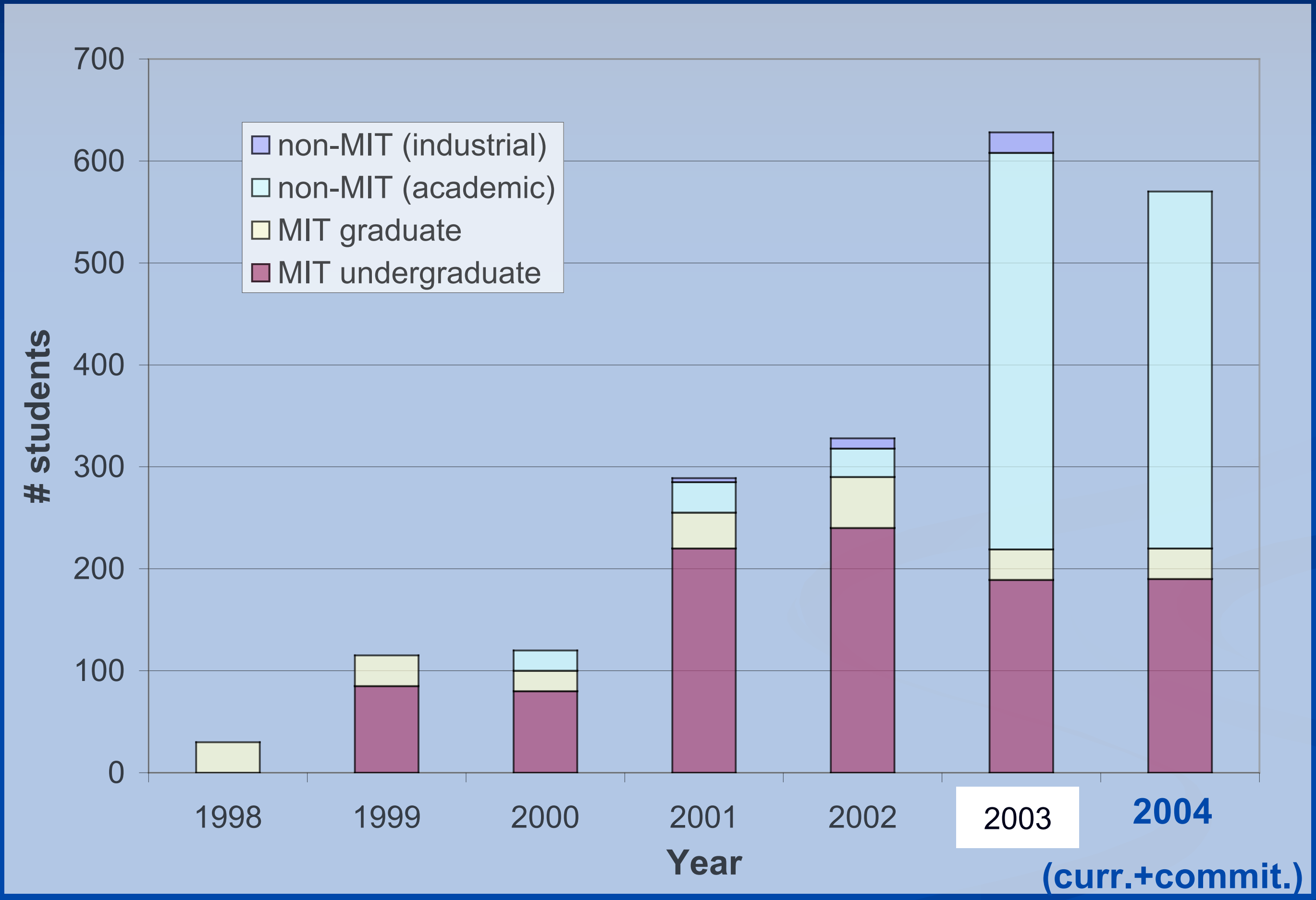


MIT graduate and undergraduate courses since Fall 1998

NUS (Singapore, 11 time zones), Fall 2000-2003 (20-30 st/yr)

Chalmers U. (Sweden, 6 time zones), Spring 2003, 2004 (250 st/yr)

Educational Use of WebLab



- Over 1900 student users since 1998 (for credit)

iLabs at MIT

Department of Chemical Engineering

- Heat exchanger *(deployed 2001)*
- Polymer crystallization *(deployed 2003)*

Department of Civil and Environmental Engineering

- Flagpole *(deployed 2000, inactive)*
- Shake table *(to be deployed early 2004)*

Department of Electrical Engineering and Computer Science

- Microelectronics device characterization *(deployed 1998)*

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

- Project funded by Carnegie Corporation
- 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.
- Partners:
  - Makerere University (Kampala, Uganda)
  - Obafemi Awolowo University (Ile-ife, Nigeria)
  - University of Dar es Salaam (Tanzania)

- MIT's iLabs involved:
  - Microelectronics WebLab (electrical engineering)
  - Heat exchanger (chemical engineering)
- Process:
  - Establish linkages
  - Study ICT infrastructure
  - Connect with faculty
  - Carry out experiments

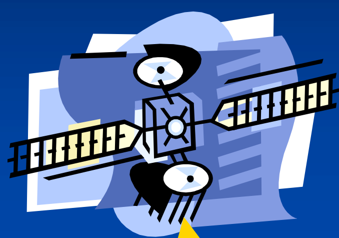
At Makerere University, Kampala (Feb. '04)

Preliminary findings

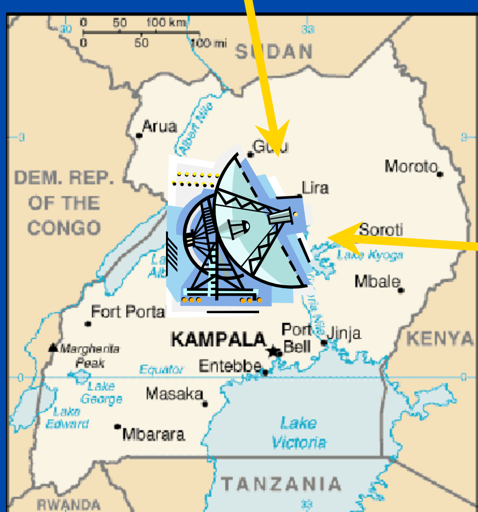
- Good match in curriculum and paucity of labs, but…
- Limited access to networked computers
  - Limited hours in institutional computer clusters
  - Negligible student ownership of PC's
  - No networked computers in student residences
- Limited computer literacy on part of students:
  - computer not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

Bandwidth limitations

(example: Makerere University, Kampala)

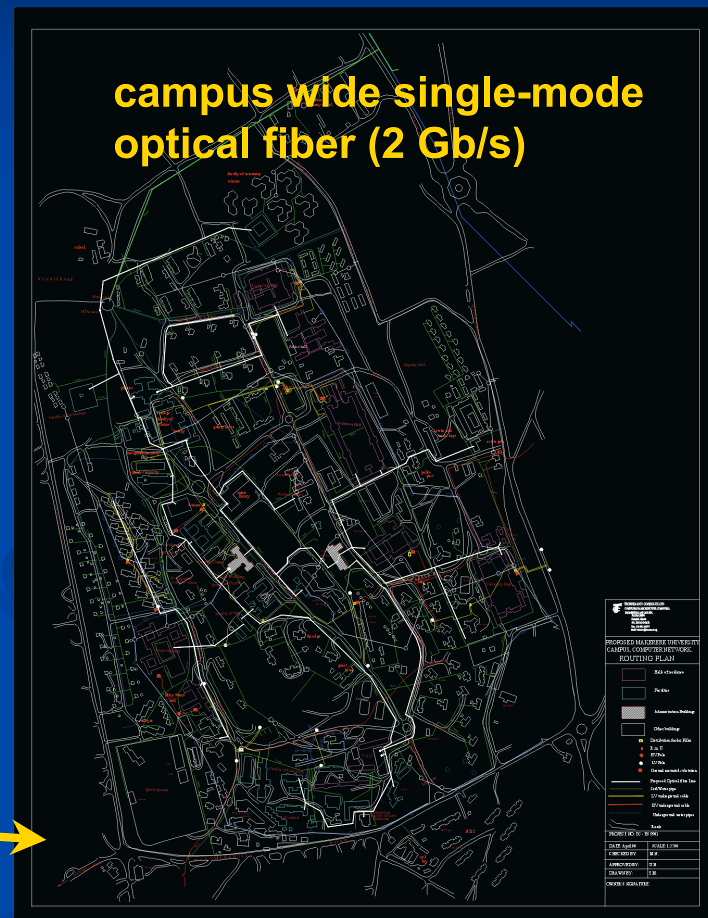


satellite gateway to Internet (total bandwidth of Uganda=25 Mb/s)

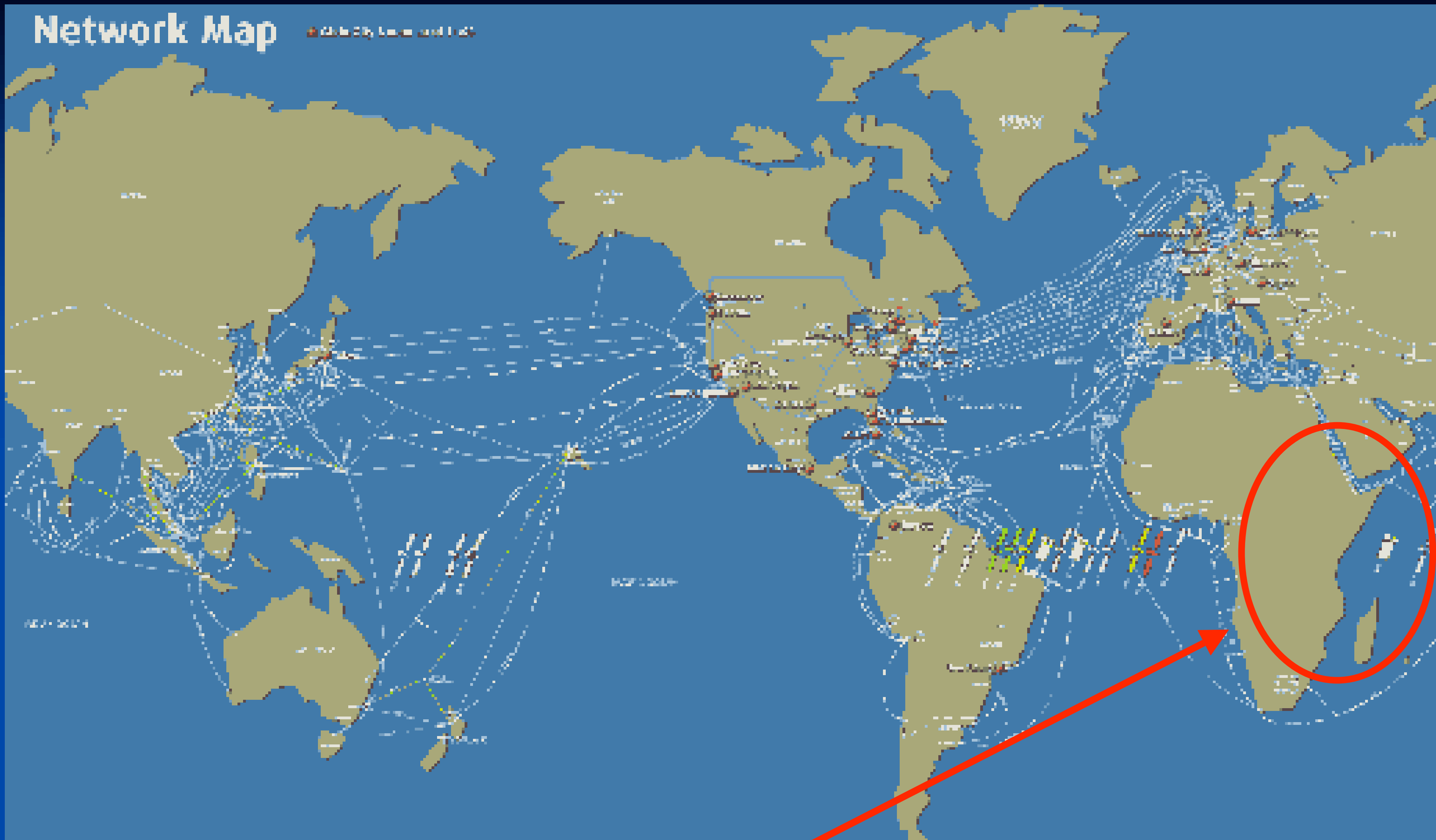


metropolitan network (total campus bandwidth=2.5 Mb/s, $28,000/mo)

campus wide single-mode optical fiber (2 Gb/s)

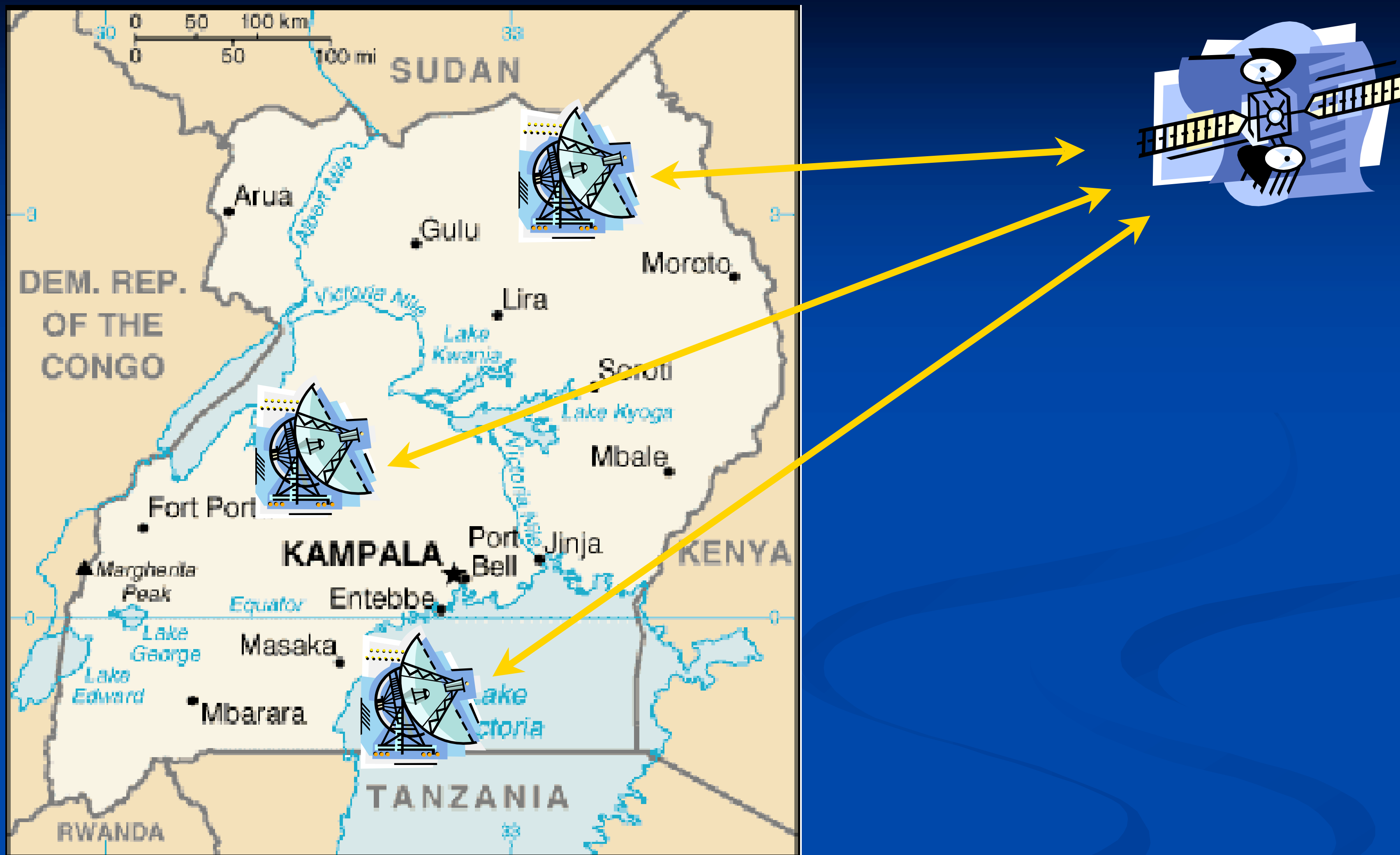


academic buildings networked at 10/100 Mb/s (but not student residences)



No optical fiber links to East Africa:

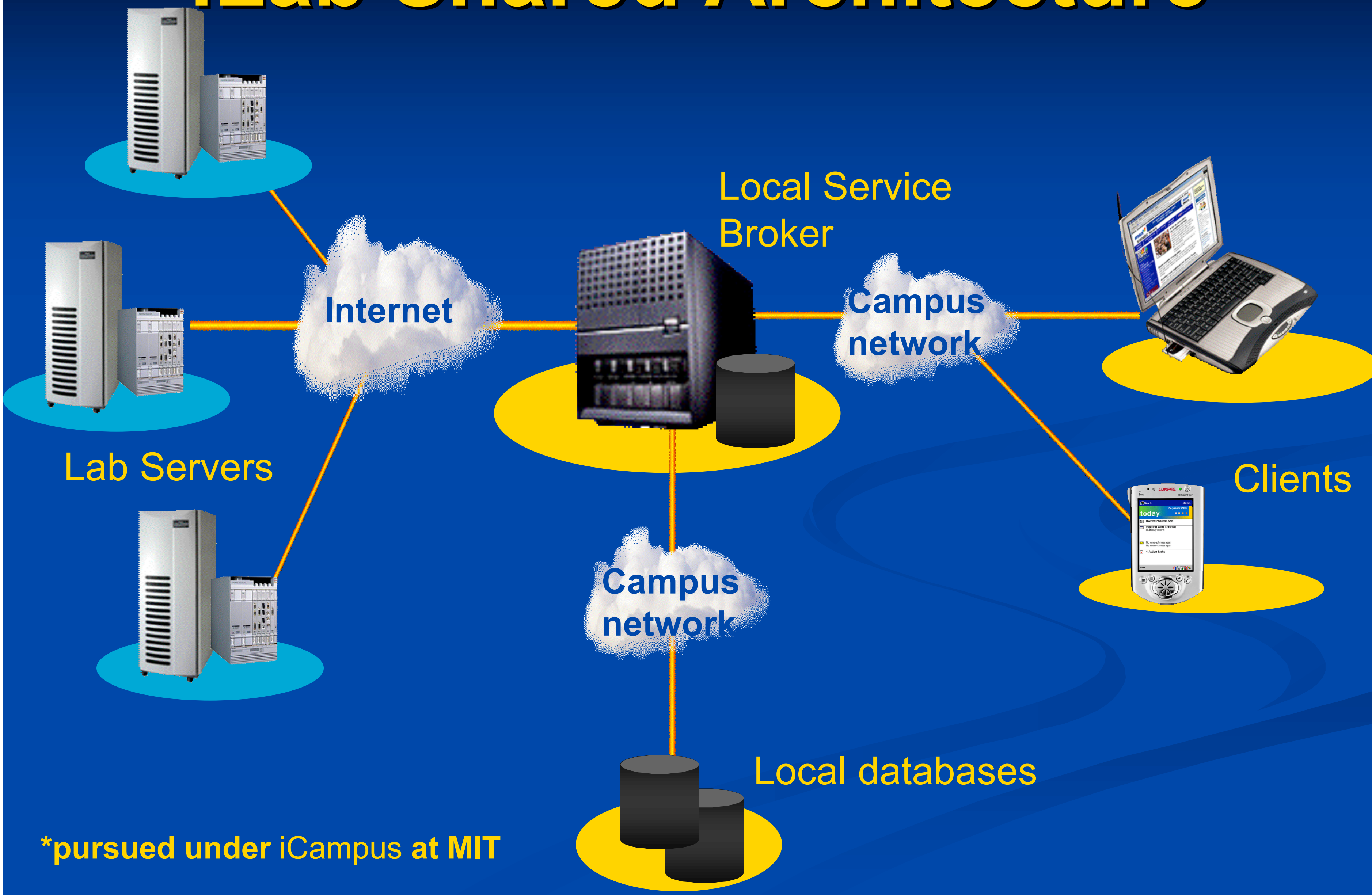
- each country is an island in the global Internet
- cannot have *regional* center to disseminate educational resources



No optical fiber links across country:

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

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
- iLabs Shared Architecture: scalable framework for iLabs, uniquely suited to needs of developing world

"If You Can't Come to the Lab… the Lab Will Come to You!"

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