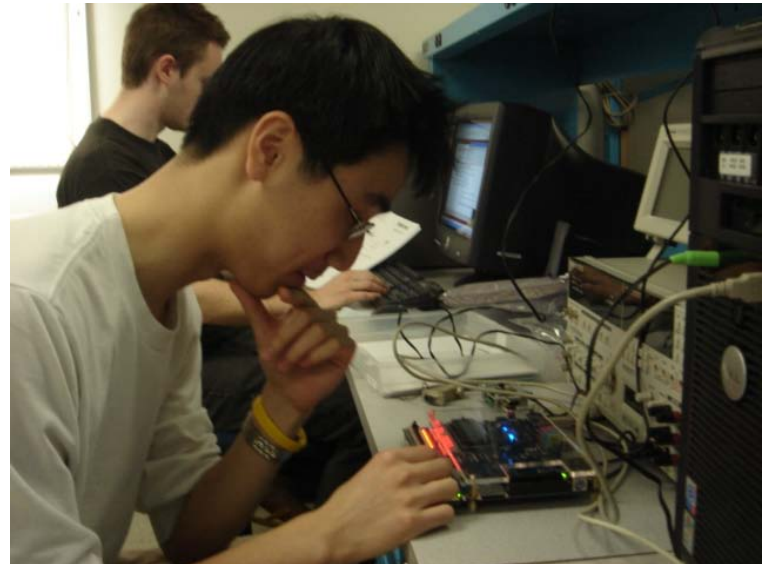# The iLab Project:

Introduction and Overview

1st iLab Europe Workshop

November 16 - 18, 2009

Motivation for 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

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

▸ http://www.cameco.com/common/images/u101/reactor2.jpg
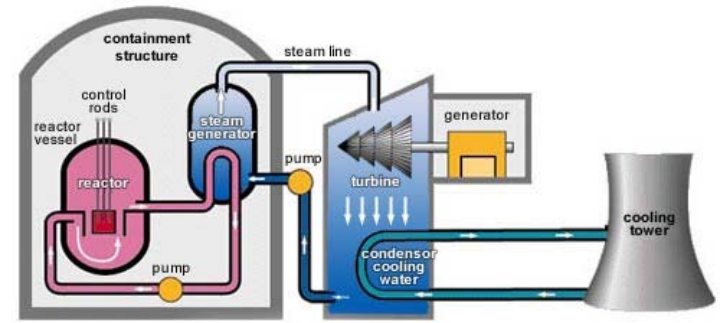
iLab: the Concept, Phase 1

To share a piece of lab equipment on the Internet:

▸ Interface it to a computer

▸ Make that computer a web server also so students can connect to it over the WWW

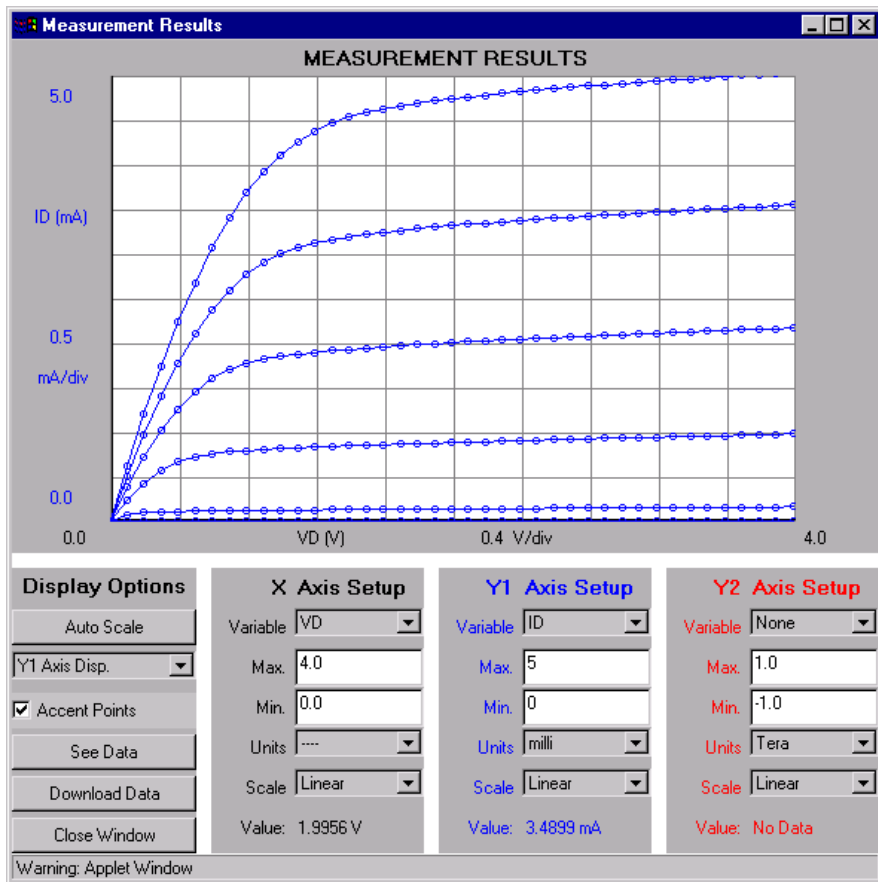▸ Support student accounts with a backend database if necessary

It all began ~10 years ago under Professor Jesus del Alamo

The First Microelectronics WebLab
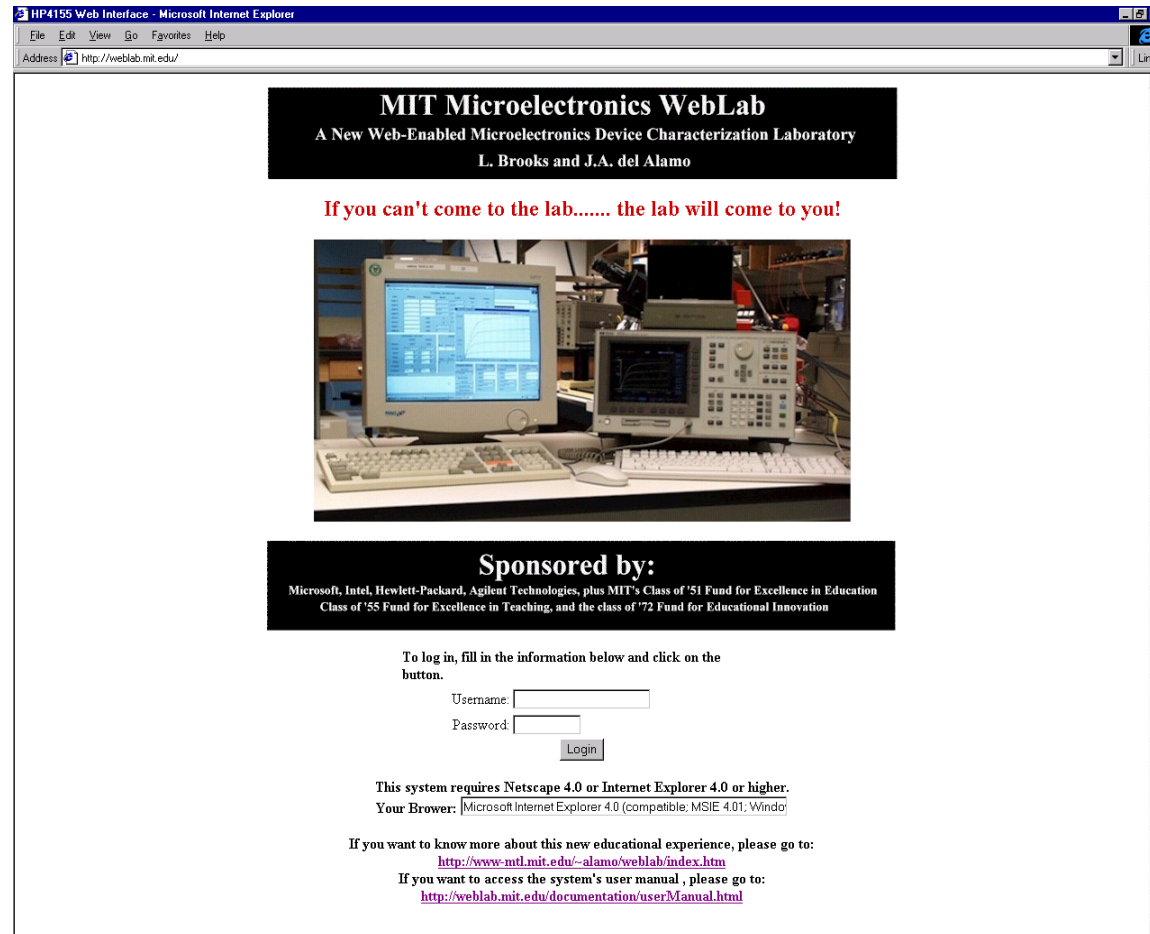
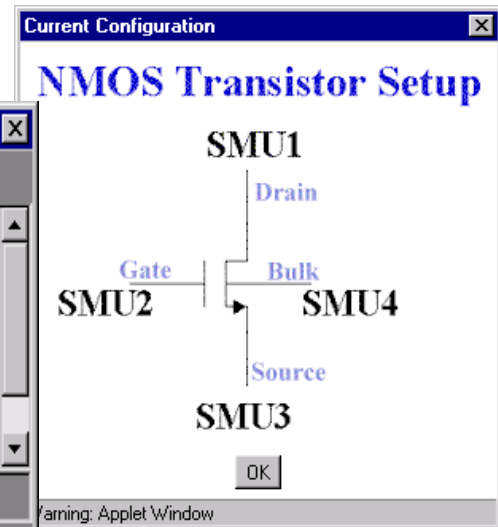▸ Original creator: Lane Brooks (then Junior in EECS), built working prototype in 6 months!

▸

MEASUREMENT RESULTS

5.0

ID (mA)

0.5

mA/div

0.0

0.0   VD (V)   0.4 V/div   4.0

Display Options

Auto Scale

Y1 Axis Disp.

☑ Accent Points

See Data

Download Data

Close Window

Warning: Applet Window

X Axis Setup	
Variable	VD
Max.	4.0
Min.	0.0
Units	----
Scale	Linear
Value:	1.9956 V

Y1 Axis Setup	
Variable	ID
Max.	5
Min.	0
Units	milli
Scale	Linear
Value:	3.4899 mA

Y2 Axis Setup	
Variable	None
Max.	1.0
Min.	-1.0
Units	Tera
Scale	Linear
Value:	No Data

Load Setup...　×

Available Setups

BJToutput
BJTgummel
schottky1
NMOSbodydiode
NMOSoutput
NMOStransfer
NMOShackgate(linear)

Load Setup:　NMOSoutput

OK　Cancel

Warning: Applet Window

Current Configuration　×

NMOS Transistor Setup

SMU1

Drain

Gate　　　Bulk
SMU2　|　　SMU4

Source

SMU3

OK

Warning: Applet Window

osfetoutput　□□×

CHANNEL DEFINITION

Unit	VName	IName	Mode	Funct	Value	Compl.
SMU1	VD	ID	V	VAR1	N/A	N/A
SMU2	VG	IG	V	VAR2	N/A	N/A
SMU3	VS	IS	COMM	CONS	N/A	N/A
SMU4	VB	IB	COMM	CONS	N/A	N/A
VSU1		N/A	V	CONS	0.0　V	N/A
VSU2		N/A	V	CONS	0.0　V	N/A
VMU1		N/A	V		N/A	N/A
VMU2		N/A	V		N/A	N/A

VARIABLE SETUP

	VAR1	VAR2
Name	VD	VG
Scale	Linear	Linear
Start	0.0　V	0.0　V
Stop	4.0　V	3.0　V
Step	100.0　mV	500.0　mV
Points	41	7
Compl.	100.0　mA	100.0　mA

USER-DEFINED FUNCTION SETUP

Add User Function

Name　Units　Function

Add

Defined User Functions

Name　Units　Function

Edit

Remove

Remove All

Warning: Applet Window

Data　×

VG, VD, ID
V, V, A
+0.000000E+000, +0.000000E+000, -2.800000E-013
+0.000000E+000, +1.000000E-001, +4.738000E-011
+0.000000E+000, +2.000000E-001, +1.024400E-010
+0.000000E+000, +3.000000E-001, +7.752000E-011
+0.000000E+000, +4.000000E-001, +8.379000E-011
+0.000000E+000, +5.000000E-001, +8.953000E-011
+0.000000E+000, +6.000000E-001, +9.600000E-011

OK

Warning: Applet Window

Typical WebLab Architecture

Lab Server:
manages lab equipment and students

Lab Hardware

Internet

Clients

Campus Network

Local Databases
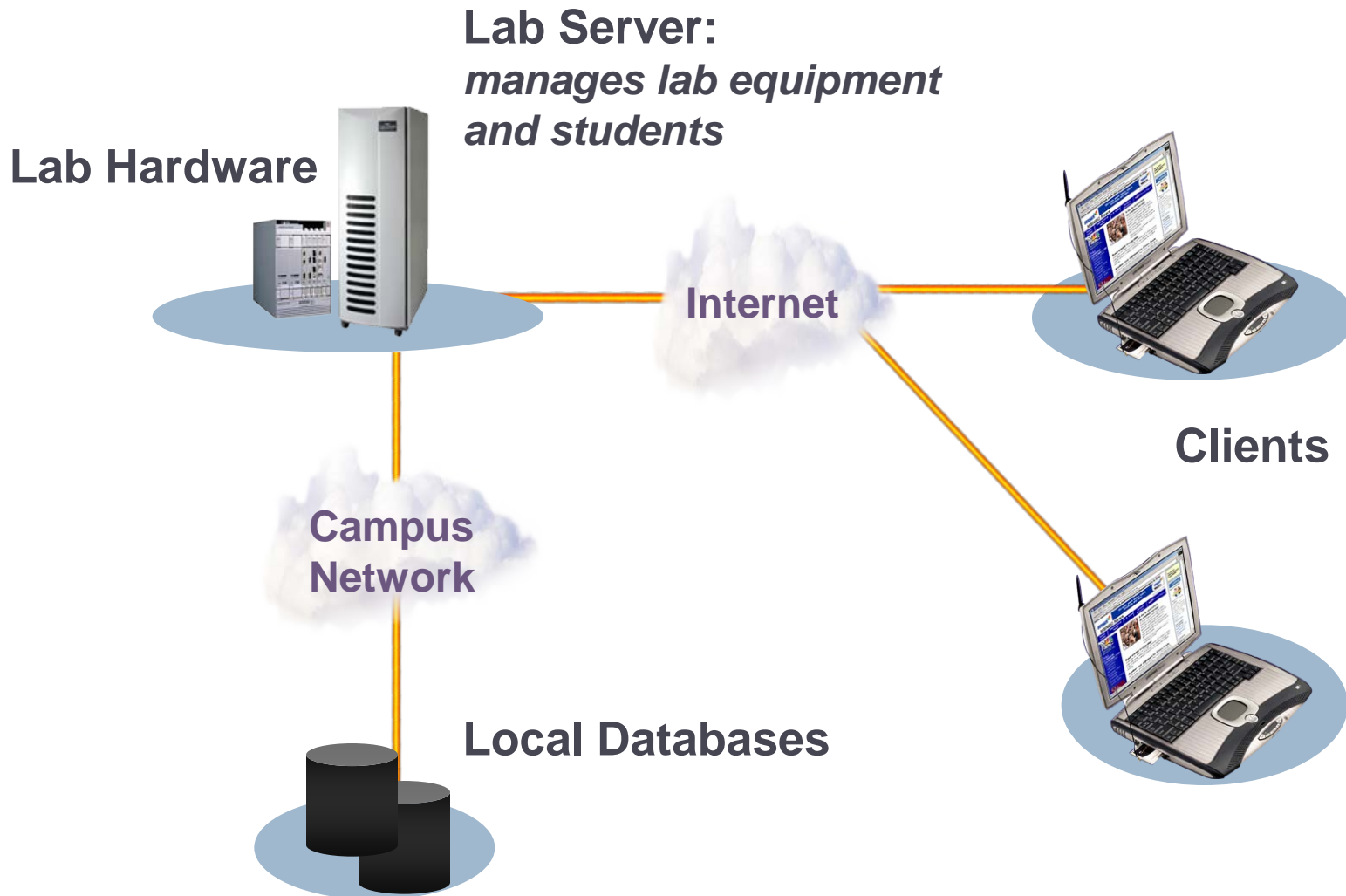
iLab: the Challenges

- 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

iLab: the Concept, Phase 2

The importance of sharing a software infrastructure

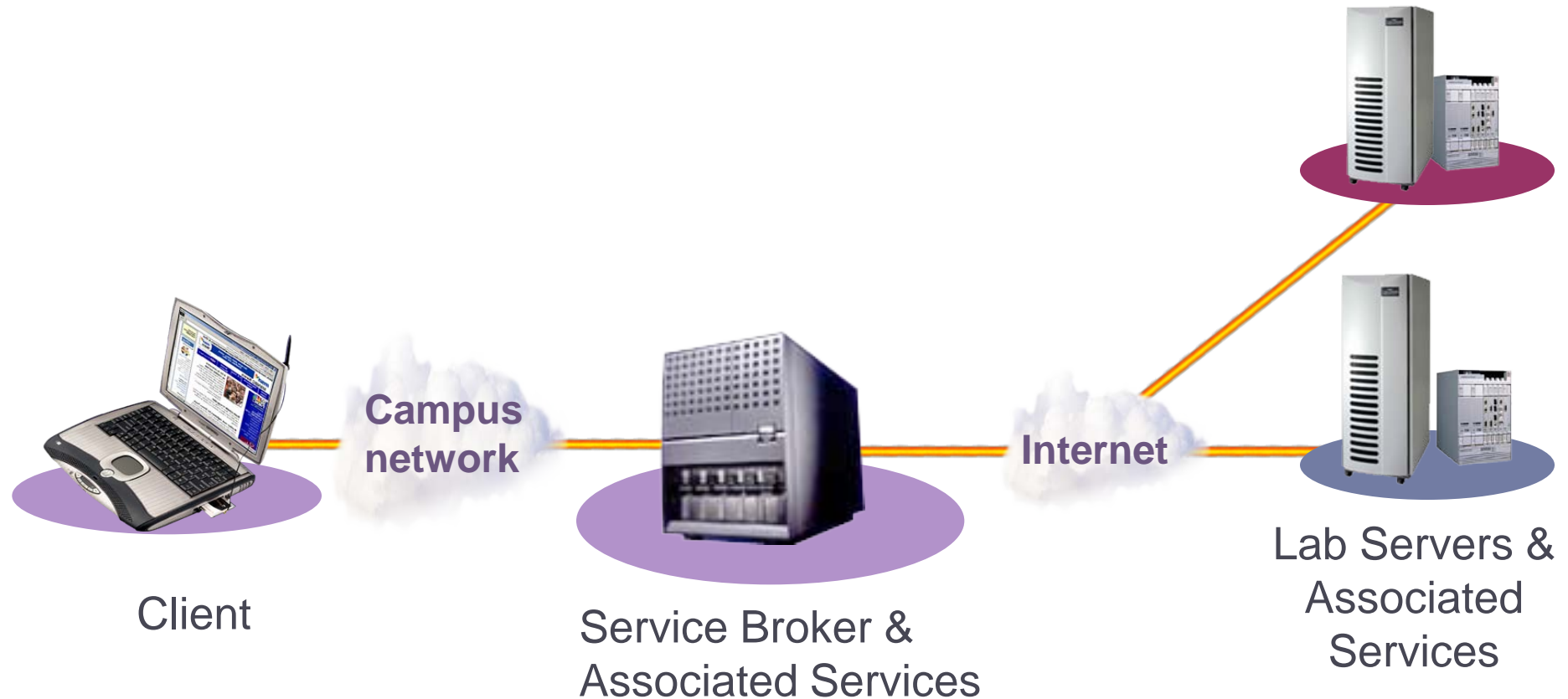▸ So that lab developers don't have to start fresh each time but can build upon a stable foundation;

▸ So that students can have a consistent interface to multiple laboratories with single sign-on;

▸ So that the infrastructure can separate the task of *providing the lab* from that of *managing students using the lab*.

Hal Abelson of MIT and Dave Mitchell of Microsoft suggested building iLabs on top of such a web service infrastructure in 2002.

This initiated the development of the iLab Shared Architecture.

▸

iLab Shared Architecture

Client

Campus network

Service Broker & Associated Services

Internet

Lab Servers & Associated Services

iLab Shared Architecture

- Special purpose system specific to an experiment
- Developed by domain specialist
- No user management here
- Verifies experiment before execution

Campus network

Internet

Client

Service Broker & Associated Services

Lab Servers & Associated Services

iLab Shared Architecture

- GUI to lab
- Embodies pedagogical experience
- Developed by domain specialist
- Contains generic modules that are recycled: i.e. graphing, collaboration

Campus network

Internet

Client

Service Broker & Associated Services

Lab Servers & Associated Services

iLab Shared Architecture

- Serves client to student's computer
- Mediates between Client and Lab Server
- Performs generic functions: user management, data storage
- Single sign-on access to many labs
- Managed by and located at end user University

**Campus network**

Internet

Client

Service Broker & Associated Services

Lab Servers & Associated Services

Scalability of the iLab Architecture

▸ The iLab architecture allows schools and universities to build out an extensible network of labs that can all be shared between schools.

▸ The system couples together like LEGOs.

▸ All software is available on an open source basis.

Clients

iLab Backbone:
Service Brokers

Labs

Campus 1   Campus 2   Campus 3
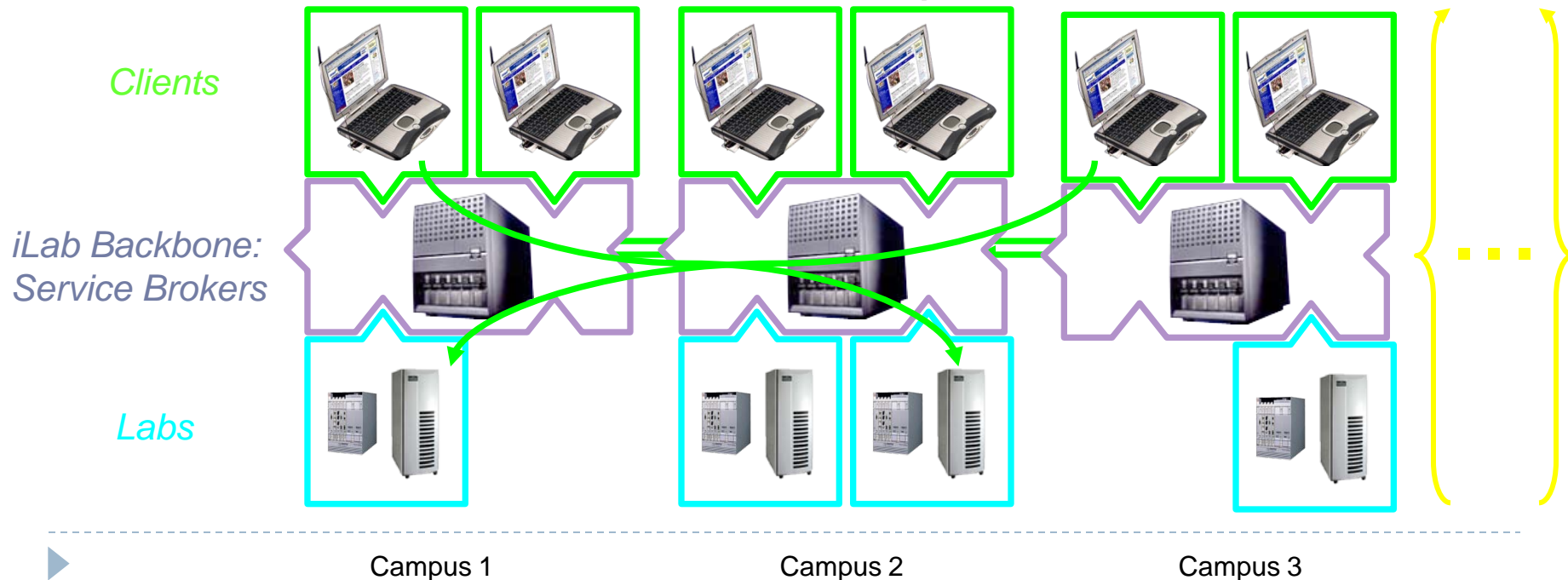
iLab Use Around the World

**Over 20 universities involved with iLabs
…and the list is growing.**

iLabs Around the World

Microelectronics Device Characterization
(MIT-EECS, deployed 1998)

ELVIS
(MIT-EECS, deployed 2006)

Dynamic Signal Analyzer
(MIT-EECS, deployed 2004)

Neutron Spectrometer
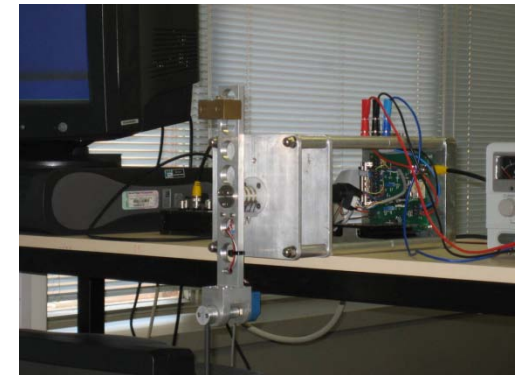*(MIT-Nuclear Eng., deployed 2008)*
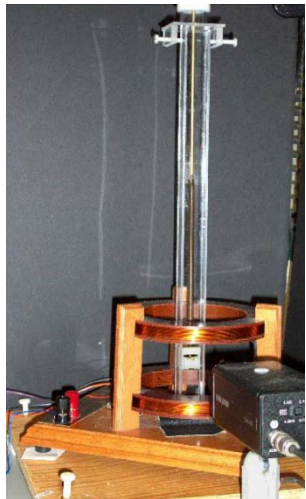
Force on a Dipole
(MIT-Physics, deployed 2008)

Logic Lab
(OAU, Nigeria, deployed 2007)

Radioactivity
(University of Queensland, Australia, deployed 2007)

Inverted Pendulum
(University of Queensland, Australia, deployed 2004)

Collaboration Around iLabs

A number of significant collaborative efforts have developed around the iLab Project:

▸ Curricular development by "consumer" institutions

▸ iLab Africa

▸ Partnership with University of Queensland

▸ MATEC

▸ Developer exchanges

The iLab Africa Project

Project goal: to leverage iLabs as an educational resource for university students in developing nations.

▸ Initiated in 2003, project formally started in 2005

▸ Involves partnerships with three sub-Saharan universities:

  ▸ Obafemi Awolowo University, Nigeria

  ▸ Makerere University, Uganda

  ▸ University of Dar es Salaam, Tanzania

▸ Regular developer exchanges, project meetings

▸ Project has produced strong development teams, valuable partnerships, important technical advancements and lessons

The iLab Africa Project

Collaboration and partnerships:

▸ African teams working together – Development teams have become more self-supporting, better able to overcome social/technical boundaries to help each other

▸ African teams working as regional iLab hubs – Outreach initiatives have begun with each institution supporting iLab use/development at other universities in their area

▸ Partnerships with National Instruments

 ▸ Combining open source and proprietary solutions to minimize cost of ownership
   ▸ LabVIEW
   ▸ ELVIS
 ▸ Turning to industry for stable, supported, cost platforms
 ▸ NI's commitment to global engineering education
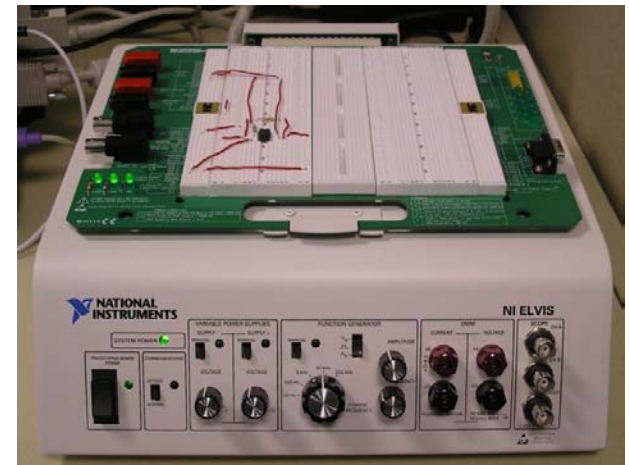
The iLab Africa Project

iLab Africa has enriched the iLab Project:

▸ Introduced new use cases and requirements

▸ Educated MIT team about the state of the IT/Internet outside of US research setting

▸ Introduced new design and pedagogical concepts

  ▸ Switching, client user-interfaces, developer documentation

▸ Motivated our search for a shared development platform that has become as important for MIT's courses as our partners'

  ▸ ELVIS

▸ Led to additional potential engagements in the region

▸

iLab Partnerships, Australia

- MIT's partnership with the University of Queensland (UQ) started in 2004.

- UQ has implemented several iLabs in physics and mechanical engineering.

- UQ has also served as a hub to educate other Australian universities about the potential of iLabs.

- Currently engaged in an active collaborative development project.

iLab Partnerships, MATEC

Partnership with Maricopa Advanced Technology Education Center on their ESyst Project

▸ Collection of community/ technical colleges designing a new, systems-oriented electronics curriculum

▸ Targets part-time, distance learners

▸ Systems-level analog electronics iLab based on ELVIS II
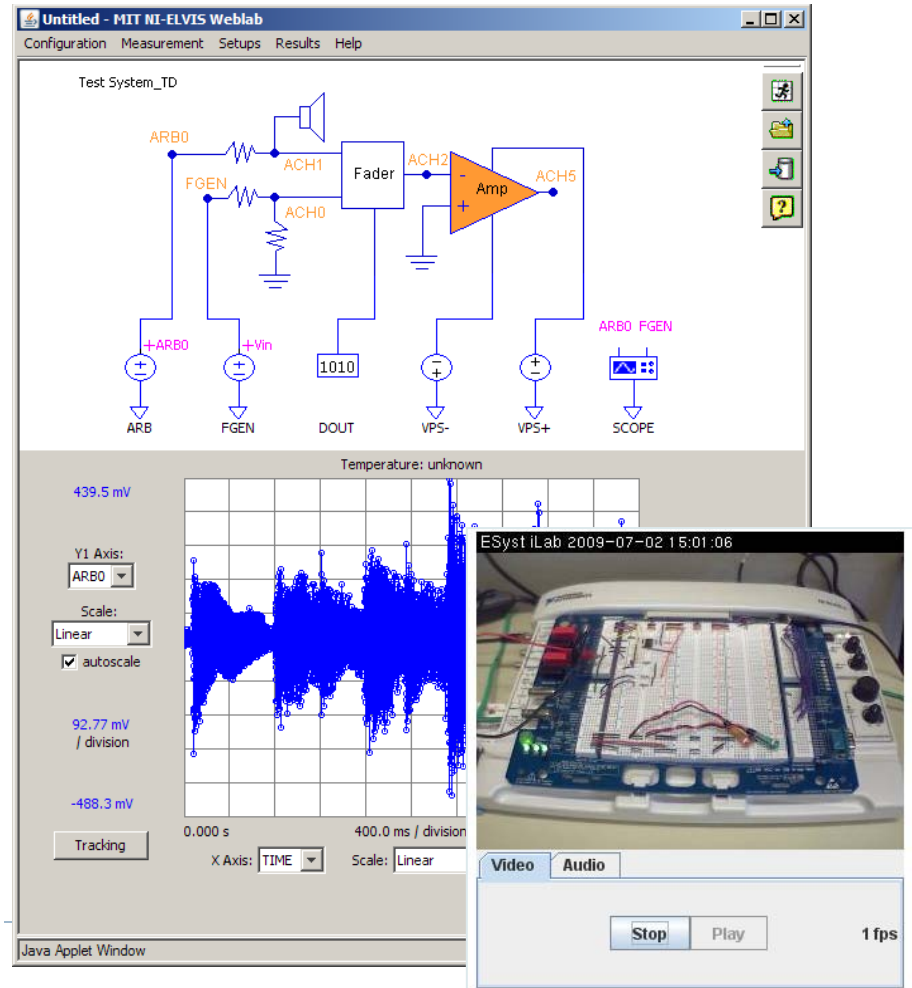
iLab Partnerships,
Graz University of Technology

- MIT iLab Project has hosted graduate students from Graz for extended visits
- Team has worked on a virtual world interface to MIT Force on a Dipole iLab
- Produced working demos and publications
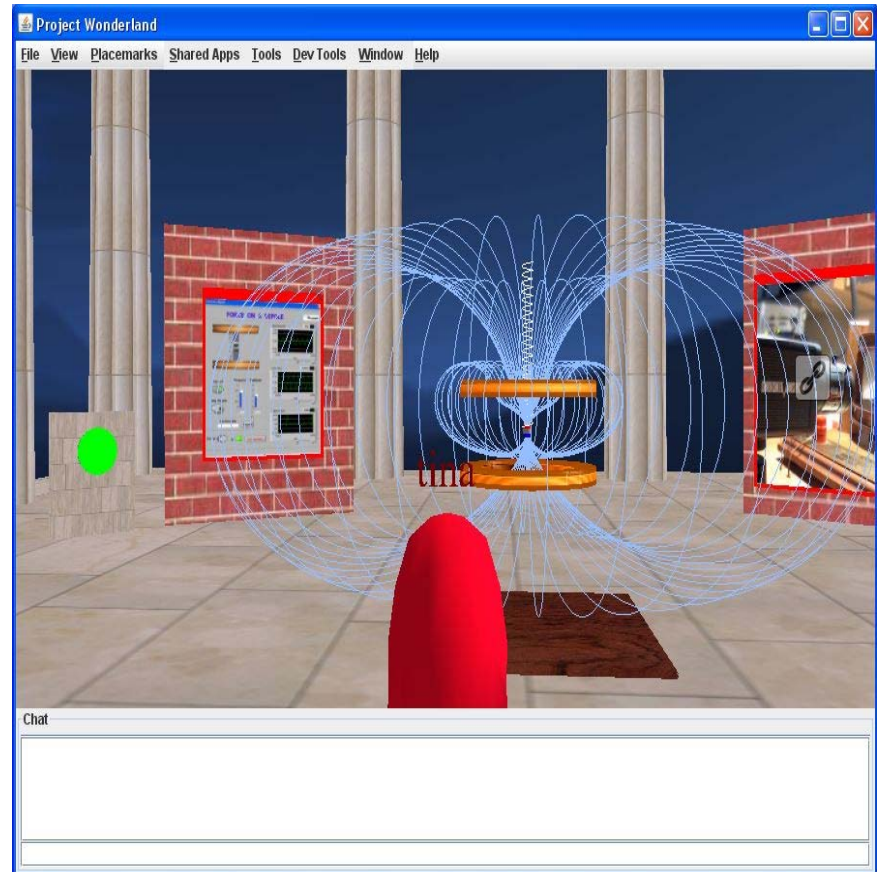
iLab Partnerships, CUAS

‣ Developer exchanges supporting iLab development

  ▸ Interactive iLab based on Altera CPLD, LabVIEW

  ▸ Interfacing between remote lab architecures – iLabs and VISIR

  ▸ Workshops
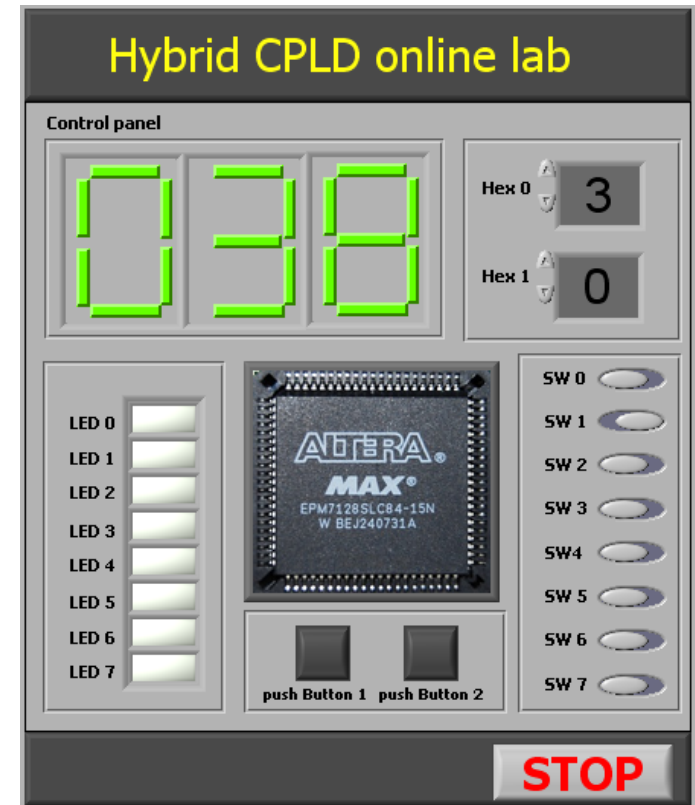
Phase 3, The "iLab" Consortium

To solidify project collaborations and properly leverage the strengths of our partners, we've started a consortium around iLabs

▸ Initial Founders meeting June 2009

▸ Goals:

  ▸ To provide a structure for institutions to become involved

  ▸ To decentralize project and provide a framework for collaboration

  ▸ To allow the development of a proper remote laboratory standard, based on participant experience and best practices – including those from other remote lab architectures

The Future

- iLab development continues along several tracks involving a broad set of partners
  - New iLabs
  - Integration with collaborative, workflow and learning management systems
  - Architectural development
- Advent of the Consortium
  - Project direction will be determined by stakeholders, not just MIT
- Development and integration of compelling remote labs that increase laboratory experiences worldwide

More immediately…

- This afternoon:
  - The iLab service broker and how it is used - Demonstration and discussion
  - General discussion - Similarities/differences between and possible integration with other remote lab architectures (everyone)
  - Dinner ~18:30
- Tomorrow
  - Morning
    - How to setup an iLab Service Broker, connect to iLabs
    - Development of iLabs/migration of existing experiments to ISA - Batched labs
  - Afternoon
    - Development of iLabs/migration of existing experiments to ISA - Interactive Labs
    - Demonstrations and discussion of new labs and architectural integration/interoperation
- Wednesday Morning
  - The lab2go online lab repository Potential & short talks about VISIR to prime discussion about lab development and interoperation
  - Discussion about new development ideas/concerns and remote lab infrastructure integration/interoperation