

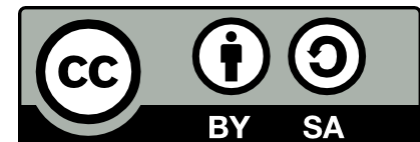
Carinthia University of Applied Sciences
Danilo G. Zutin

TA02

Introduction to Remote Laboratories, Technologies and Implementations



Co-funded by the
Erasmus+ Programme
of the European Union



Agenda

Day 1 – 05.09.2016

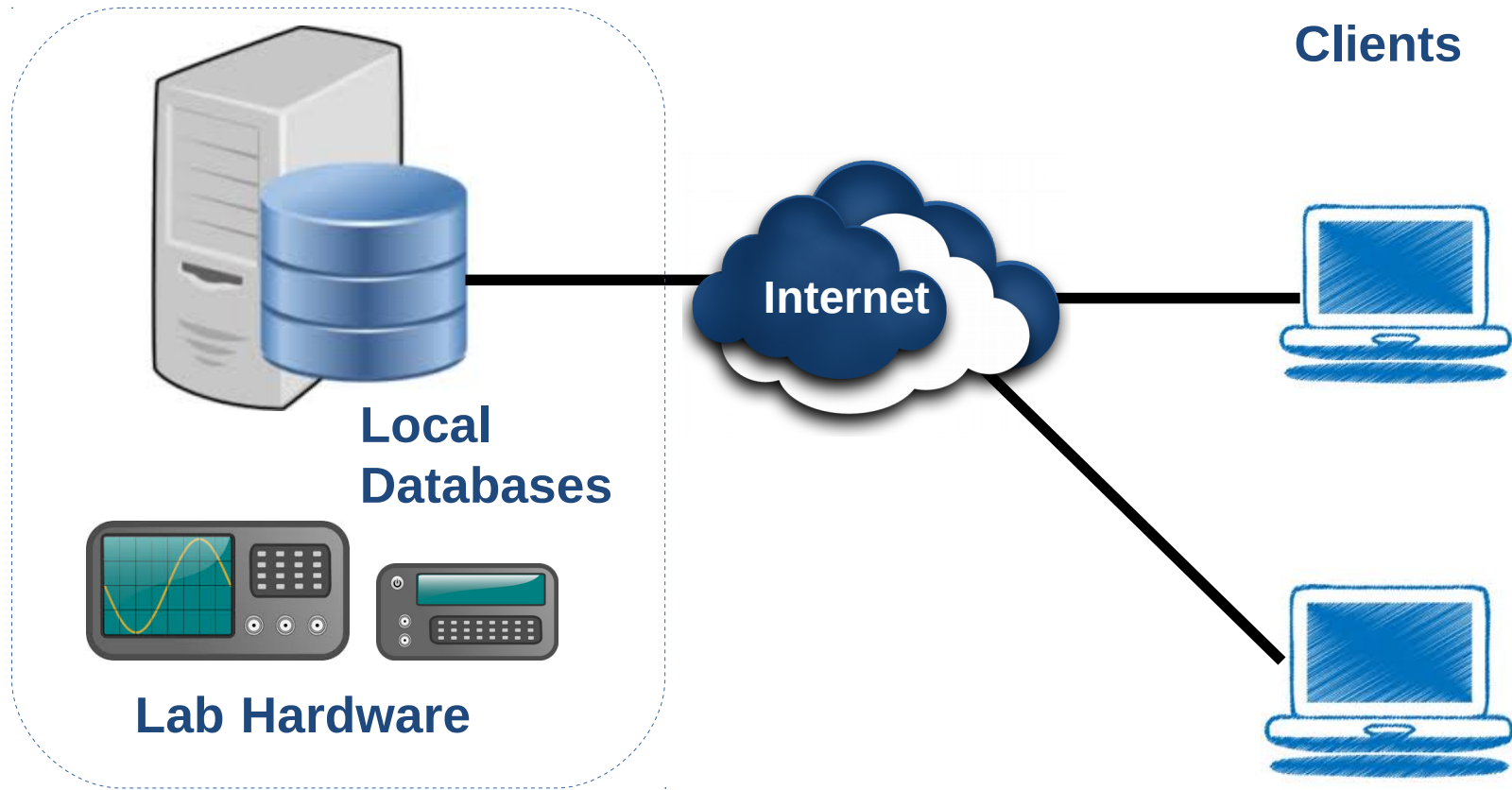
- 9:00h – 9:20h Introduction
- 9:20h – 10:00h **Introduction to Remote Laboratories, Technologies and Examples**
- 10:00h – 10:20h Basics of VISIR (with some use cases)
- 10:20h – 10:40h Examples of Usage of VISIR
- 10:40h – 12:00h Hands-on Session
- 14:00h – 14:30h Hands-On Session (continued)
- 14:30h – 15:30h The VISIR Hardware and Software
- 15:30h – 16:00h Wrap up & Discussions

Day 2 – 05.09.2016

- 9:00h – 11:00h Creating Lab Exercises with VISIR
- 11:00h – 12:00h Interactive Session (Hands-on)
- 14:00h - .. Interactive Session (Continued)

Typical *Ad hoc* Online Lab Architecture

Lab Server:
manages lab equipment and students



Available Technologies

{JSON}

http://

Web Services
SOAP XML WSDL REST service

LS

AJAX
Asynchronous Javascript And XML

RSS XML ATOM

HTML5

WebSockets

XML

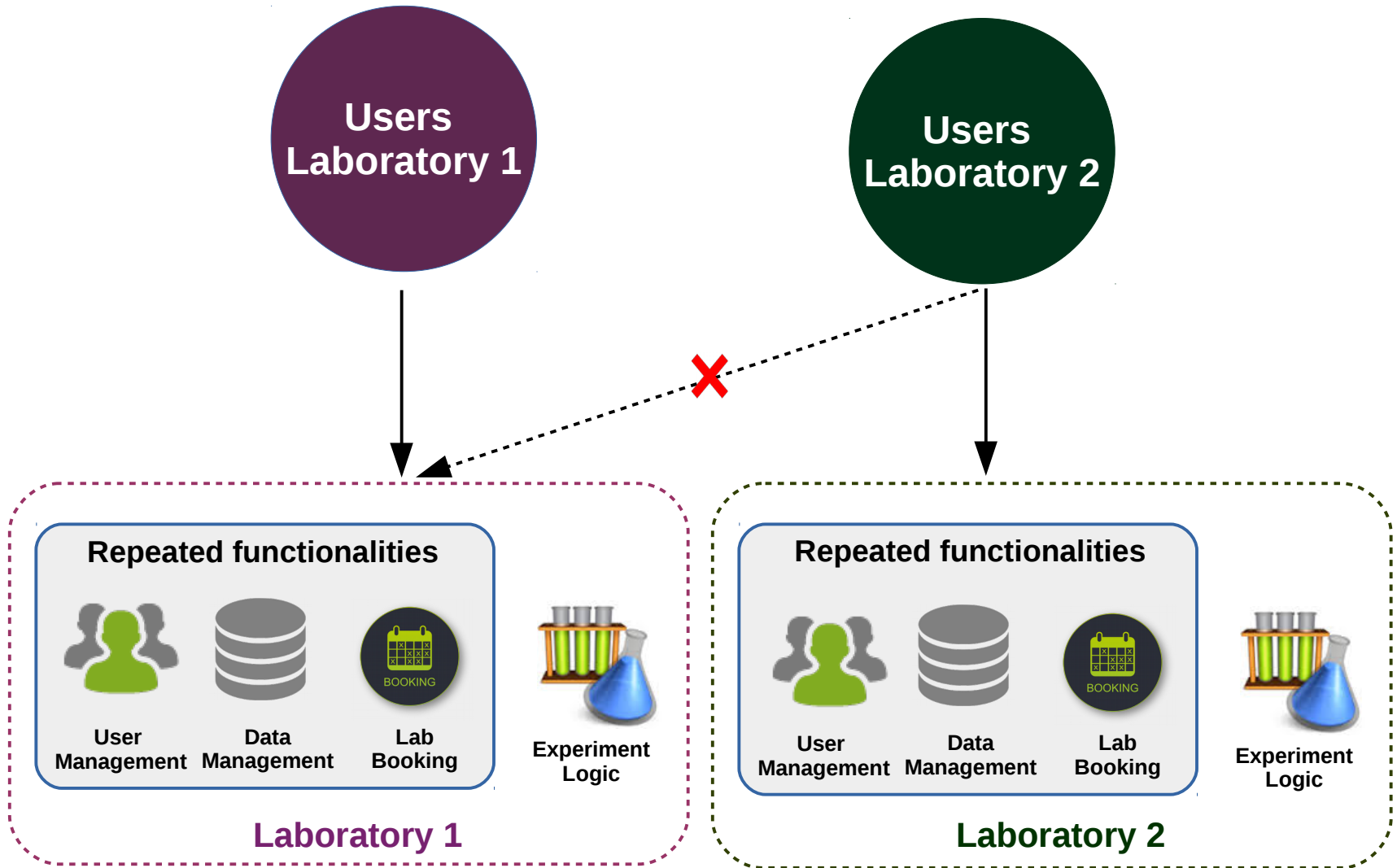
XML-RPC

JSON-RPC

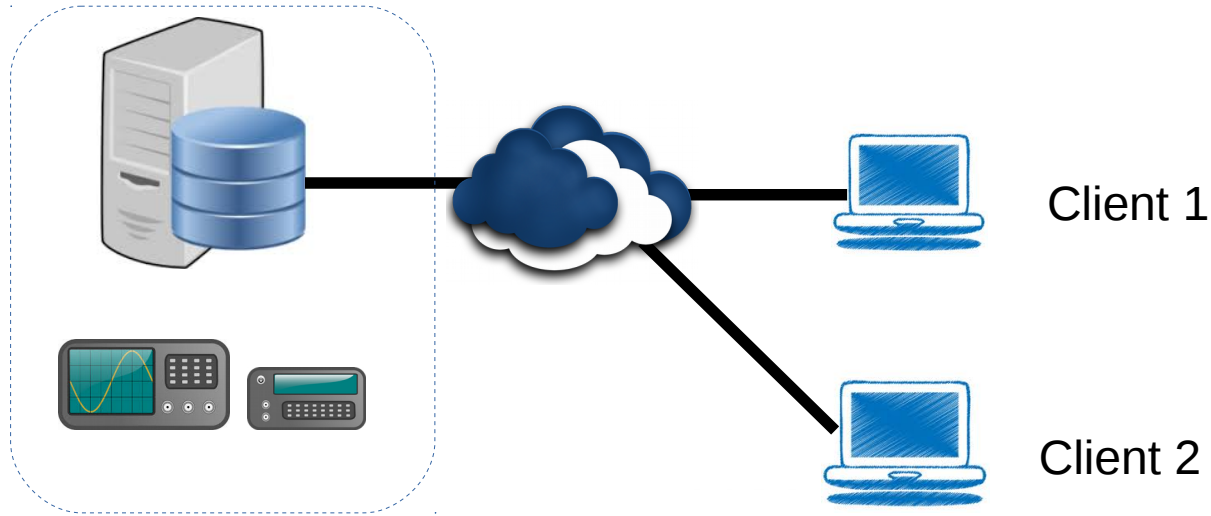
CORBA

OpenSocial

The big picture before RLMS



Common functionalities..



- Authenticate users
 - Manage users
 - Lab Booking
 - Queue experiments
 - Experiment data storage
- } Lab Session Management

Common functionalities of an Online Lab system

Lab Session Management

Calendar based booking



- Lab session typically takes longer
- User can reserve an specific time-slot
- Reliable: lab server will be available at reserved time

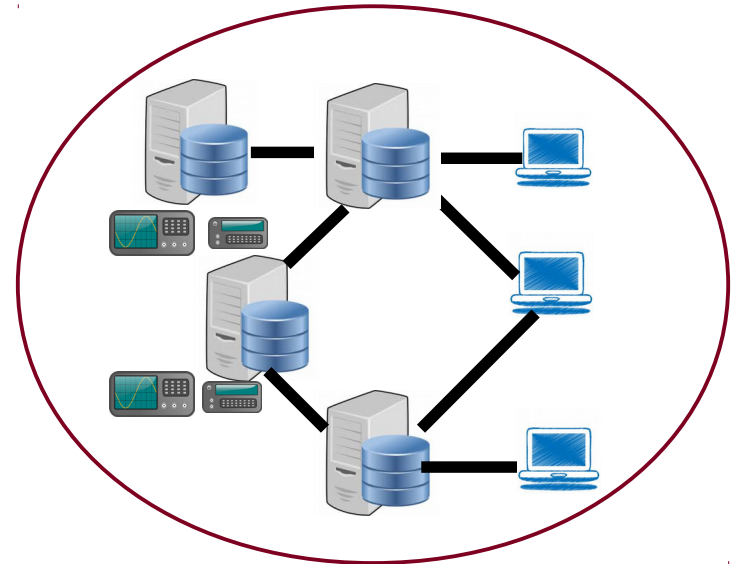
Queueing mechanism



- Usually implemented as first in first out (FIFO)
- Experiments usually run fast
- Requests can be prioritized

RLMS – Remote Lab Management Systems

- RLMS group common functionalities that are present in nearly all *ad-hoc* implementations around a single system/software framework
- Examples:
 - iLab Shared Architecture
 - Weblab Deusto
 - LabShare Sahara
 - Labicom
 - RemlabNet



Examples of RLMSs



The Contributions of RLMS

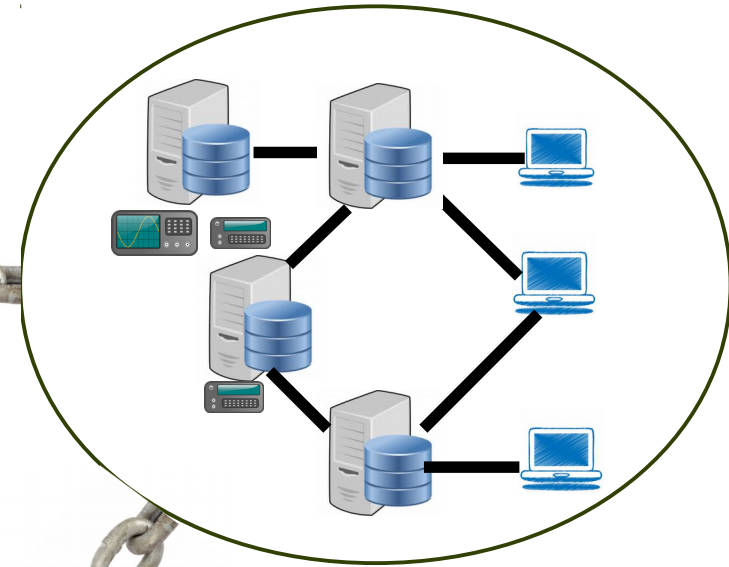
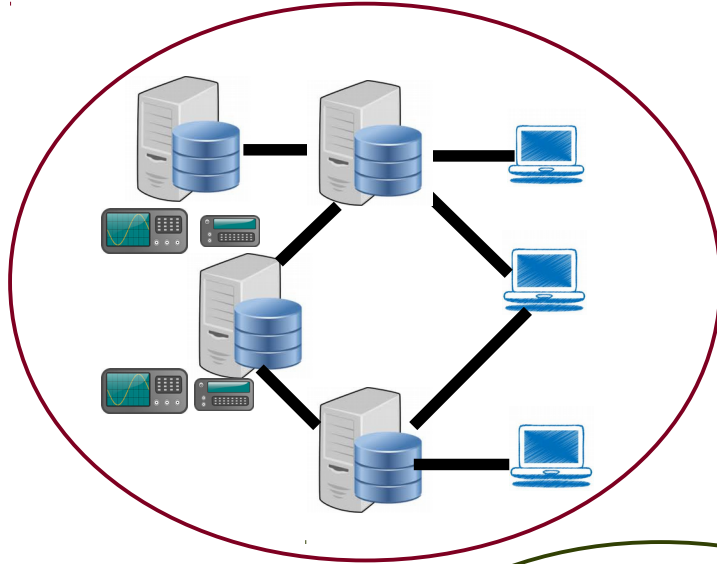
Sharing a software infrastructure

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*.

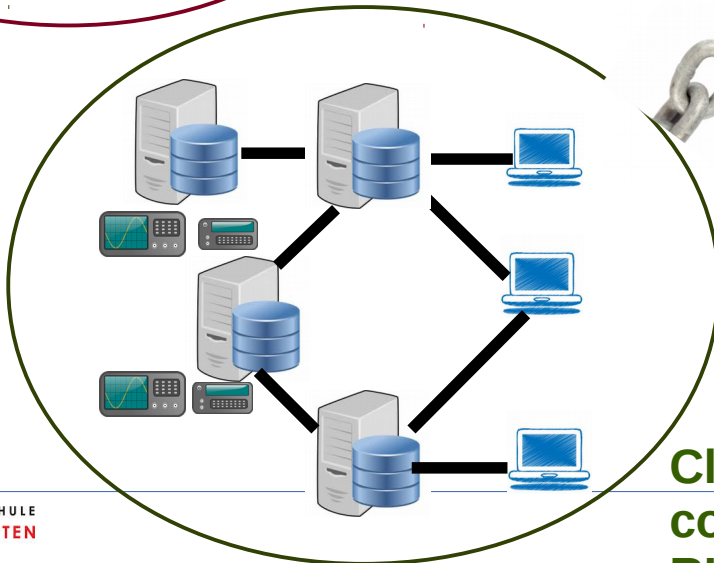


With RLMSs

Cluster of Labs compatible with RLMS X

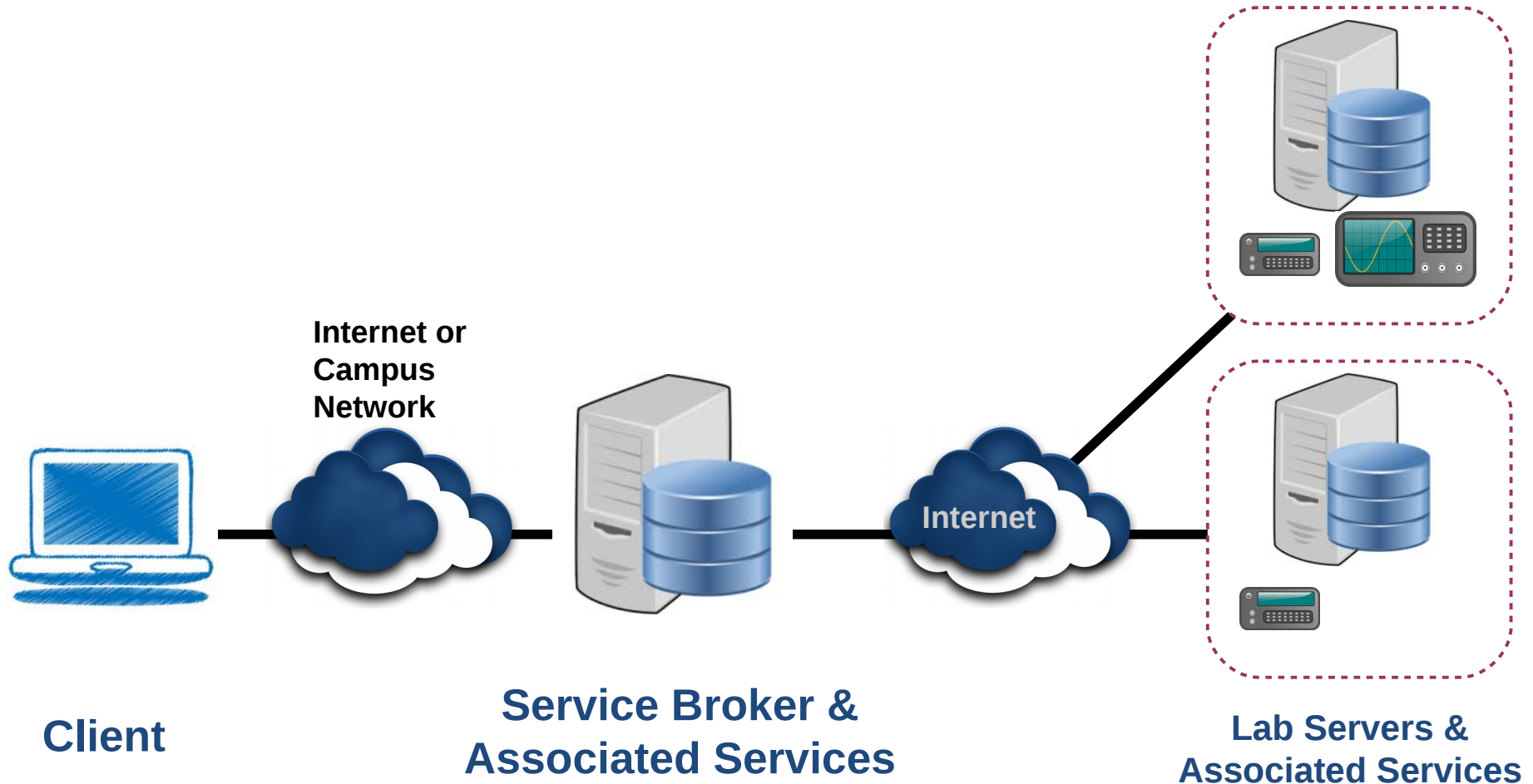


Cluster of Labs compatible with RLMS Y

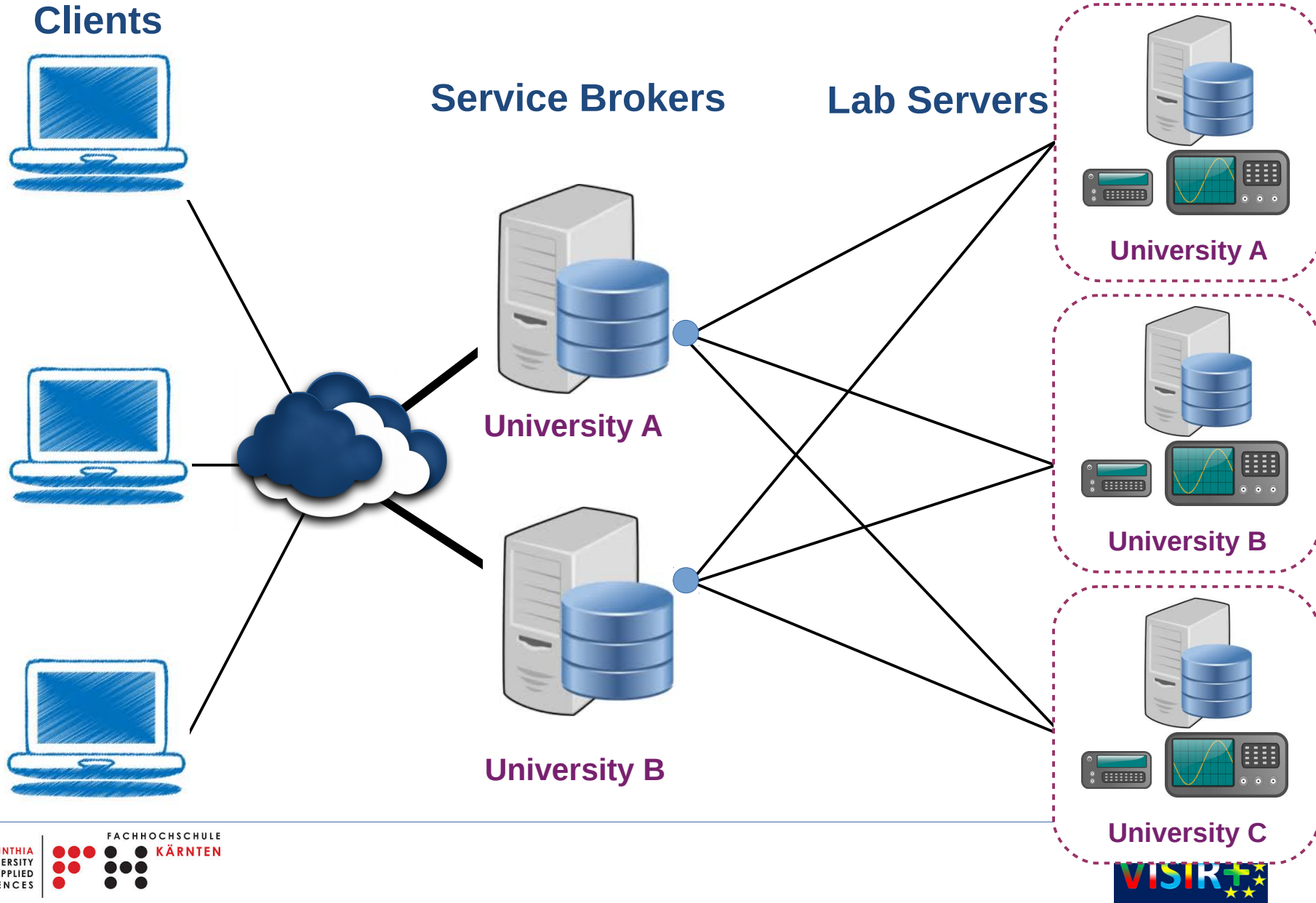


Cluster of Labs compatible with RLMS Z

The iLab Shared Architecture (ISA)



The ISA Federation model (multi campus architecture)



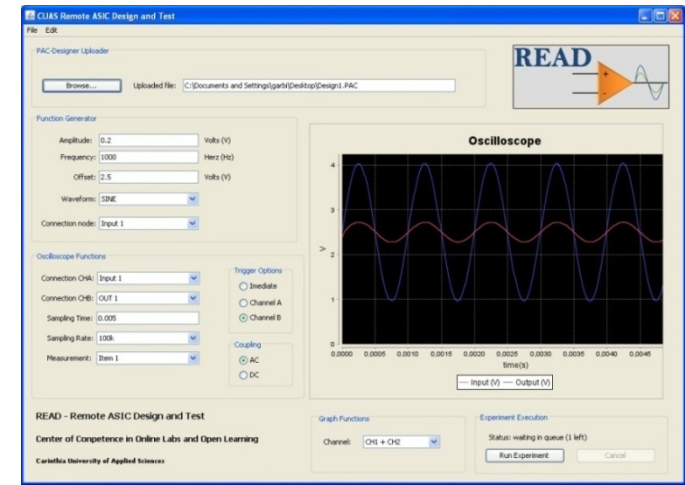
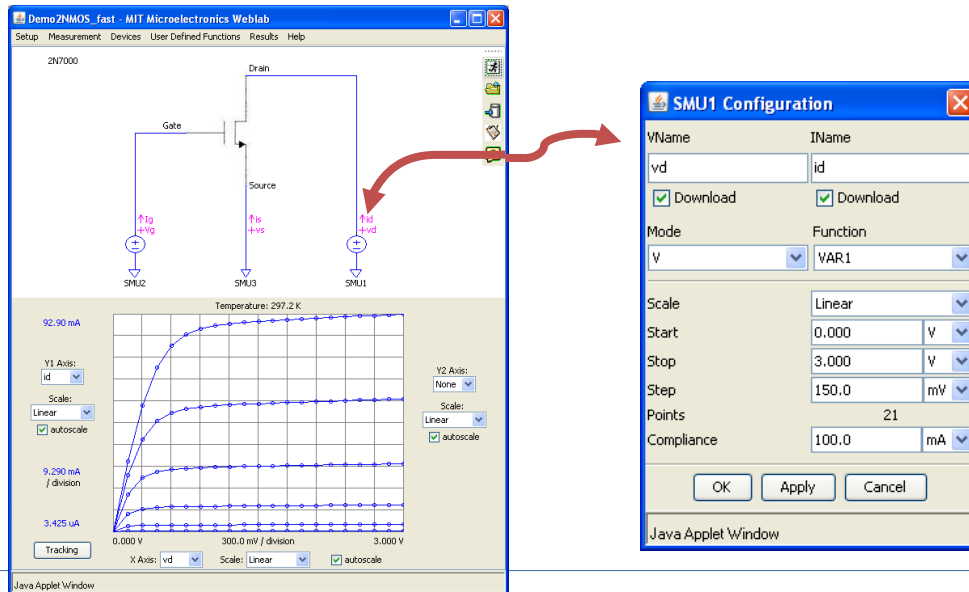
The iLab Shared Architecture

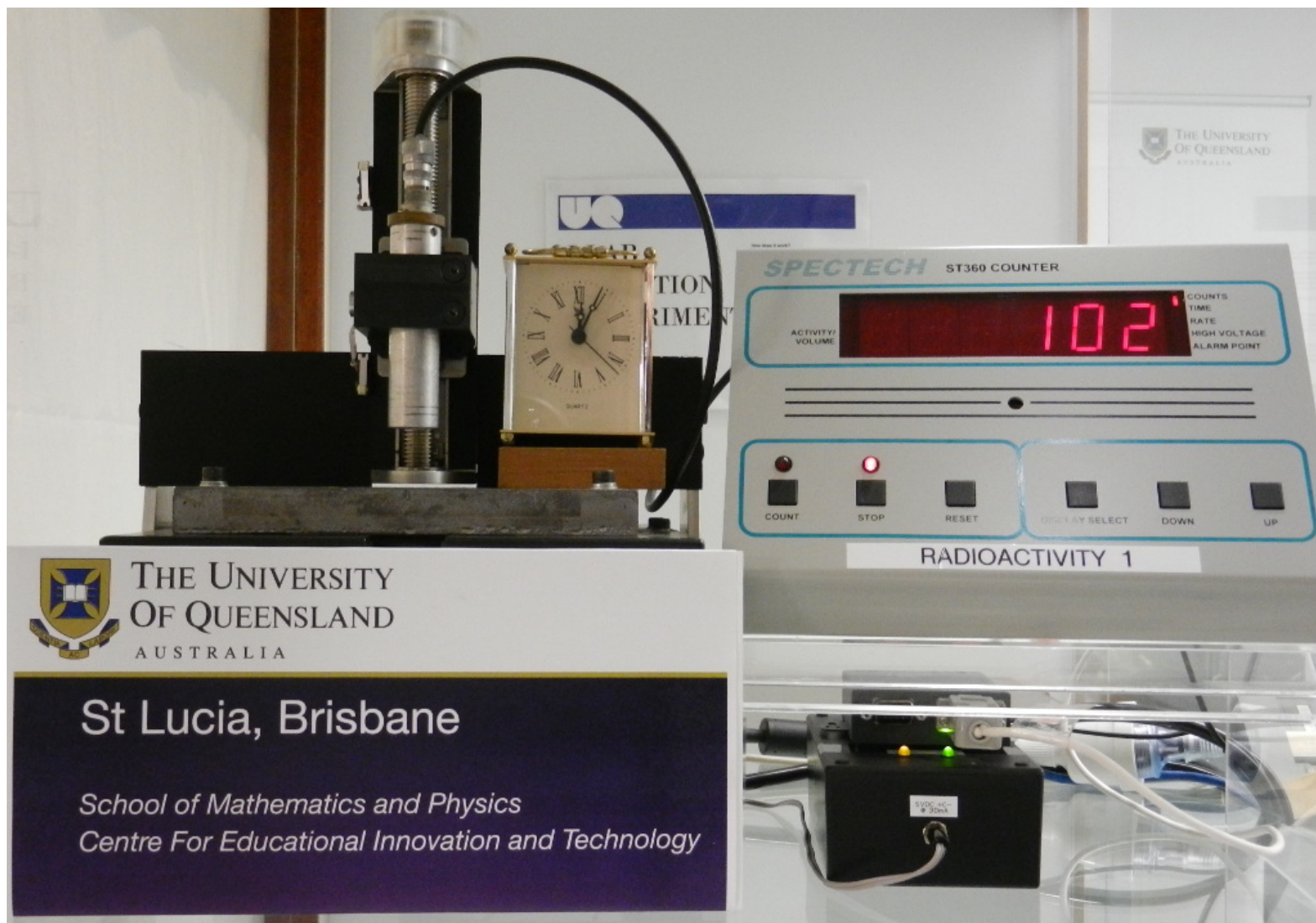
Asynchronous (Batched) Experiments:

Batched experiments are those in which the entire course of the experiment can be specified before the experiment begins.

Batched experiments should be queued for execution in order to maximize the efficiency of the lab server.

Example: MIT's Microelectronics WebLab for device characterization, CUAS READ System.



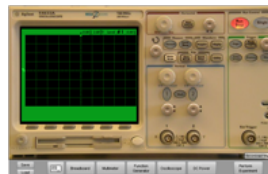
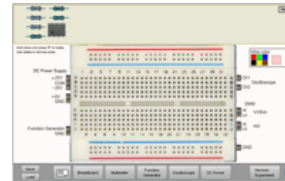
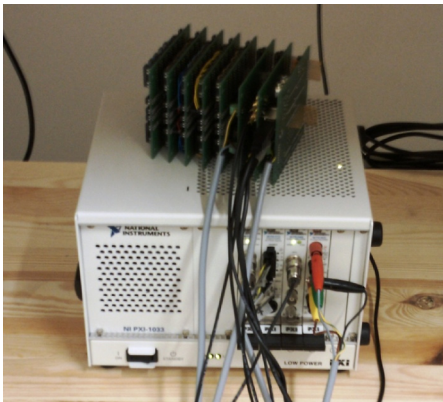


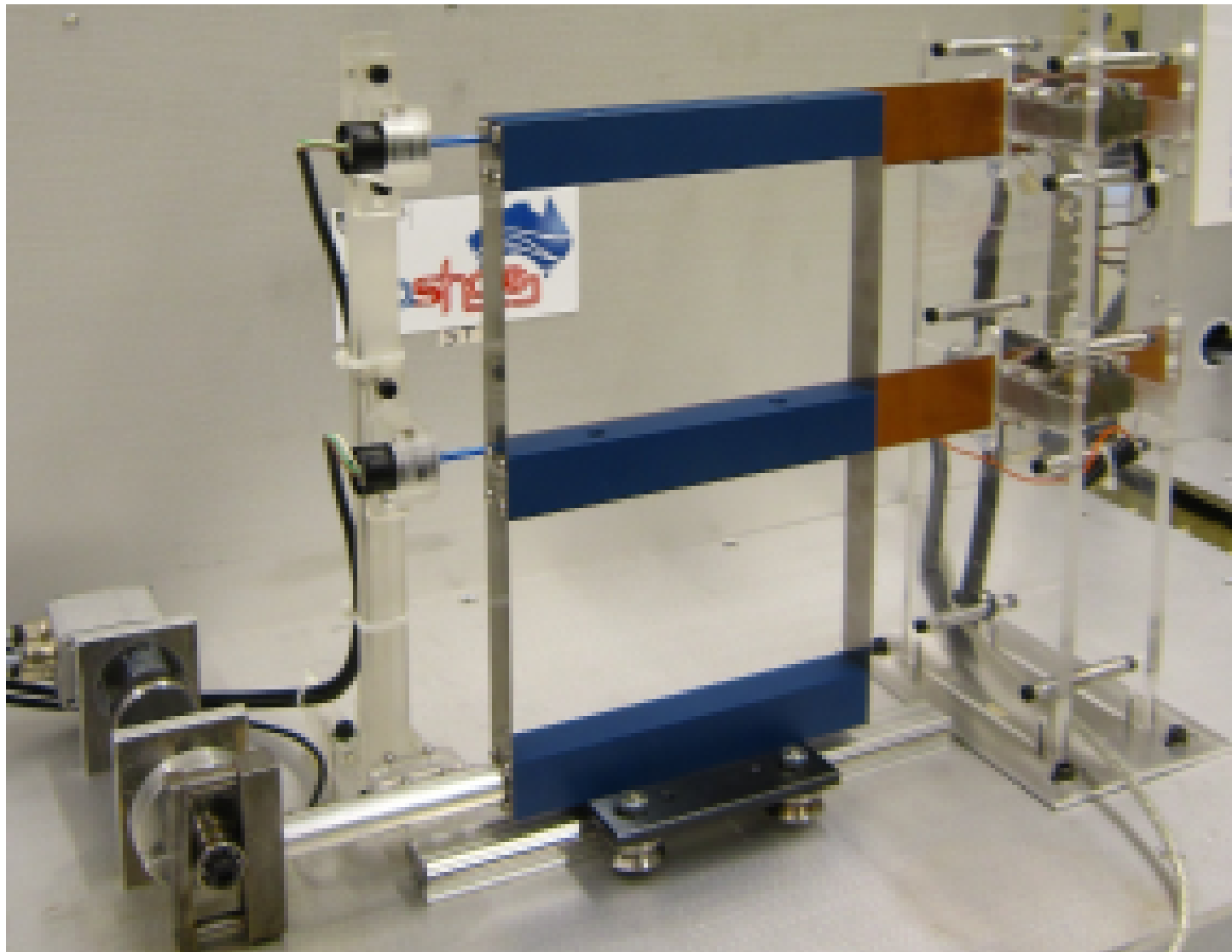
Synchronous Experiments

Synchronous (Interactive) Experiments:

Interactive experiments are those in which the user monitors and can control one or more aspects of the experiment during its execution.

Example: CTI's REL (Remote Electronic Lab). Students can dynamically change the input to the oscilloscope, function generator, power supply and multimeter and watch live data being displayed on the oscilloscope screen as parameters are changed.





What are the tasks of an Online Lab developer?



Typical tasks of a lab developer:



- Design Lab Clients
- Implement Lab-specific UI requirements, RLMS API
- Design Lab Server
- Implement communication with hardware
- Define Client-Server message schema

Specifically for ISA

- Implement the Web Services interface to communicate with the Service Broker
- Develop, deploy and consume SOAP Web Services
- Design Lab Server, queue experiments for execution
- Create/parse experiment specification (could be any format like XML, JSON, etc)
- Design Client-Server message schema

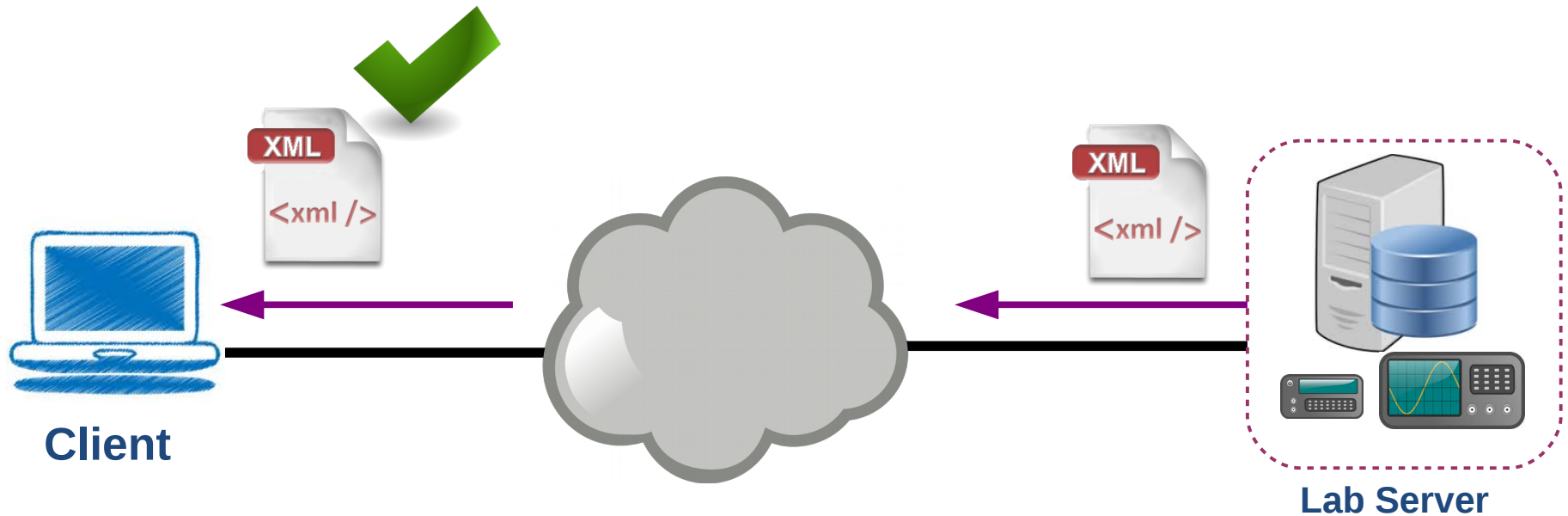
iLABS
Remote Lab Access

Client-Server message schema

Messages passed between Client and Lab Server communicate key lab information.

- Lab Hardware Configuration/Status
- Experiment Parameters & Results

This information is necessarily lab-specific.



Global Initiatives and Projects

The Global Online Laboratory Consortium

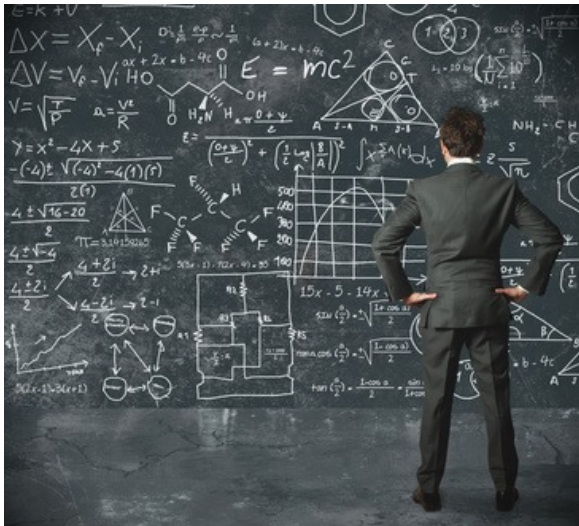


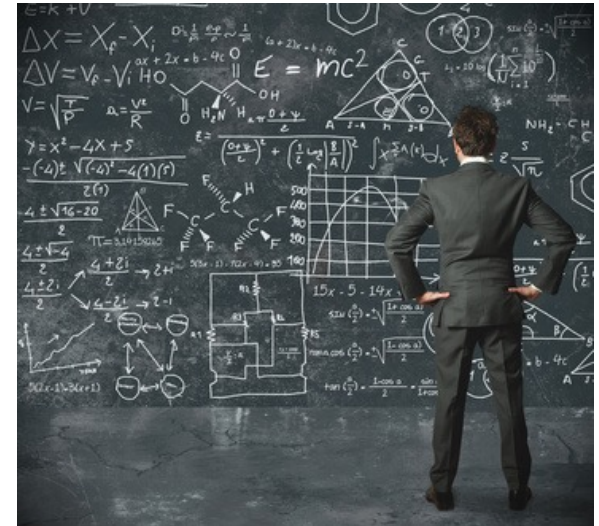
- to encourage and support the creation of new online labs and associated curricular materials;
- **to sponsor the design of an efficient mechanism for sharing, exchanging and trading access to online labs by creation of a global network of shareable experiments**
- to support communities of scholars created around online laboratories; and
- to lead the evolution of an architecture that enables the sharing of online labs by unified standards.
 - We need ..
 - **Common** terminology, **common** metadata schema, **common** APIs ..
 - An effective business model where different roles are taken into account



OnlineLabs4All

The Problem

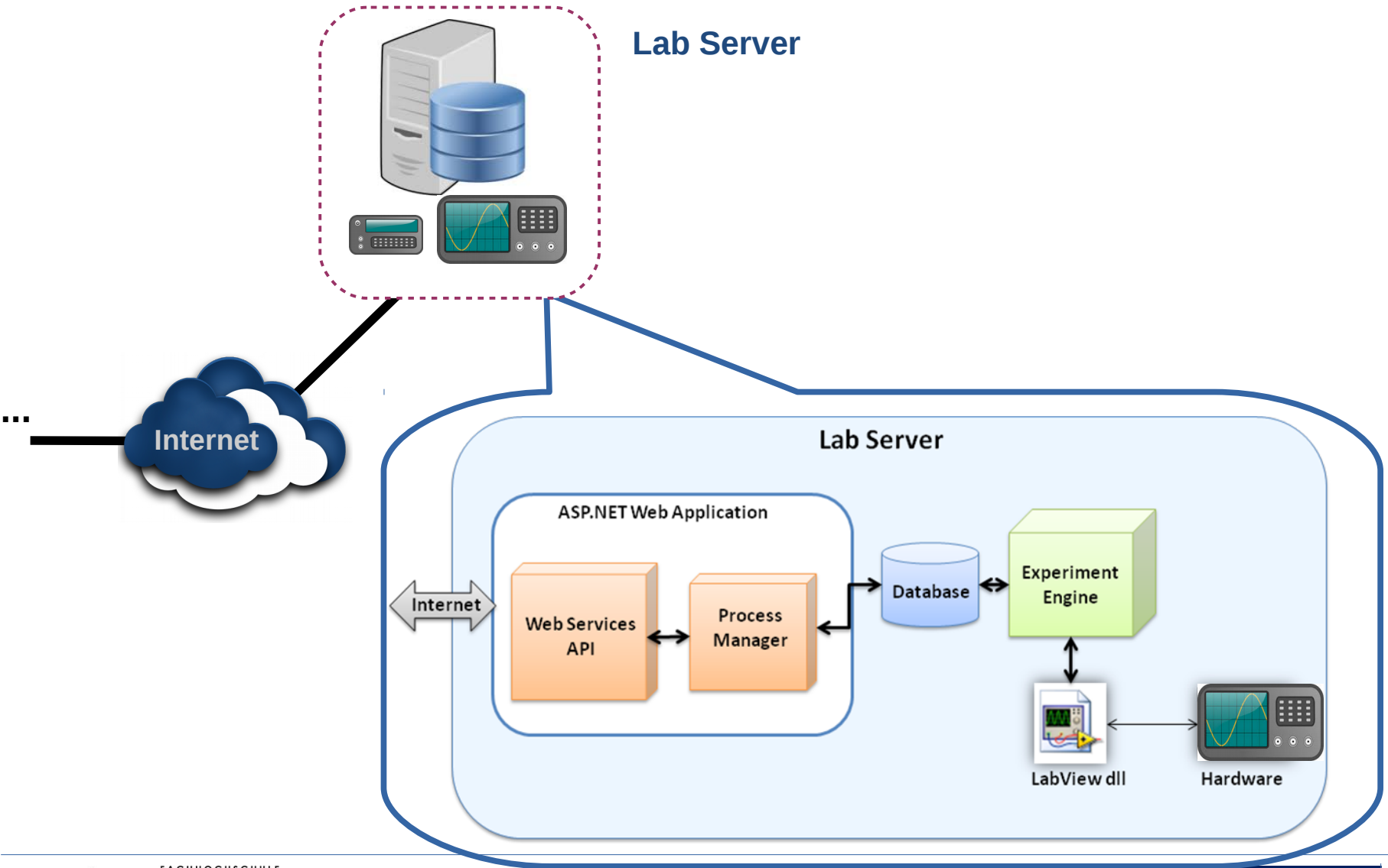
- Developing a new online laboratory is a complex task and requires advanced software development skills
-
- Design Lab Clients
 - Bound by Lab-specific UI requirements, RLMS API
 - Design Lab Server
 - Bound by lab instrumentation, desired functionality
 - Design Client-Server communication framework
-
- 
- A man in a dark suit stands with his back to the camera, looking at a large chalkboard filled with complex mathematical and scientific equations. The chalkboard is covered in white chalk markings, including the equation
- $E=mc^2$
- , chemical structures, and various formulas. The man is standing in the center of the frame, looking at the board. The background is dark, and the chalkboard is the main focus.



And more...

- Ensure proper **ICT infrastructure**
- Ensure proper system security
- Intense collaboration with institution's IT department
- **Reachability:**
 - Lab must be reachable from external network
- **Security:**
 - Online lab should not be affected by firewall and network security policies
- Setup of the server environment respecting institution's **network policies**

Components of a Typical Lab

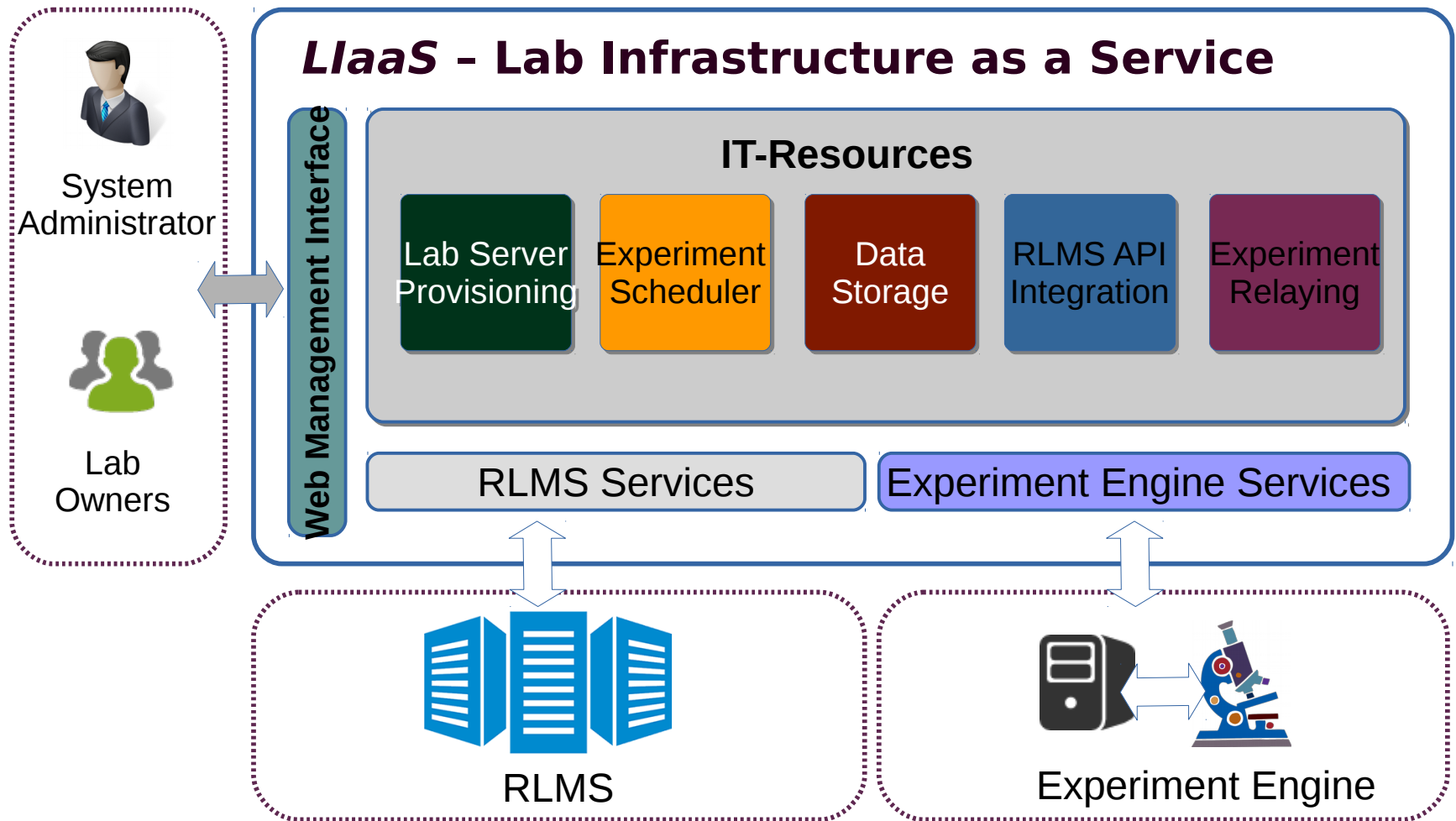


Lab Infrastructure as a Service

- Queuing mechanisms
- Integration with RLMS (iLab)
- Pose zero or at least very few requirements for lab owner
- Do not require extra skills other than the knowledge in their domain of expertise



Lab Infrastructure as a Service

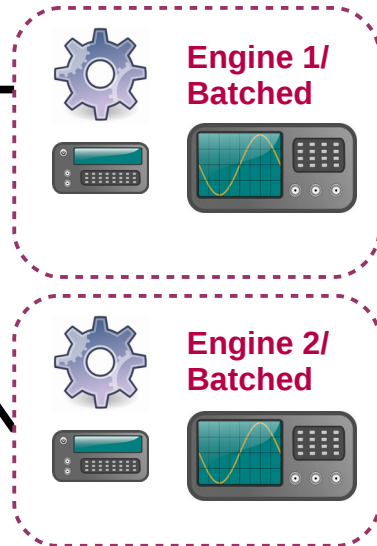


Experiment *Dispatcher*

- **Abstracts several aspects of Online Lab development and deployment:**
 - Integration with RLMS
 - Experiment Queuing
 - Lab Server setup: In the ***Cloud***
- **Publish/Subscribe** Pattern for experiment execution.
- Batched Labs: multiple subscribers are possible, what creates a built-in support for ***load balancing***
- Support for **interactive** (or synchronous) experiments by providing a virtual channel between lab server and client over WebSockets

Experiment *Engine*

Subscribers:



- **Subscribers** or Experiment Engines can be kept very simple and lightweight.
- Don't need to queue and store experiments, since this is done in the Cloud.
- Only task is to process experiments.
- Must subscribe for execution of experiments from one Lab Server.
- Communicate via a simple RESTful Web Services API.
- Checks for new experiments by polling via the REST WS API.
- Subscriber Engines are registered and receive an API key.

Templates for several platforms

Subscribers:

RESTful WS API



Microsoft
C#.net



- Toolkits in different development platforms will be offered to lab owners:

- LabVIEW
- PHP
- C#
- Java
- Python
- ..

Demonstration

The Go-Lab Project



GO-LAB

Global Online Science Labs for
Inquiry Learning at School

Objective:

Supporting European wide federation and use of remote laboratories and virtual experimentations for learning and teaching purposes.

The Go-Lab project will open up remote science laboratories, their data archives, and virtual models (“virtual labs”) for large-scale use in education. Go-Lab enables science inquiry-based learning that promotes acquisition of deep conceptual domain knowledge and inquiry skills and directs students to careers in science.

The Go-Lab Project

- Session 1 Go-Lab EU Project • Nov 2012 • 4 years • 10M€
- Global Online Science Labs for Inquiry Learning at School
- Objective: Raise interest for and stimulate carriers in STEM using online labs (remote labs • virtual labs • scientific data)
- Pedagogical Coordinator: University of Twente
- Technical Coordinator: EPFL

STEM Education at School (10-18)
Science, Technology, Engineering, and Mathematics

Technology
Online Labs

Community
School Networks

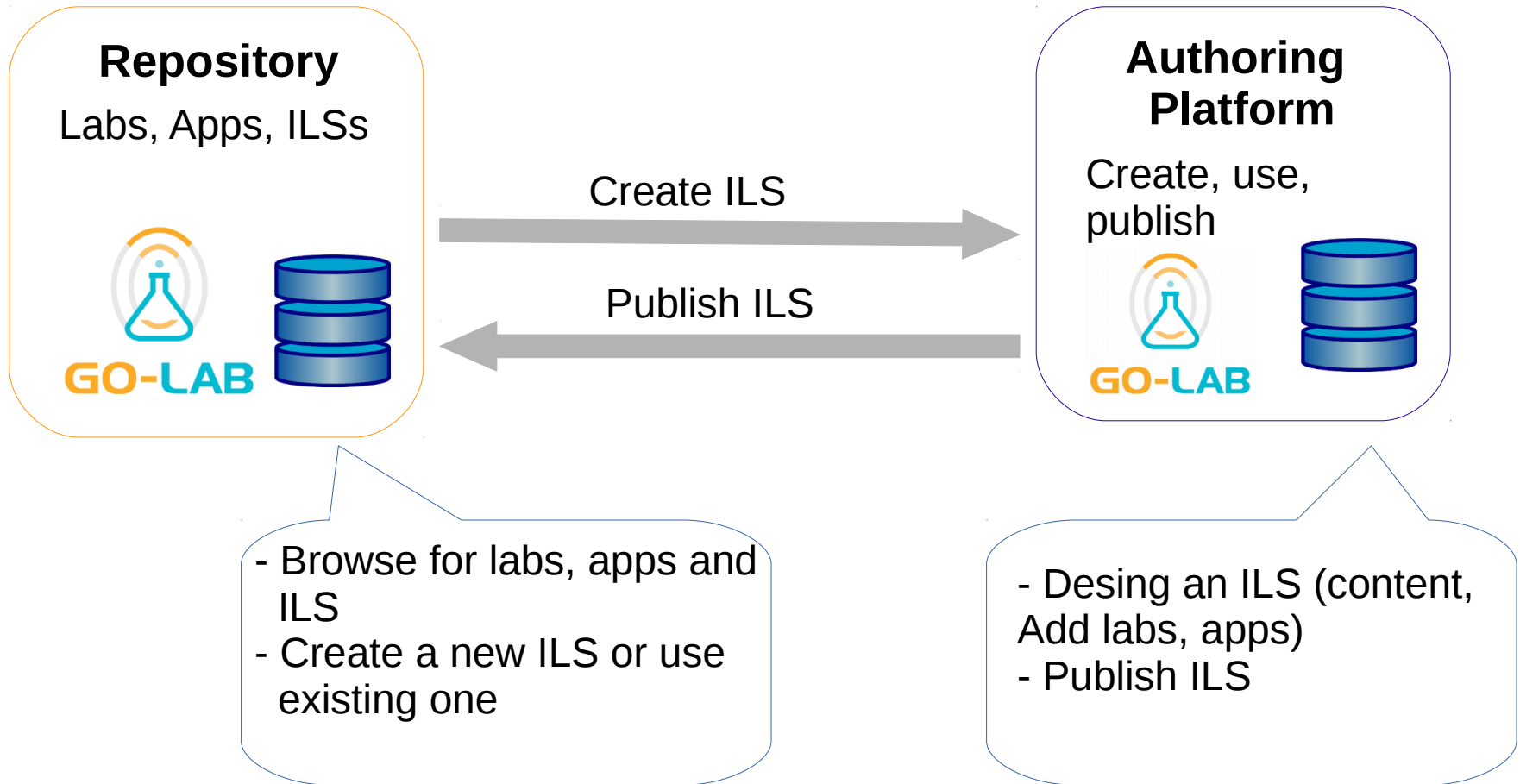
Pedagogy
Inquiry Learning

The Go-Lab Project: Core Principles

- **Pedagogy:** Focus on inquiry learning sessions relying on online labs and preserving teacher's role, scenarios and modalities
- **Technology:** Select the most simple existing technology and rely on existing repositories (resources and online labs)
- **Communities:** Build on existing outreach activities, domain leaders, early adopters, and teacher networks (European Schoolnet)
- **Scientific Hubs:** Federate existing resources in a single portal providing a coherent user experience (CFRN, FSA, ...)



Repository and Authoring Tool

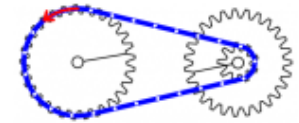
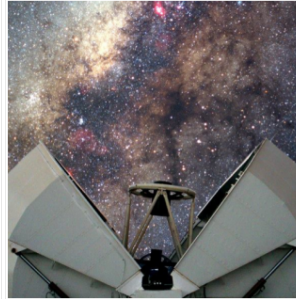
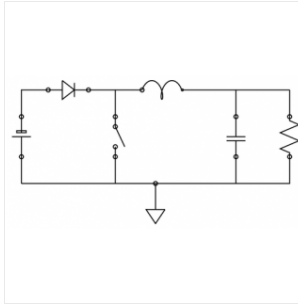
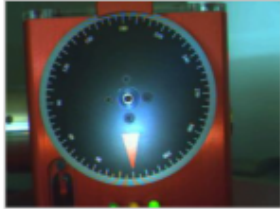


Repository and Authoring Tool

<http://golabz.eu>



Labs



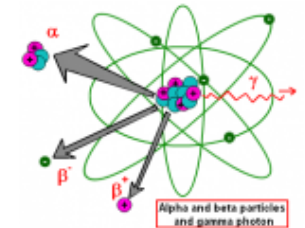
Black Body Radiation

Planck's Law:

$$q_{\lambda} = \frac{2\pi c^2 h \lambda^{-5}}{e^{hc/\lambda kT} - 1}$$

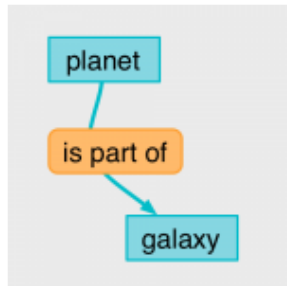
you plug in T and λ
 h is Planck's constant
 k is Boltzmann's constant
 c is the speed of light

This is the equation that led to quantum mechanics



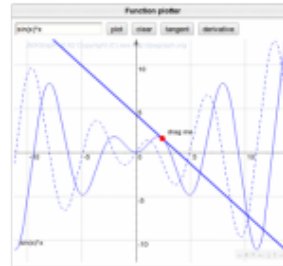
Apps

Concept Mapper



Periodic Table

Function Plotter



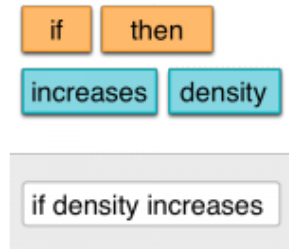
Wiki gadget



Mindmeister Widget



Hypothesis Tool



Check Spelling

Scratchpad

Scratch pad
Tasks:
1) Buy groceries
2) Wash my car
3) Call T-Mobile service
Last saved on Wednesday, November 25, 2009 3:59:02 PM

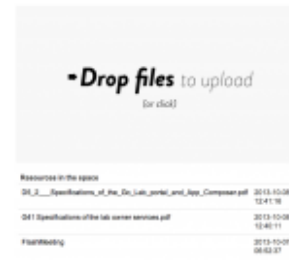
Sysquake

Sysquake Mobile

```

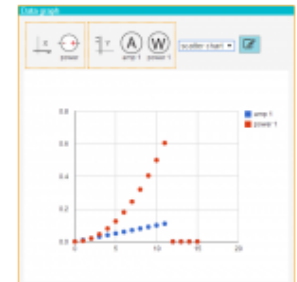
Sysquake js 1.0
x = 0;pi/15;4*pi;
y = -exp(2*cos(x));
plot(x,y,'r+');
  
```

File Drop



Questioning Scratchpad

Data Viewer



How can you use Go-Lab?



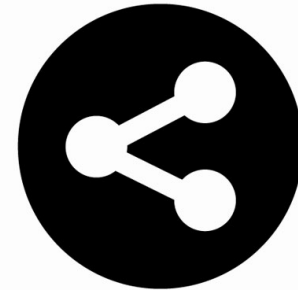
- If you are a school teacher:
 - Go ahead and use it with your students!
 - www.golabz.eu



- If you are a lab owner:
 - Share your labs with the Go-Lab community!
 - Use all Go-Lab features

How to share your labs with Go-Lab

1. Redesign according to the Smart device paradigm
2. Sharing via the *Smart Gateway*



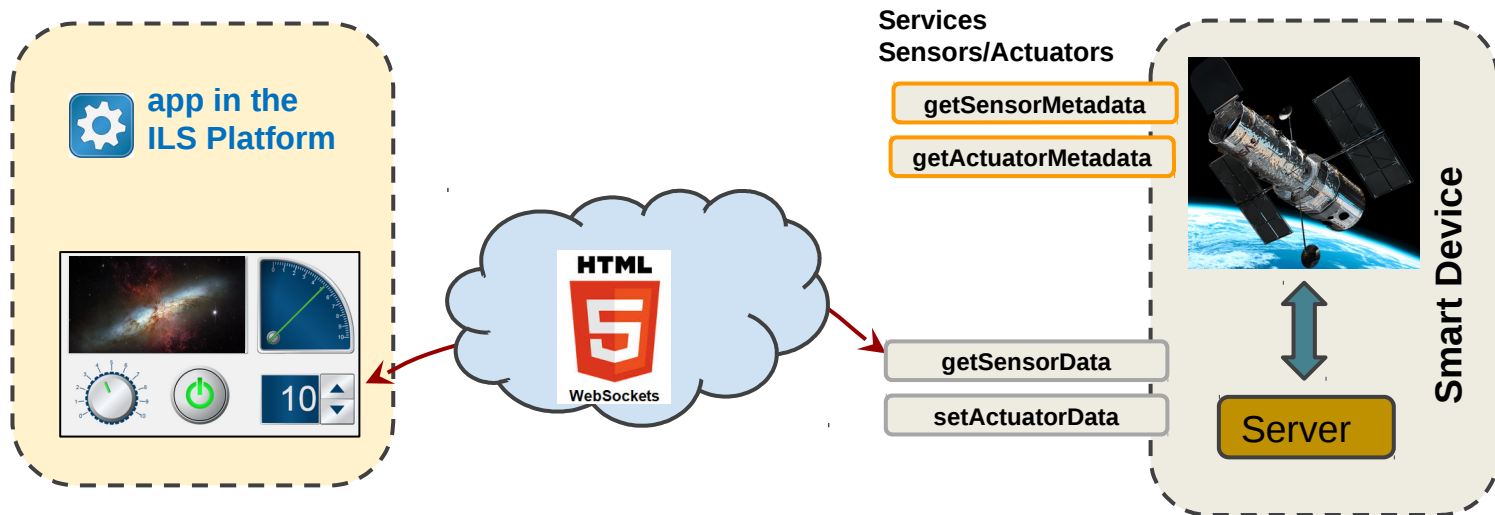
The Smart Device Specification

➤ Metadata Service

- Used by the app client for discovery and adapt to an specific client
- Describes the Smart Device in terms of sensors/actuators supported, data types, etc.

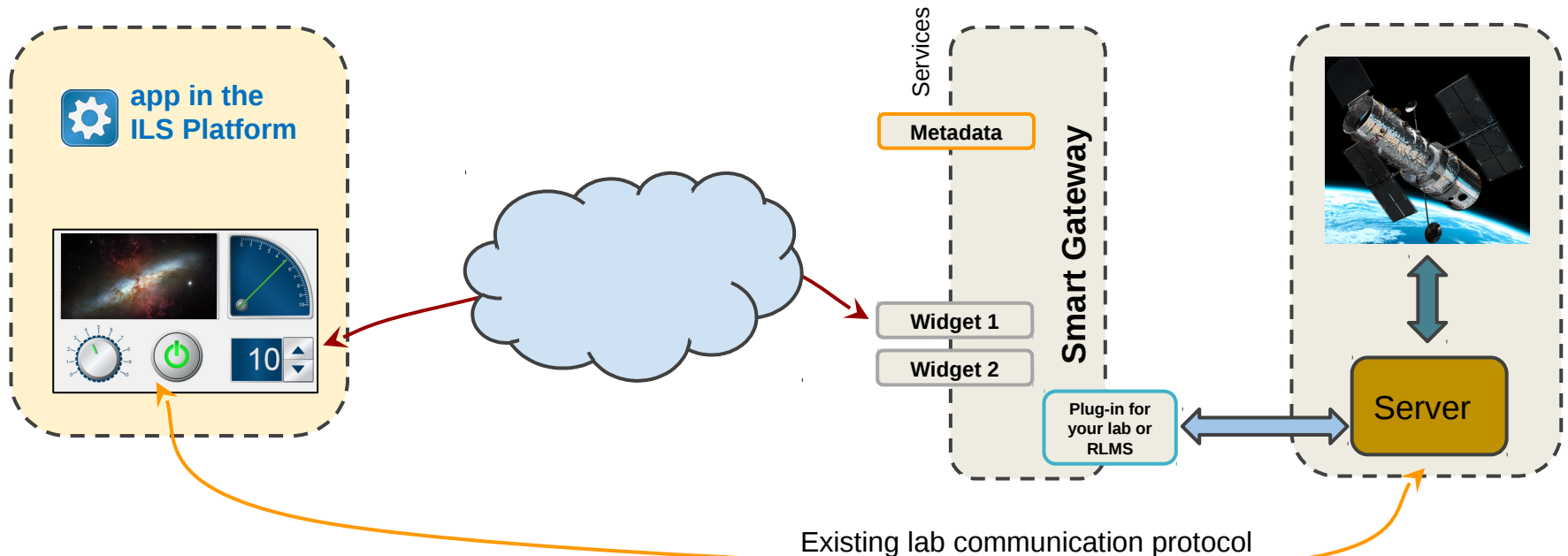
➤ Sensor/Actuator Services

- Used by the app client to send/receive data (measurements, etc)



Integrating Labs into the Go-Lab ecosystem

- Packages existing lab clients in an OpenSocial container
- Manages authentication with the Remote Laboratory systems

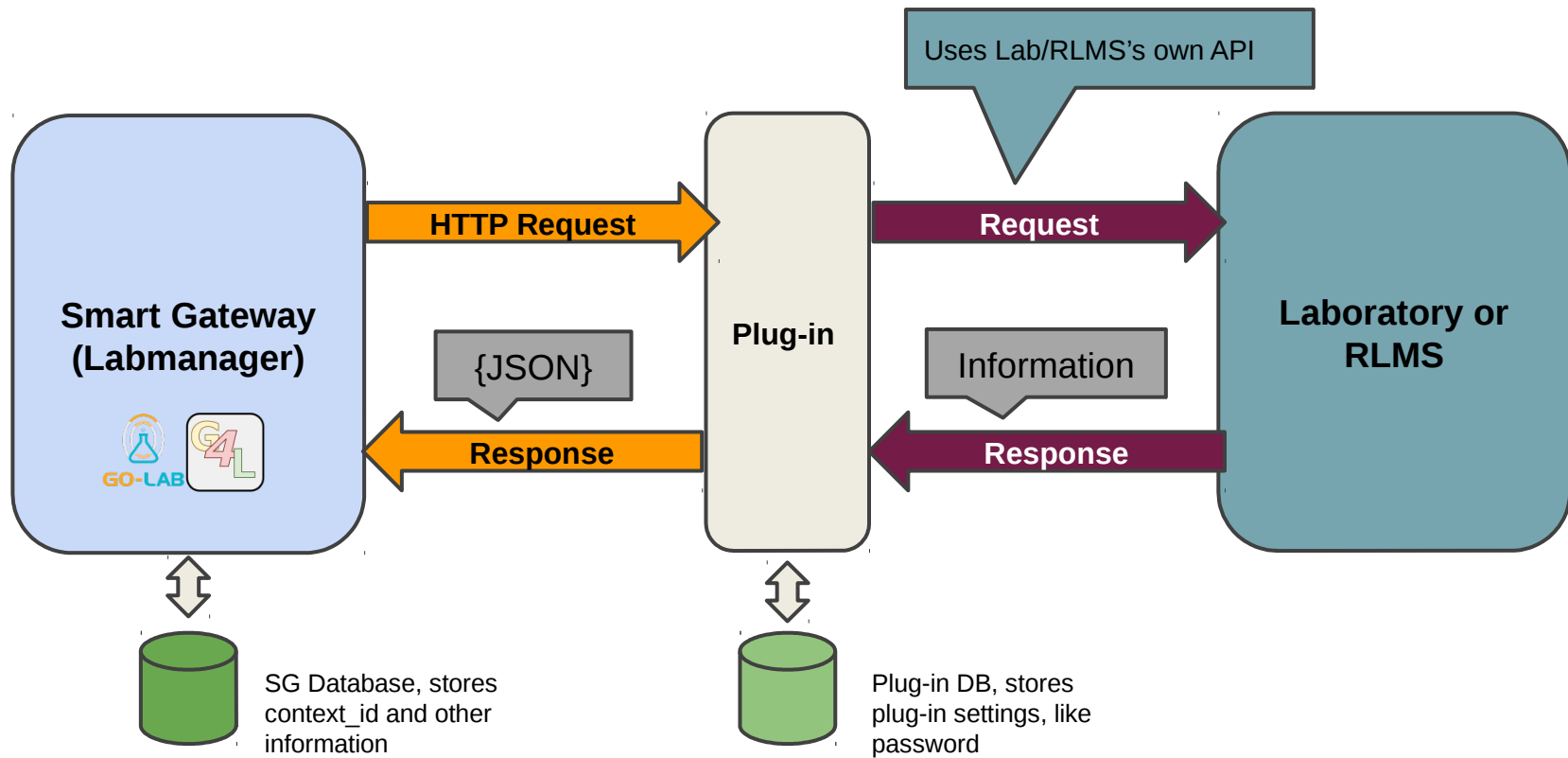


- No need to rewrite client/server
- Smart Gateway steps out of the scenes after serving widgets and authenticating user against lab system - no delay added
- Lab native client is used

Advantages for Lab Owners

- Go-Lab Ecosystem support
- Visibility
- App Composer Translator
- Logging mechanism
- Outside:
 - LMS support

Developing an HTTP plug-in



Thank you!

IAOE.

