

eTEE 2019, Gdańsk, Poland, September 19, 2019 – Janusz Zalewski

Google

Building 41

**Creating Networked Smart Learning
Objects for Online Laboratories
according to IEEE Std 1876**

Janusz Zalewski

**Dept. of Software Engineering
Florida Gulf Coast University**

Secretary

IEEE Std 1876 Working Group

zalewski@fgcu.edu

Preamble

- **Creation Process**
- **Learning Objects**
- **Online Labs**
- **IEEE Standards**



Talk Outline

- **Motivation for Online Labs**
- **(Smart) Learning Objects**
- **Interface Calls (Standardized)**
- **How To Make an Online Lab?**
- **Conclusion**

Motivation #1

Motivation – Why is this important?


Computer systems are controlled remotely in the most demanding real-time safety-critical applications, such as:

- **flight control systems**
- **accelerator control**
- **space missions**
- **road vehicle control, etc.**

Motivation #1



Remote Vehicle Control

 **Fermilab**

Managed by Fermi Research Alliance
For  Office of Science/US Department of Energy

Motivation #1



Remote Accelerator Control (LHC)

Motivation #1

Remote Accelerator Control (LHC)

Motivation #1



Pathfinder Mission to MARS

Courtesy NASA Jet Propulsion Laboratory

Motivation #1

Ames Campus

T-35

T35 Complex
Intelligent
Systems Division

Wind Tunnel at NASA Ames



Motivation #2

STEM

- Science
- Technology
- Engineering
- Mathematics



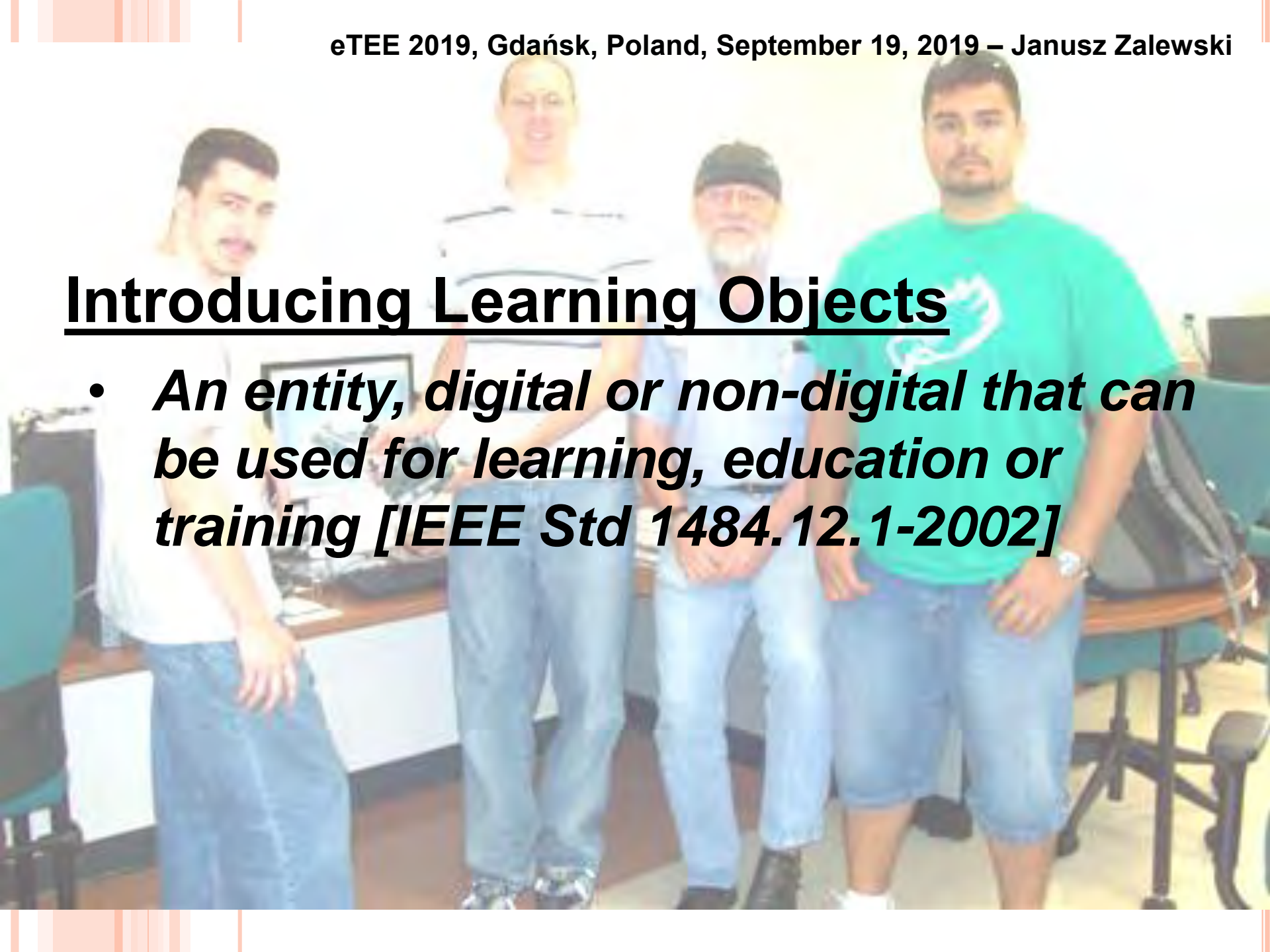
Motivation #3

Labs in typical engineering curricula:

- **may have difficulties with operating and maintaining appropriate H/W and S/W**
- **hardware and system software often require knowledge of device architecture combined with low-level programming**
- **significant attention has to be paid to technical support, rarely available at the college level.**

Introducing Learning Objects

- *An entity, digital or non-digital that can be used for learning, education or training [IEEE Std 1484.12.1-2002]*



Introducing Learning Objects

- *An entity, digital or non-digital that can be used for learning, education or training [IEEE Std 1484.12.1-2002]*
- *An entity (most commonly, a device) encapsulating certain educational functions*

Introducing Learning Objects

- ***Examples: cell phone, robot, website***
- ***Accessible only via its well defined interfaces, that is, functions to perform pre-determined learning activities***
- ***A student interacts with an LO only by using interfaces.***

Introducing Learning Objects

- *Electronic boards*
- *Robotic devices*
- *Wireless sensor networks*
- *Solar plants*
- *Others: webpages, modules*

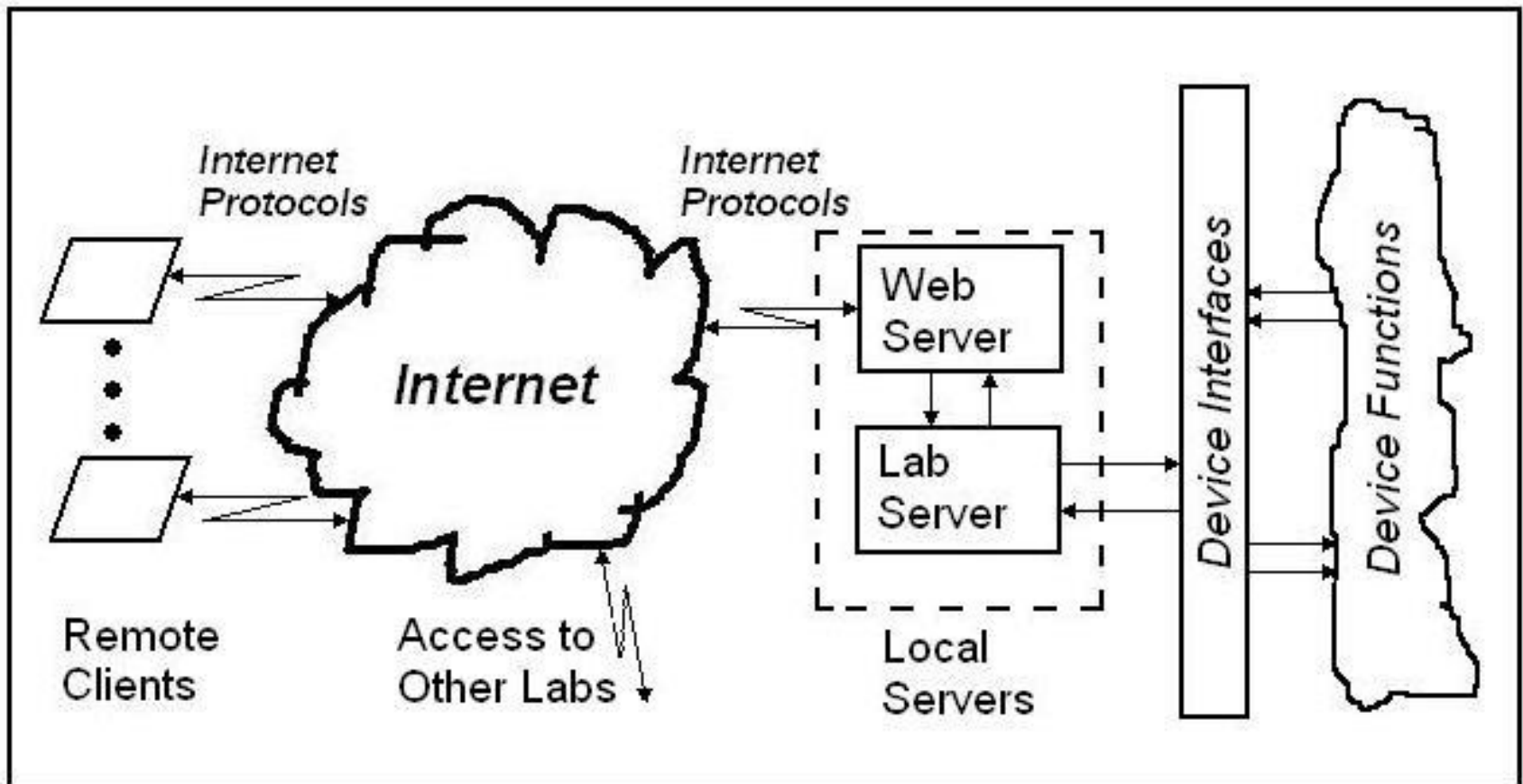
Introducing Learning Objects

- *Electronic boards*
- *Robotic devices*
- *Wireless sensor networks*
- *Solar plants*
- *Others: webpages, modules*
- *Textbooks*

Introducing Learning Objects

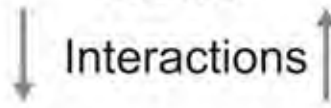
- ***IEEE Standards Association***
- ***IEEE Std 1876-2019***
- ***Developed by Working Group P1876
Networked Smart Learning Objects
for Online Laboratories***
- ***<http://iee-sa.centraldesktop.com/1876public>***

Introducing Learning Objects

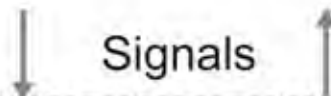




Users

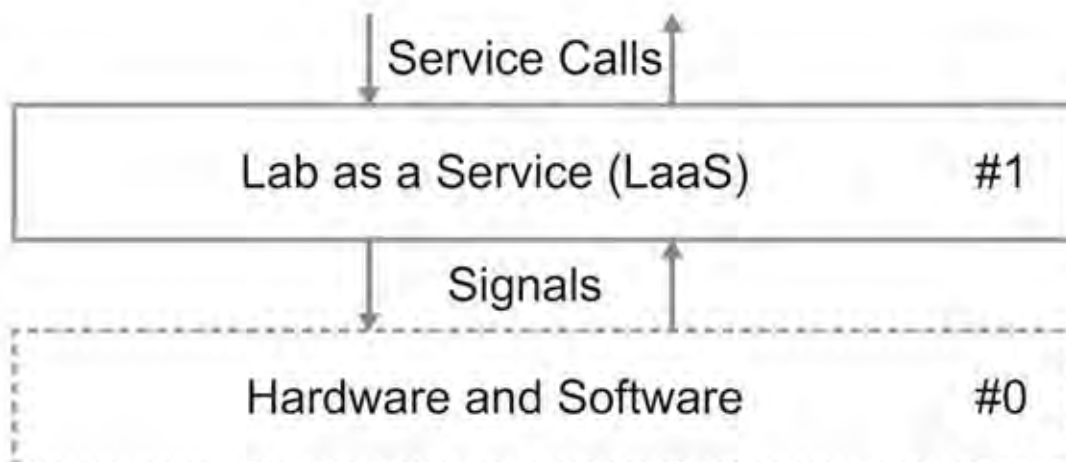
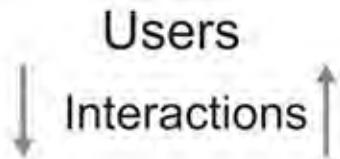


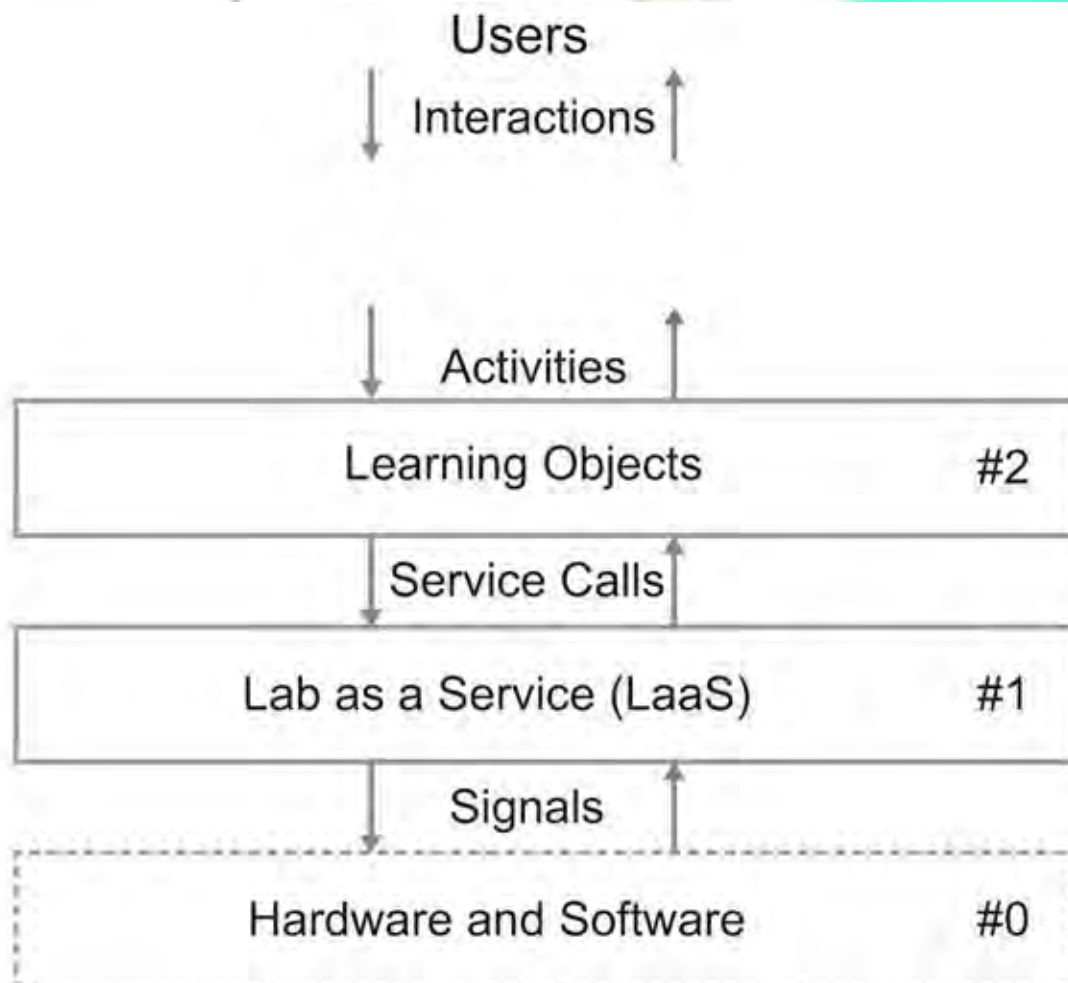
Signals

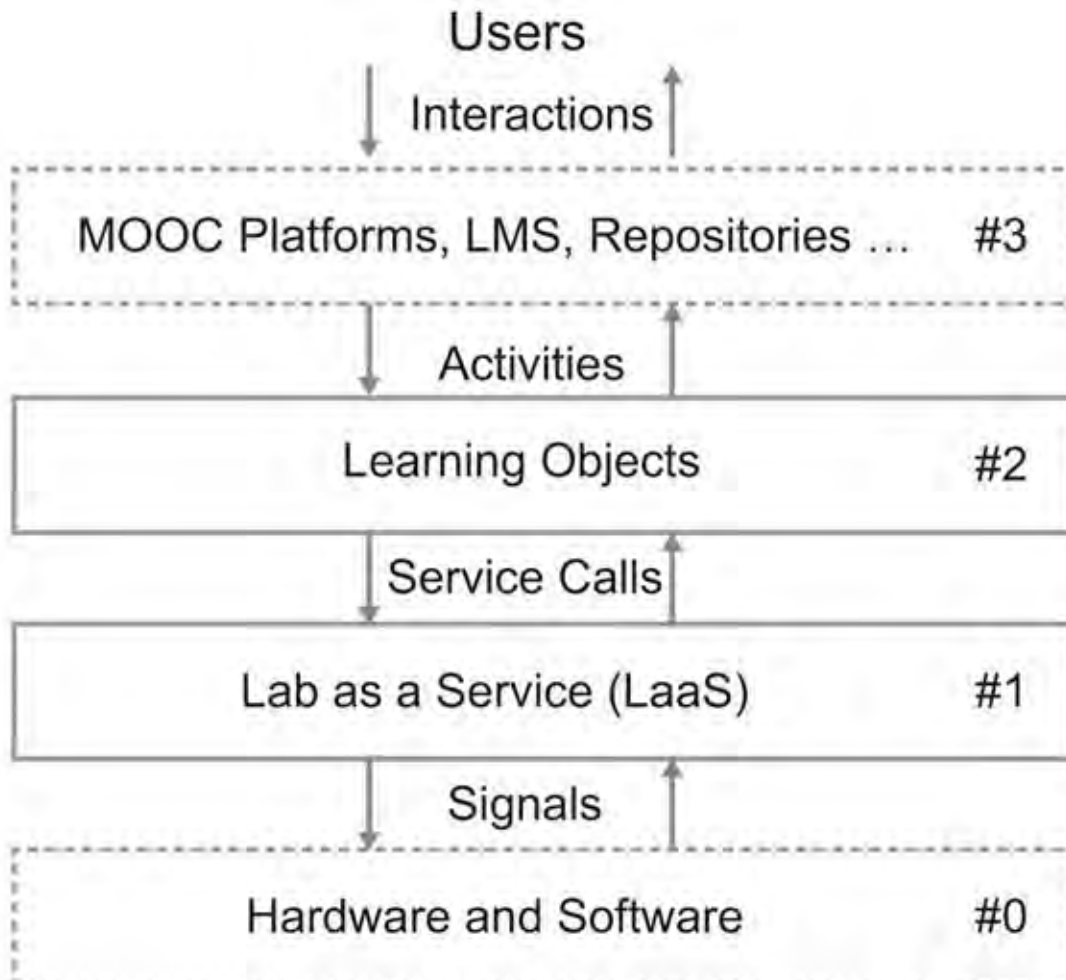


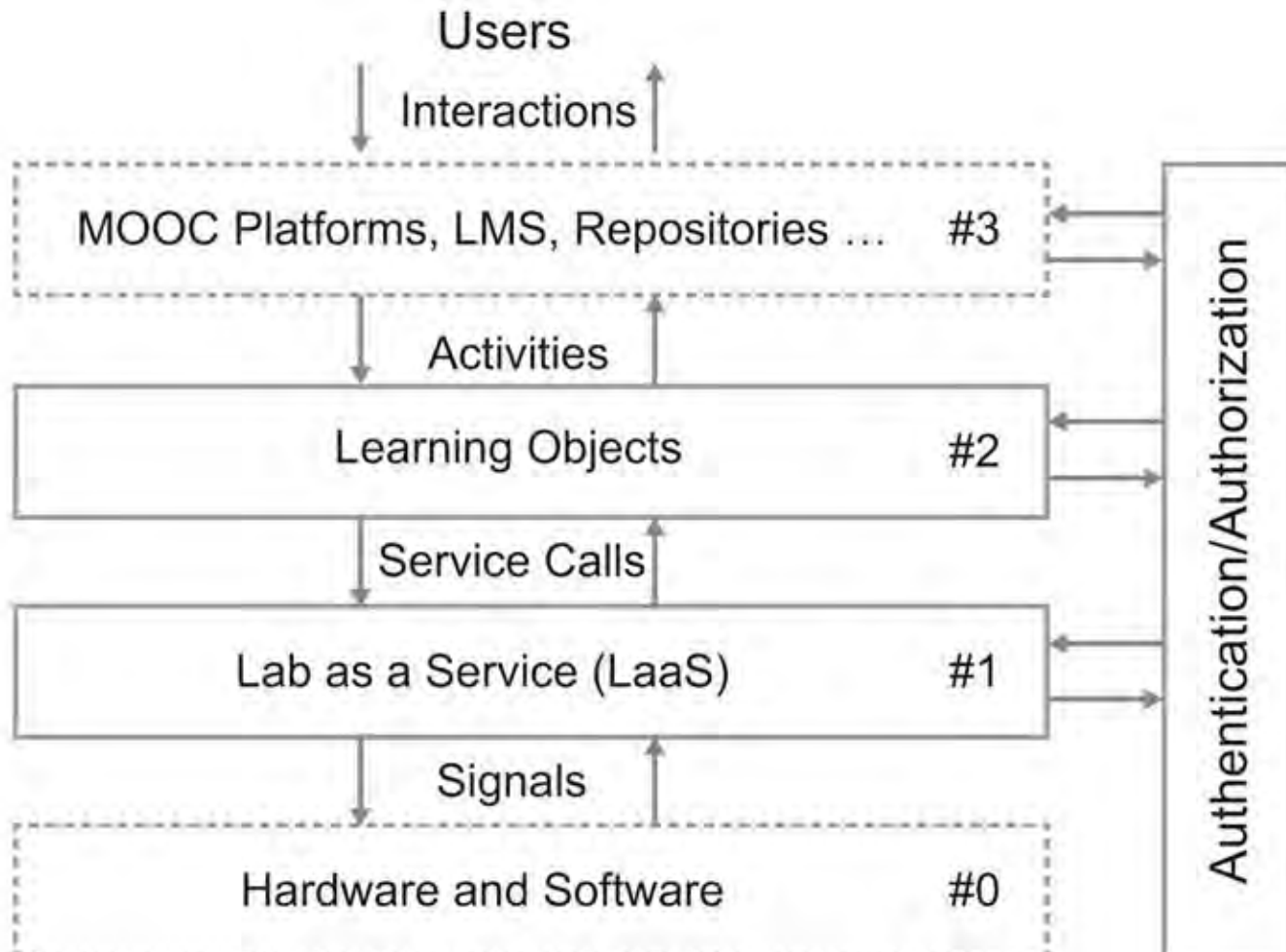
Hardware and Software

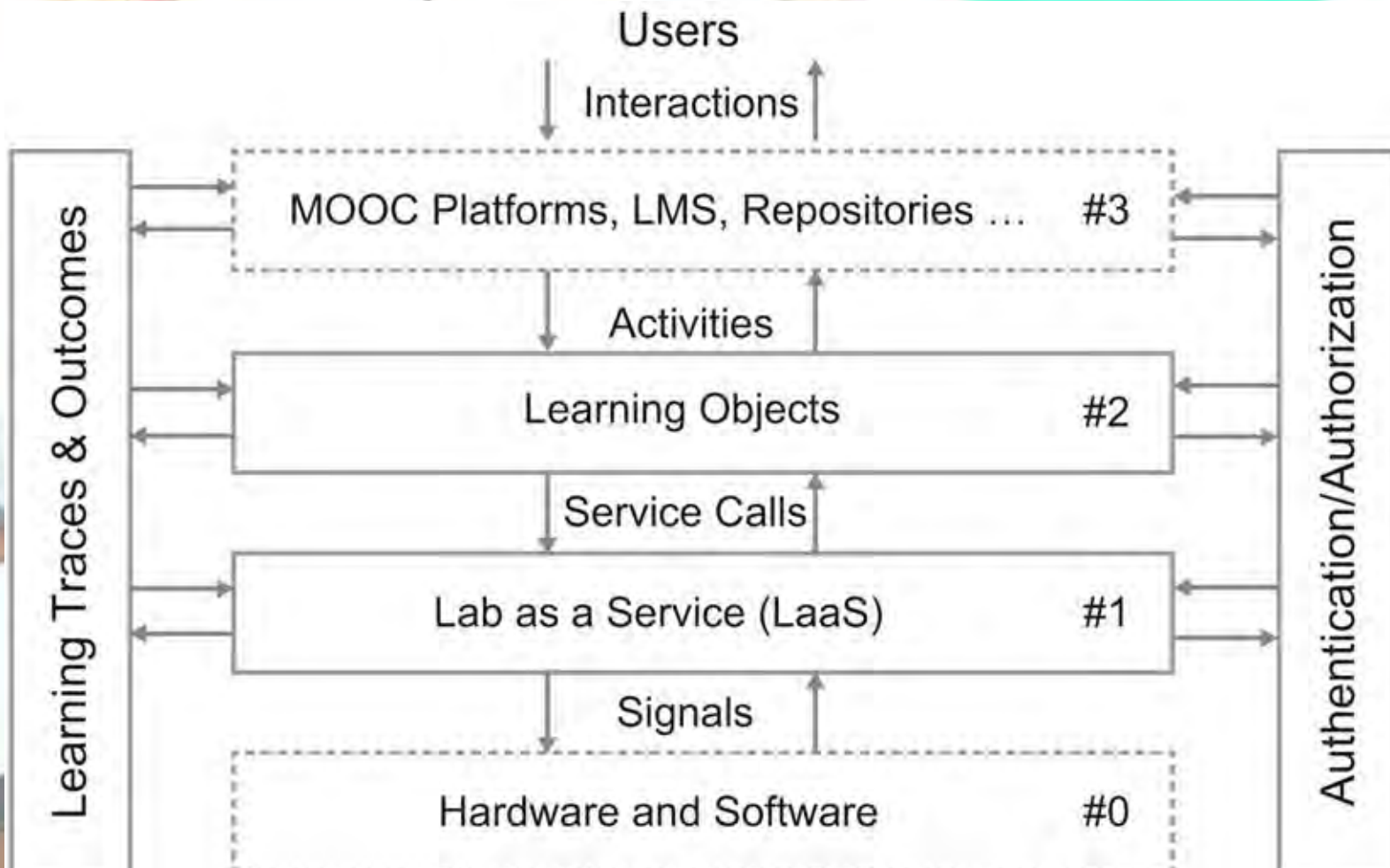
#0











Required Services

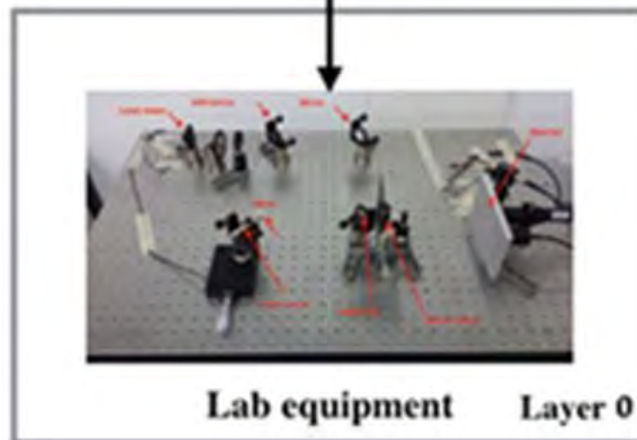
- `getSensorMetadata()`
- `getSensorData()`
- `getActuatorMetaData()`
- `setActuatorData()`
- `getConfigurasion()`
- `setConfiguration()`

Optional Services

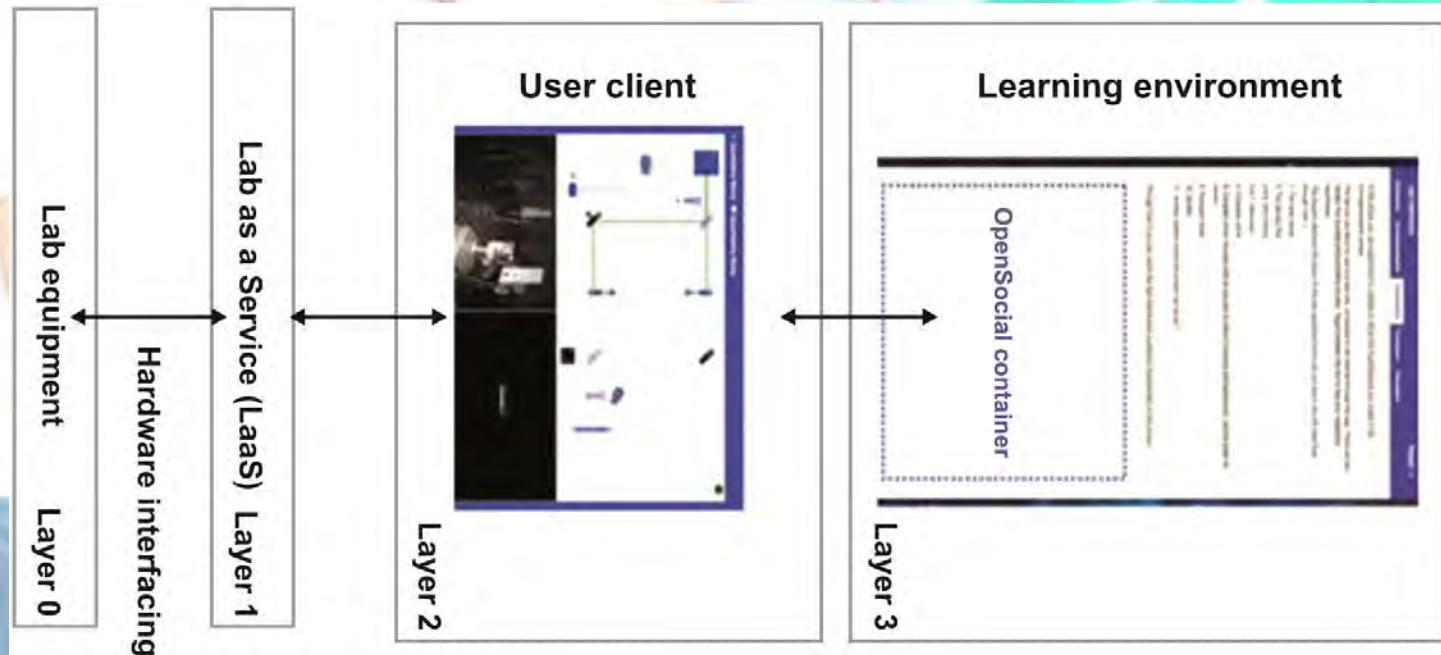
- `getClient()`
- `getExperiment()`
- `getLoggingInfo()`
- `setModels()`



Hardware interfacing

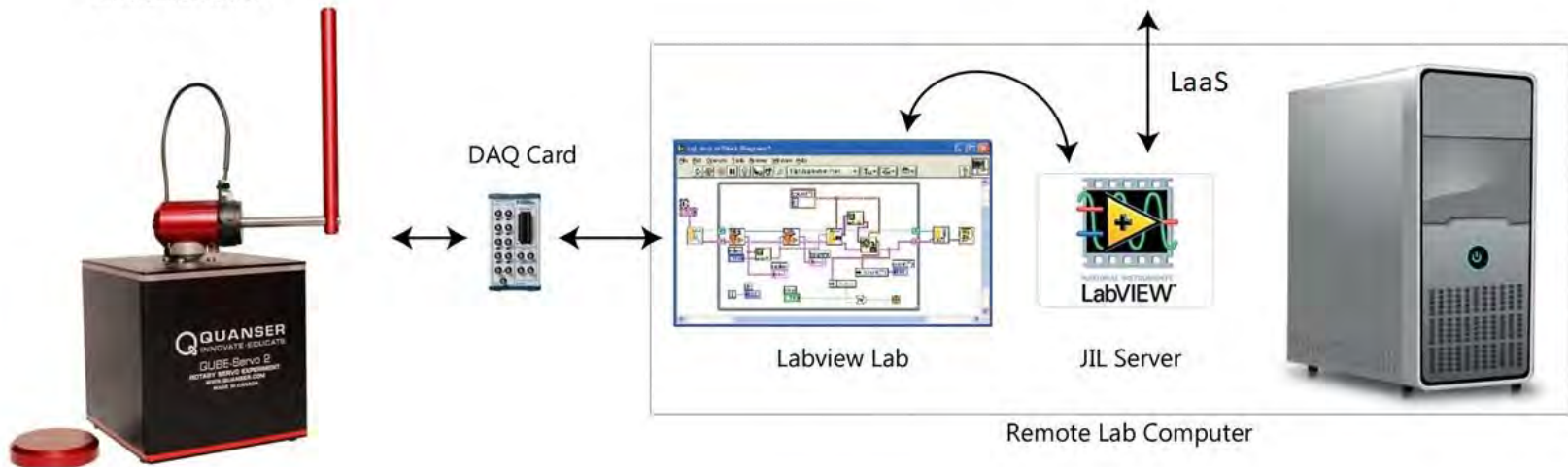


First Layer of the Mach-Zehnder Interferometer in Graasp.



Second and Third Layers of the Mach-Zehnder Interferometer.

Instrumentation



Furuta Pendulum Lab Setup as LaaS.

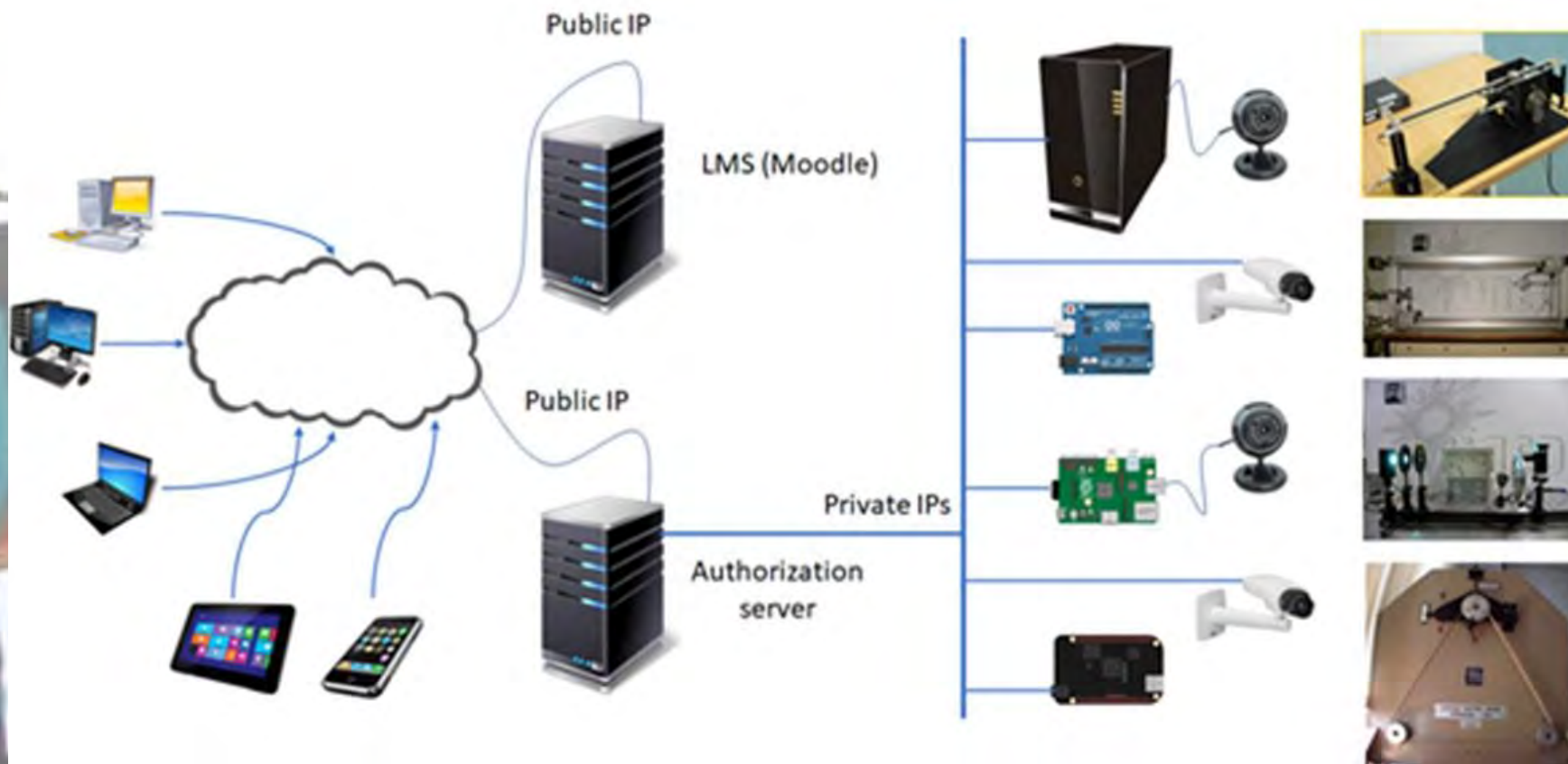
The screenshot displays the LabVIEW software interface for the Furuta Pendulum Lab. At the top left, there is a photograph of the physical pendulum system, which consists of a red motor mounted on a white box with a circular logo. Below the photo, the control panel features a 'Period (s)' slider set to 0.010 and a 'Reference' slider set to -1.1. There are 'Disconnect' and 'Run code' buttons. The right side of the interface shows a plot window titled 'grafico' with a single data series 'alpha' plotted as a horizontal line at approximately 3. The x-axis is labeled 't' and ranges from 0 to 30. Below the plot is a code editor with the following blocks:

```
start data collection
set DefaultController to false
replace function controller
input parameters: alpha, beta, dalpha, dbeta, betaRef
code set u to 0
return 0
```

On the right side of the code editor, there is a 'create chart' block for 'grafico' with the following configuration:

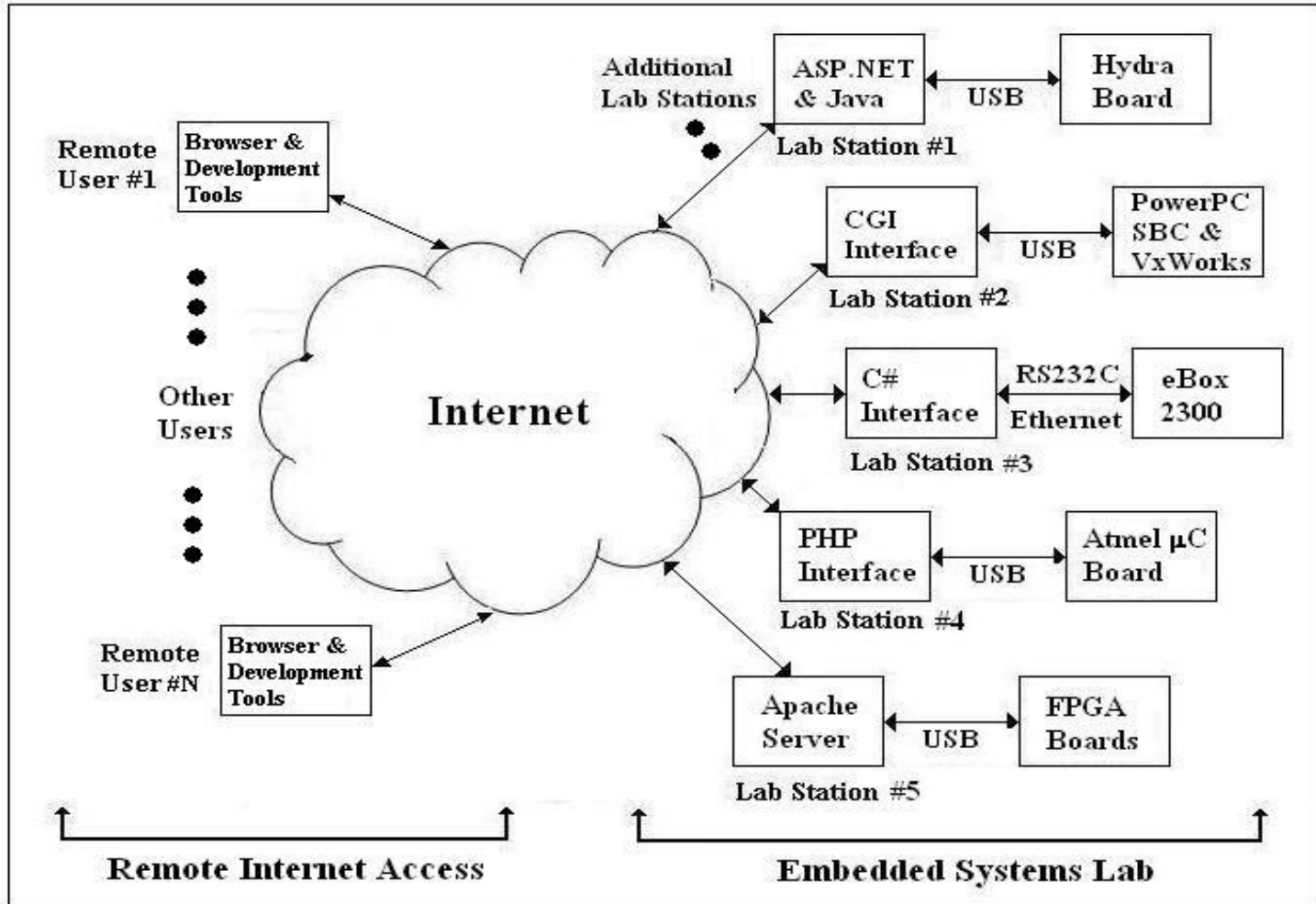
- options: plot every 1000 milliseconds, only the last 100 values (checked)
- data: x axis t, y axis alpha

Learning Object and Its Interface in Furuta Pendulum Lab.



Overall Architecture of the Furuta Pendulum Lab

FGCU CPS Lab Architecture

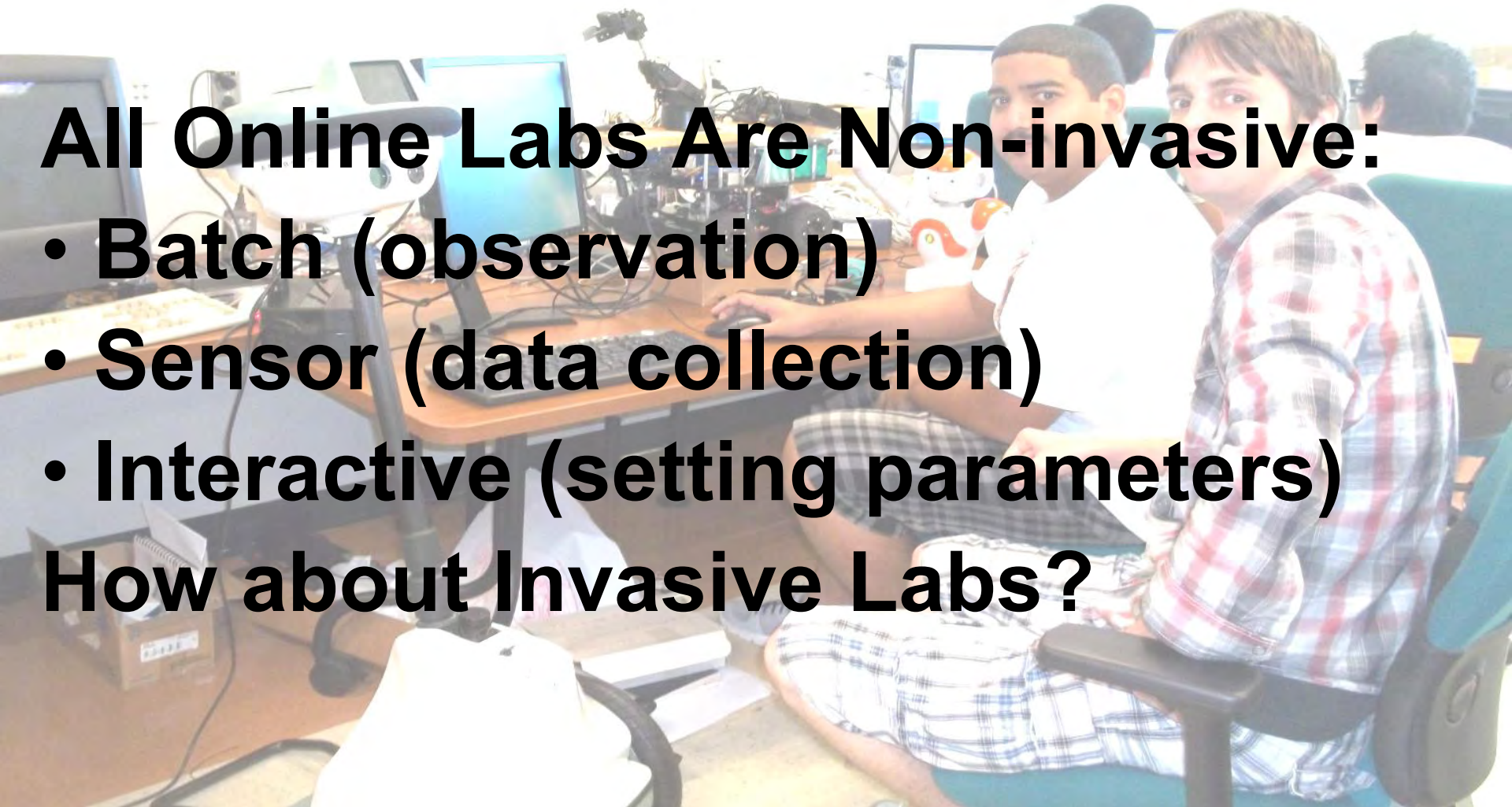


Lab Devices: Remote Access

All Online Labs Are Non-invasive:

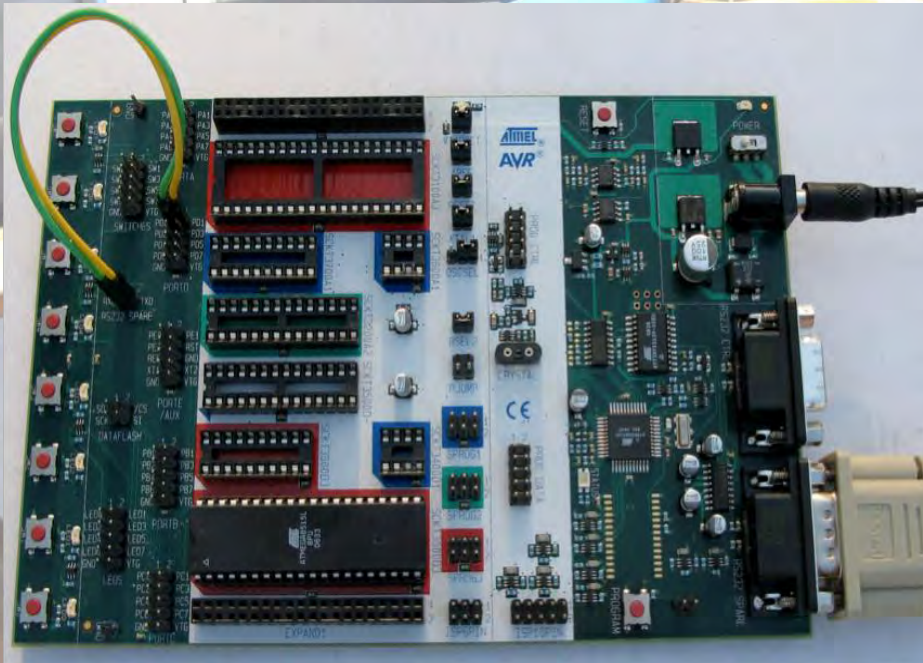
- **Batch (observation)**
- **Sensor (data collection)**
- **Interactive (setting parameters)**

How about Invasive Labs?



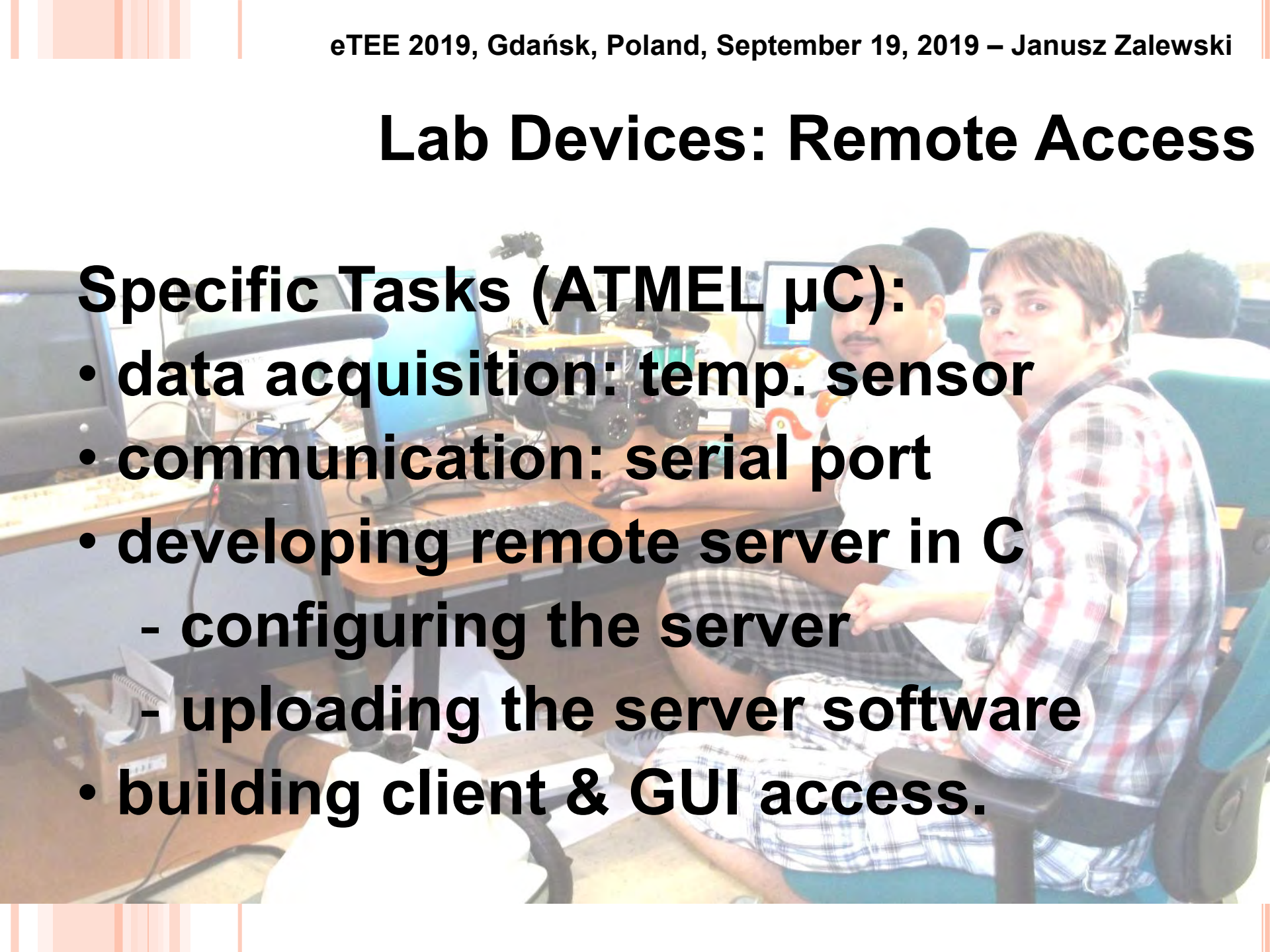
Lab Devices: Remote Access

Remote Microcontroller Access



Lab Devices: Remote Access

Specific Tasks (ATMEL μ C):

- data acquisition: temp. sensor
 - communication: serial port
 - developing remote server in C
 - configuring the server
 - uploading the server software
 - building client & GUI access.
- 

Networking VxWorks Real-Time Kernel for Data Acquisition



Wind River's Single Board Computer

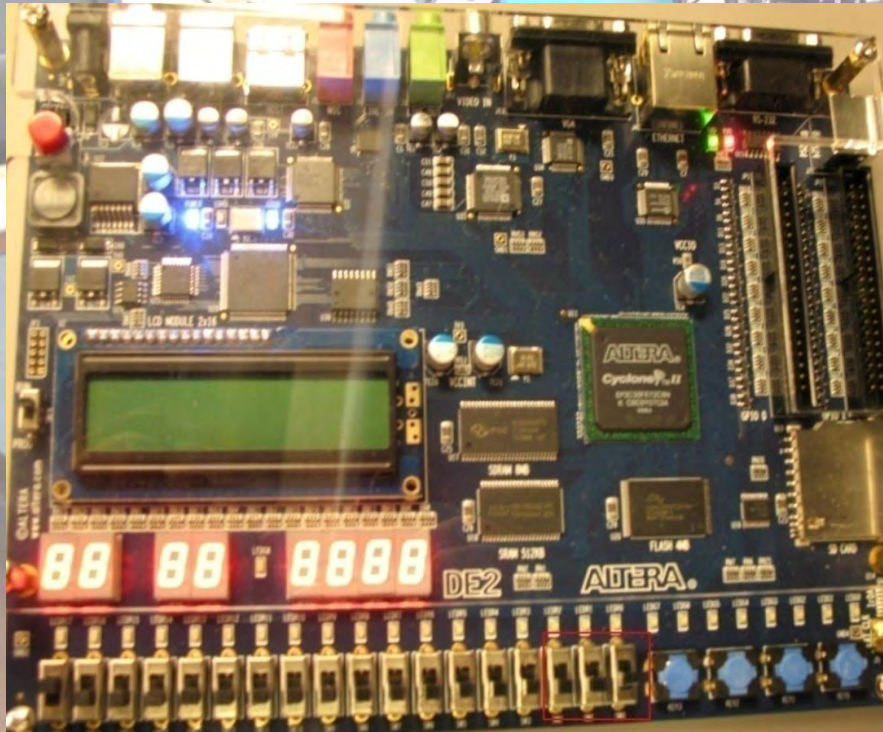


Networking VxWorks for Remote Testing

Specific Tasks (VxWorks):

- embedded controller: PowerPC
- communication: sockets & RPC
- double role of the project
 - programming under VxWorks
 - web access development for test
- data acquisition devices.

Web-based FPGA Lab

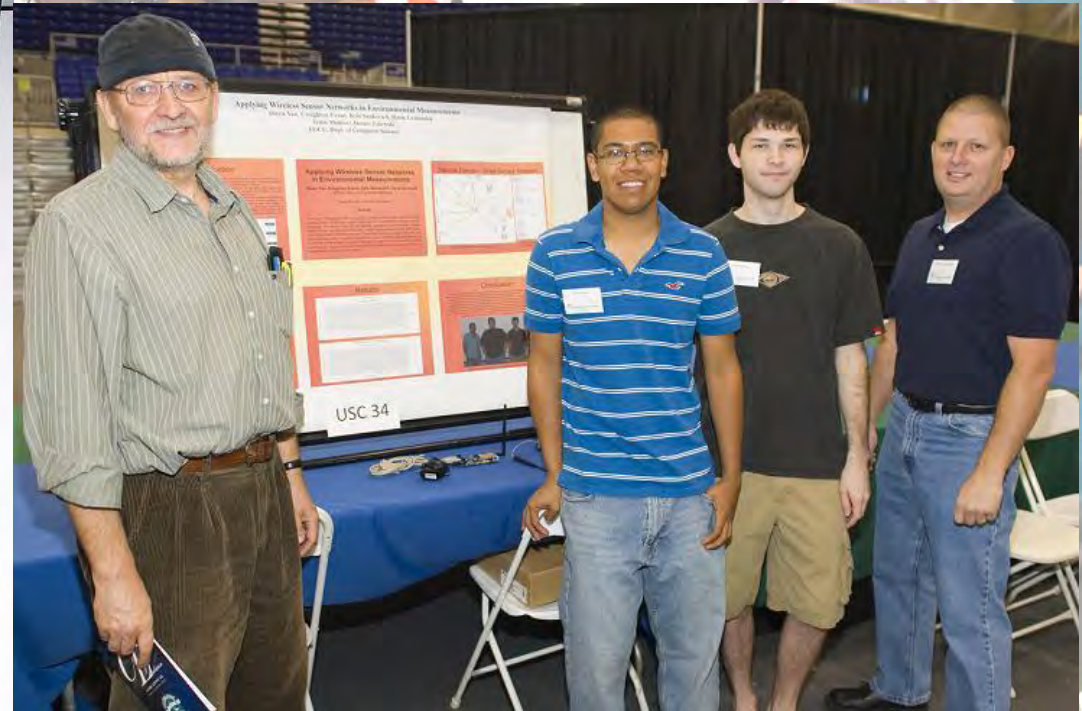
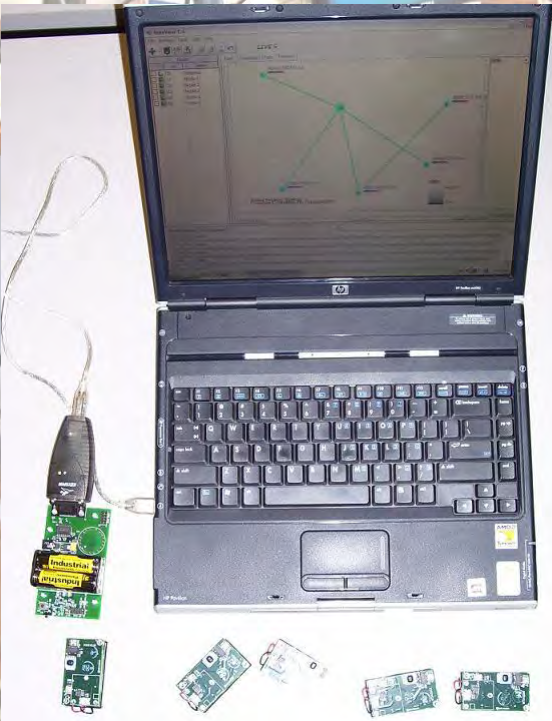


Web-based FPGA Lab

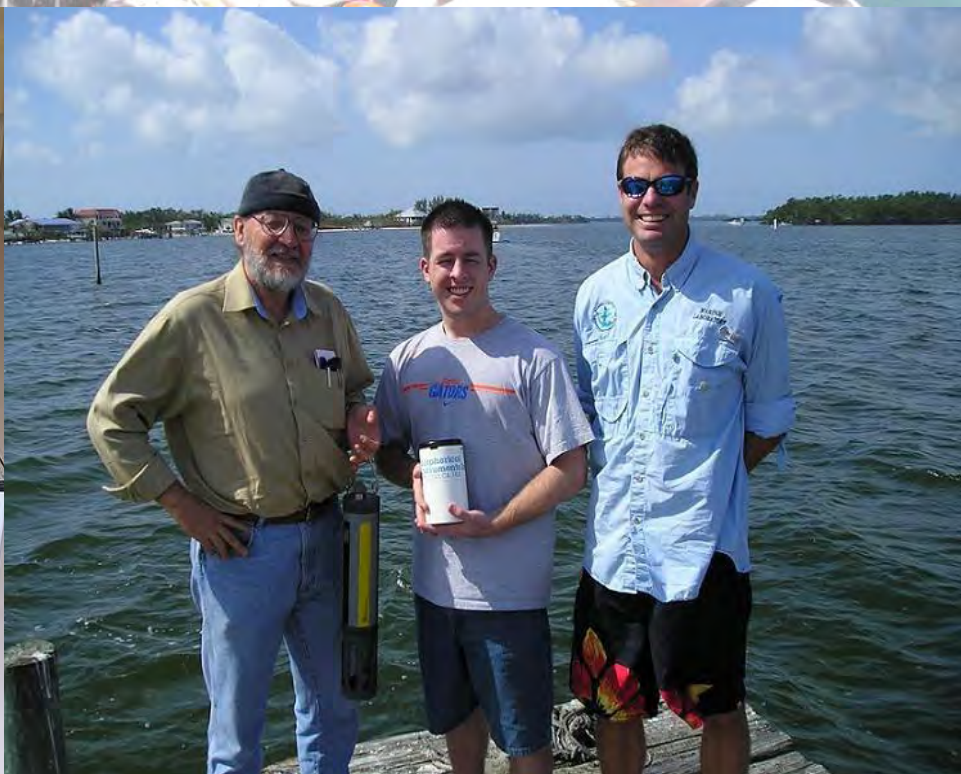
Specific Tasks (Altera & Xilinx):

- **control: servo & webcam**
- **communication: USB port**
- **double role of the project**
 - **developing the remote access**
 - **programming FPGA's in VHDL**
- **FPGA development: display/LED's.**

Web Access to Wireless Sensor Networks



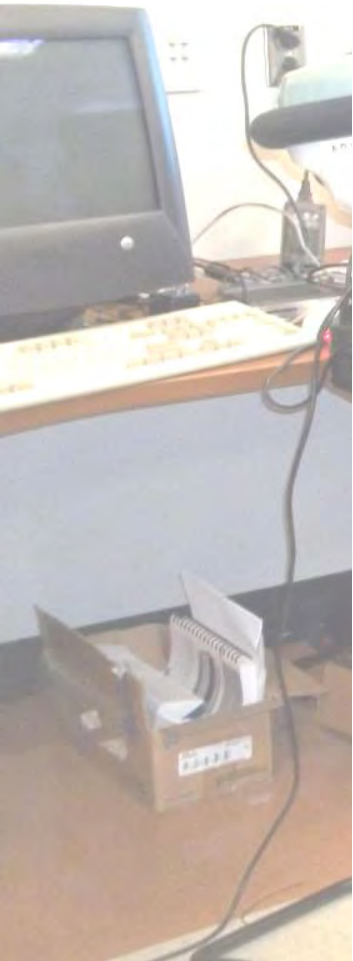
Web Access to Wireless Sensor Networks – Community Service Project



Online Health Monitoring Smartwatch and Android



Online Health Monitoring Smartwatch and Android



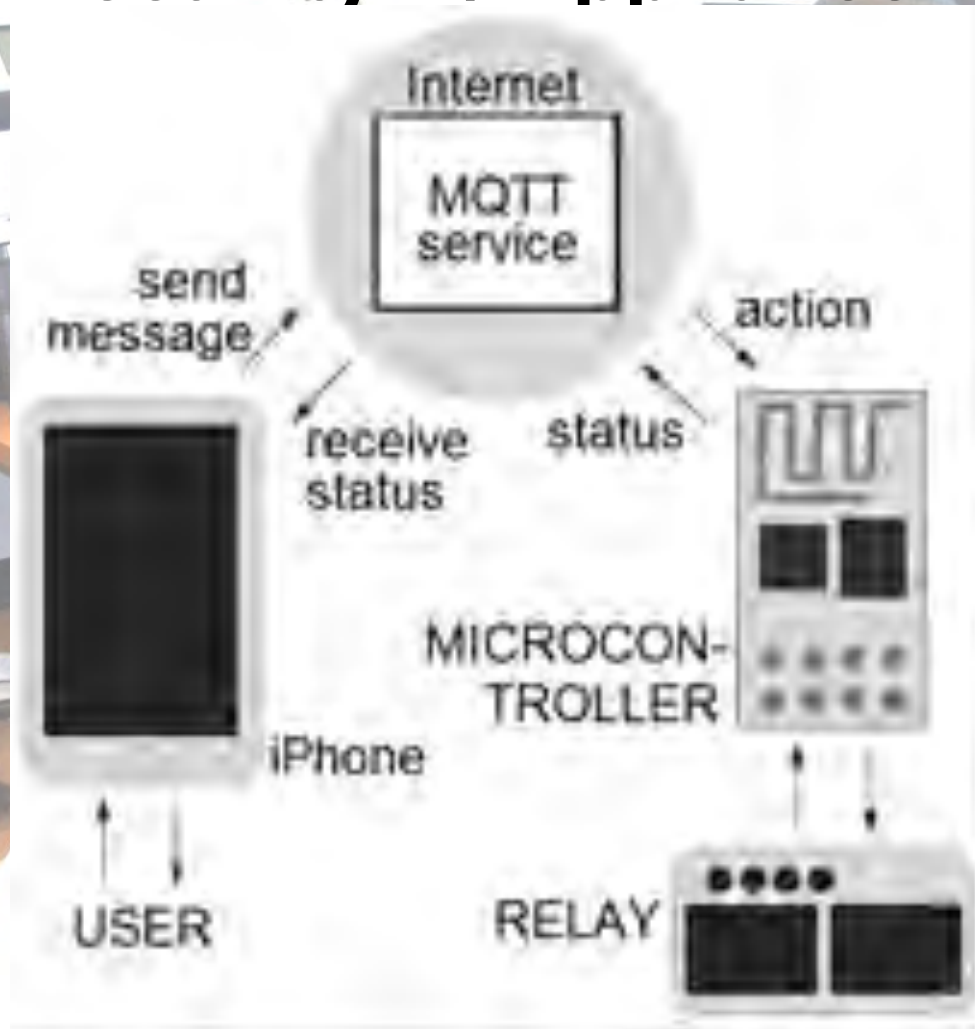
Smart Home with Access from iOS

ESP8266 Microcontroller Board



Smart Home with Access from iOS

iPhone Connectivity w/ Appliance



Remote DAQ and Control



1. Power Port
2. Power Switch
3. PS2 Port
4. Serial Port
5. Monitor Serial Port
6. Ethernet Port
7. USB Port
8. USB Port

The screenshot displays the eBox Remote Station Control software interface. It includes a video feed of a laboratory setup with a sign that reads "PLEASE DON'T USE IT FOR MORE THAN 5 MIN. GIVE OTHERS THE CHANCE TOO!". A large circular temperature gauge shows a reading of 66. Below the video feed are control panels for "Servo Control" (with Up, Down, Left, and Right buttons) and "Still Capture" (with a SnapShot button). A "Temperature Panel" shows a "Read" button and "Disconnect" and "Alarm" buttons. A "Connection Panel" displays the eBox 2300 IP address (69.88.163.25) and Port (18888), with "Connect" and "Disconnect" buttons. A "CLOSE" button is located in the bottom right corner.

Remote DAQ and Control

Specific Tasks (ARM processor):

- data acquisition: temp. sensor
- control system: servo motor
- building remote server in C#
 - configuring and deploying CE
 - uploading the server software
- building local client & GUI in C#.

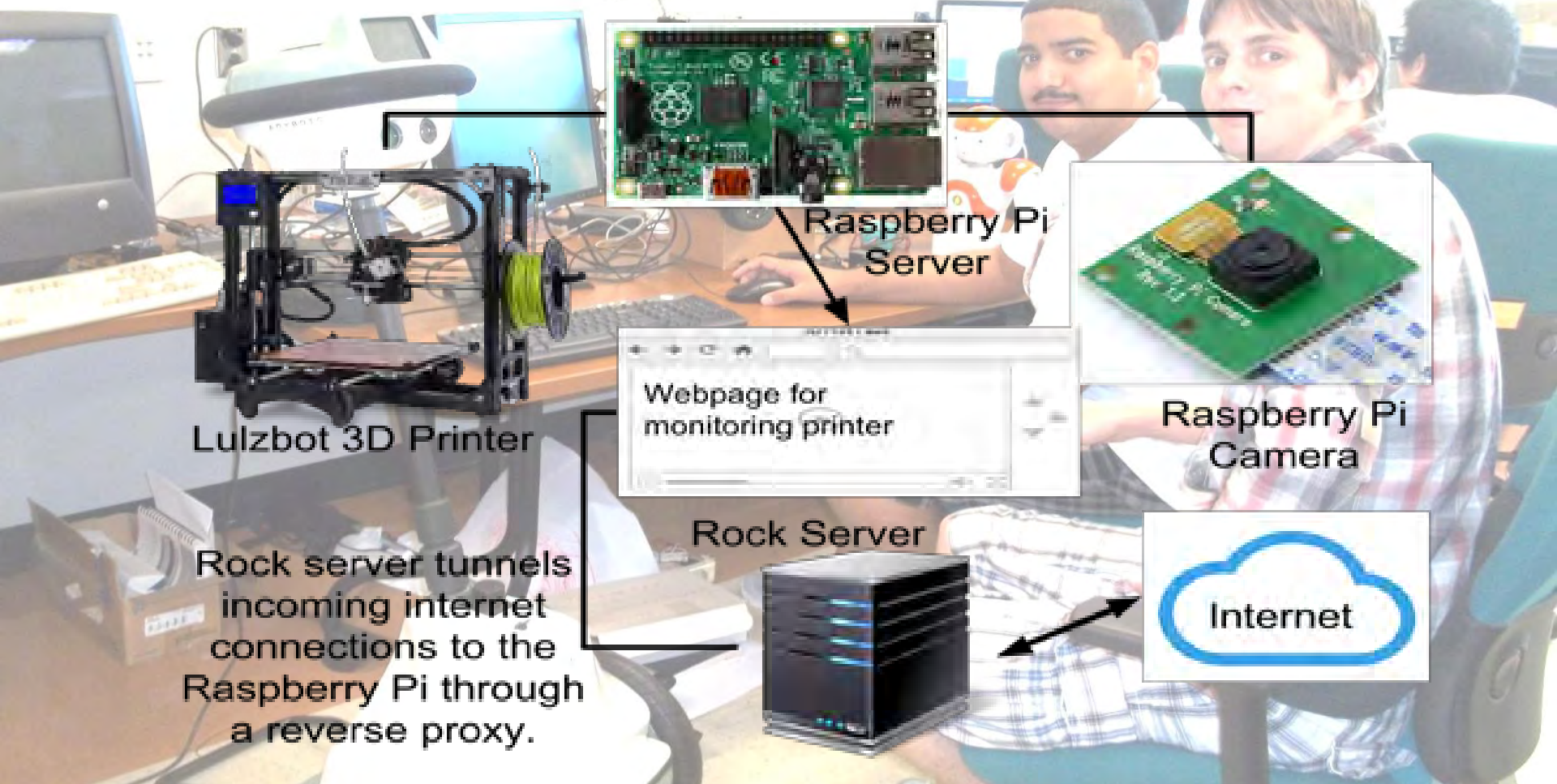
3D Printer

Factory Made w/o Connectivity



3D Printer

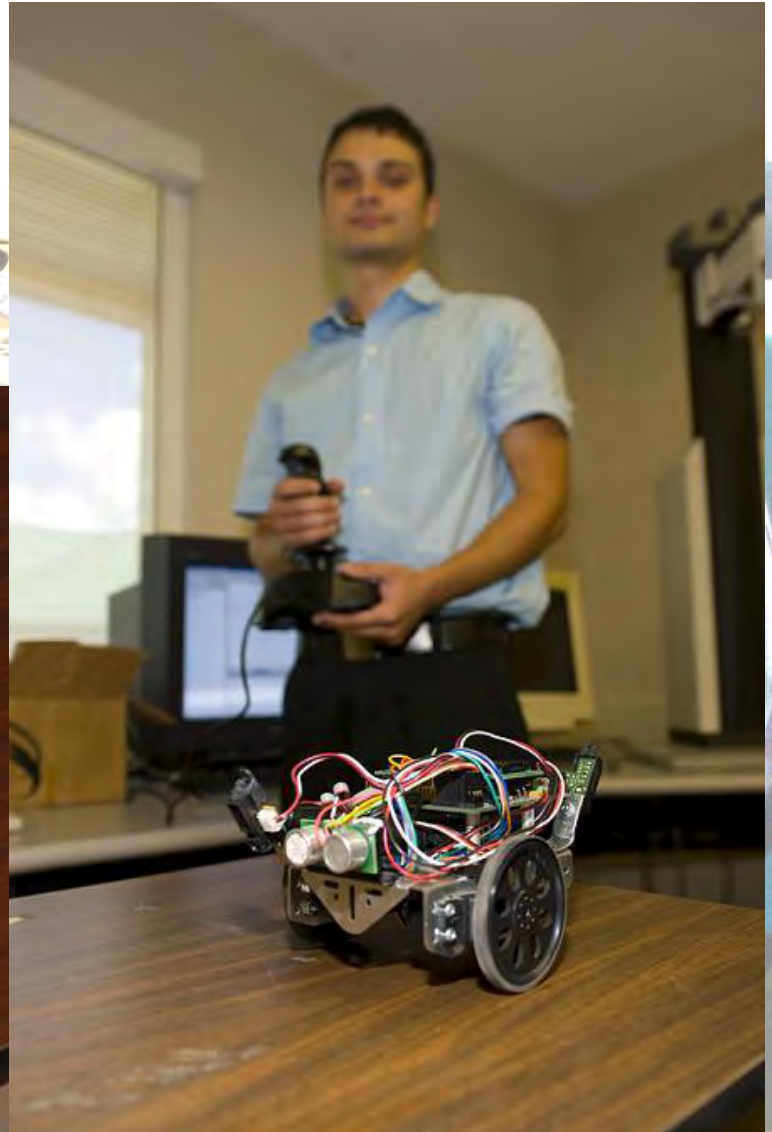
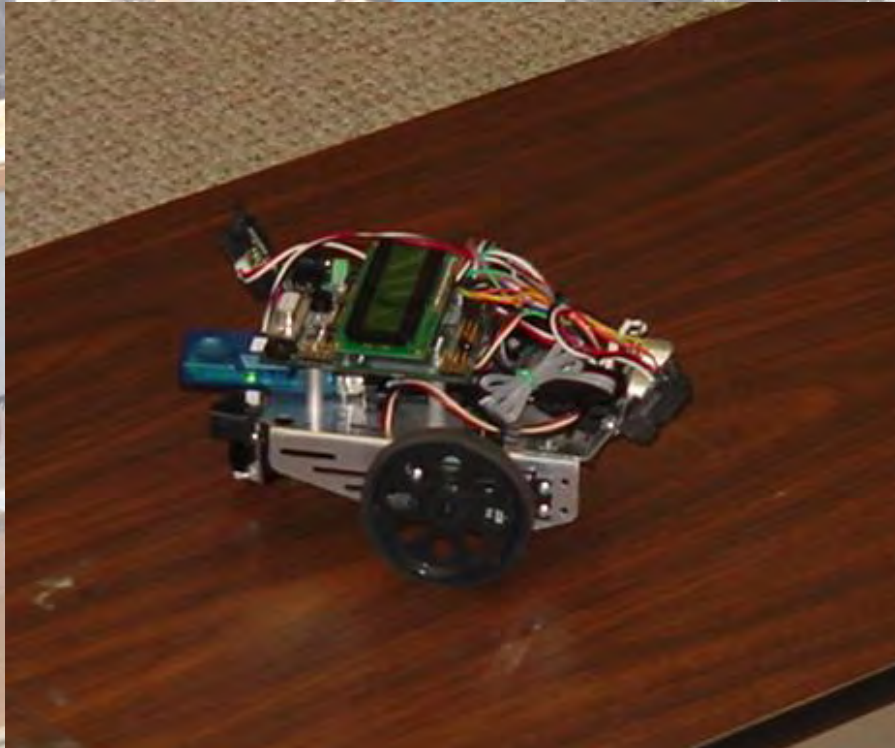
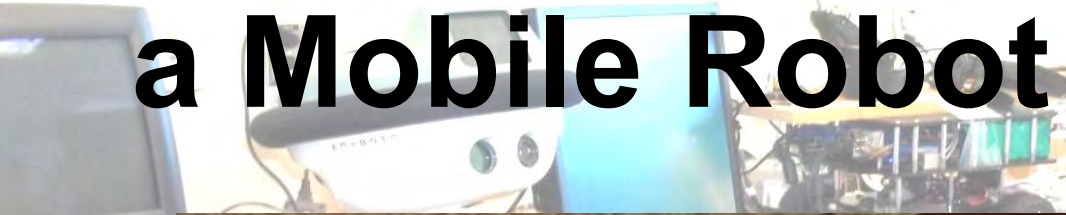
Raspberry Pi Controller



Web Access to a Robotic Arm



Web Access to a Mobile Robot



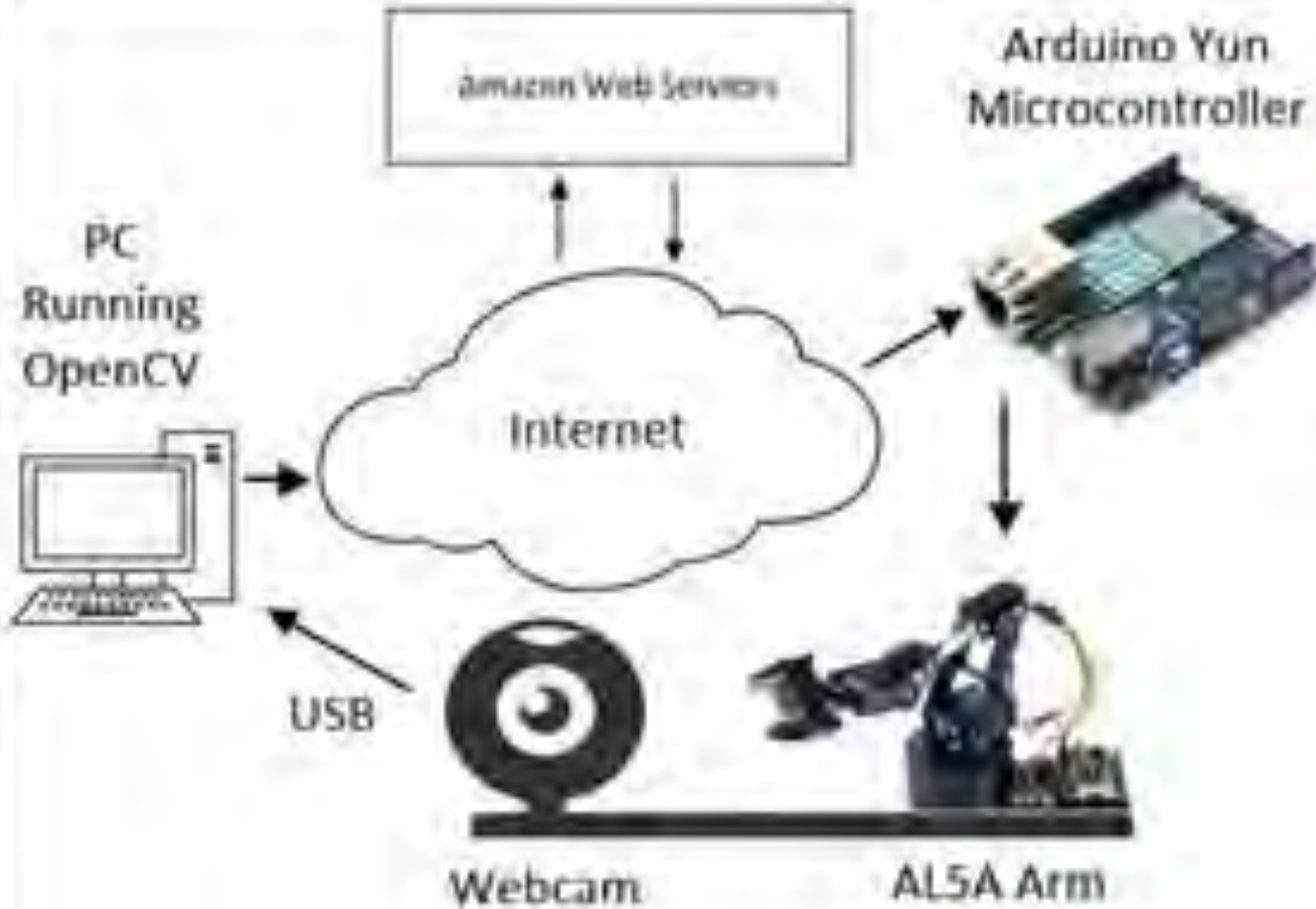
Remote Robot Access

AL5A Robotic Arm



Remote Robot Access

Connectivity of the Camera



Robotic Devices



Nao Humanoid

Robotic Devices



CoroBot

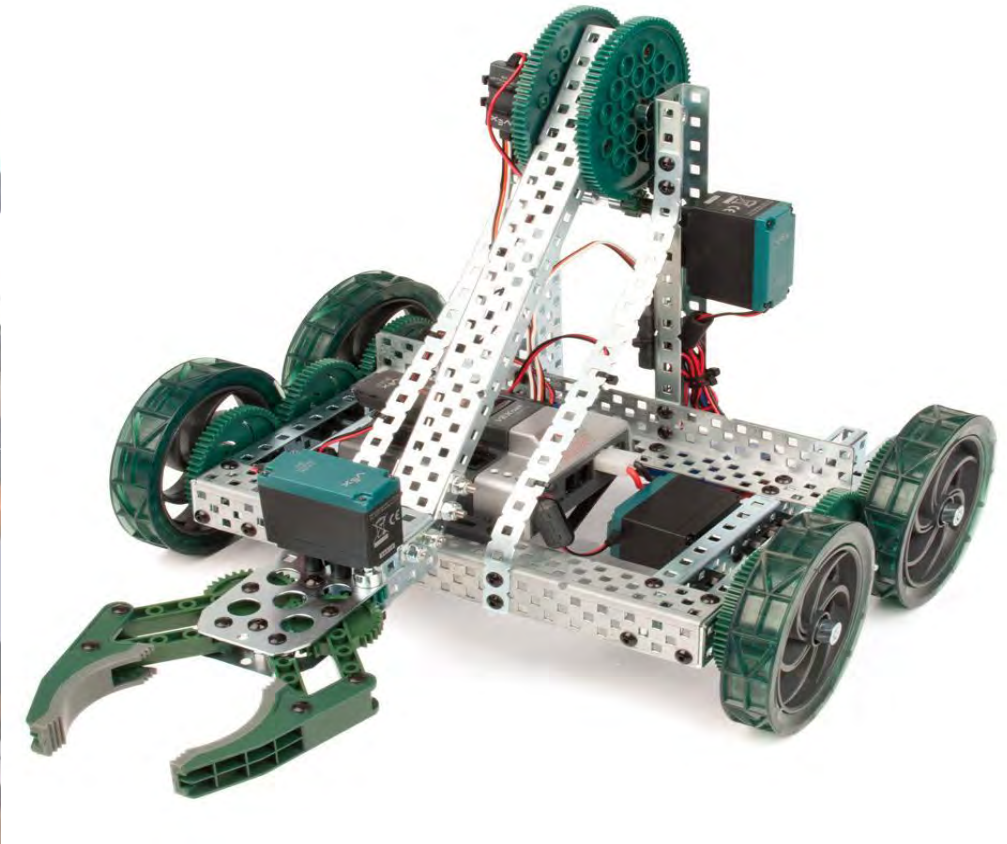


Robotic Devices



Anybots QB

Robotic Devices



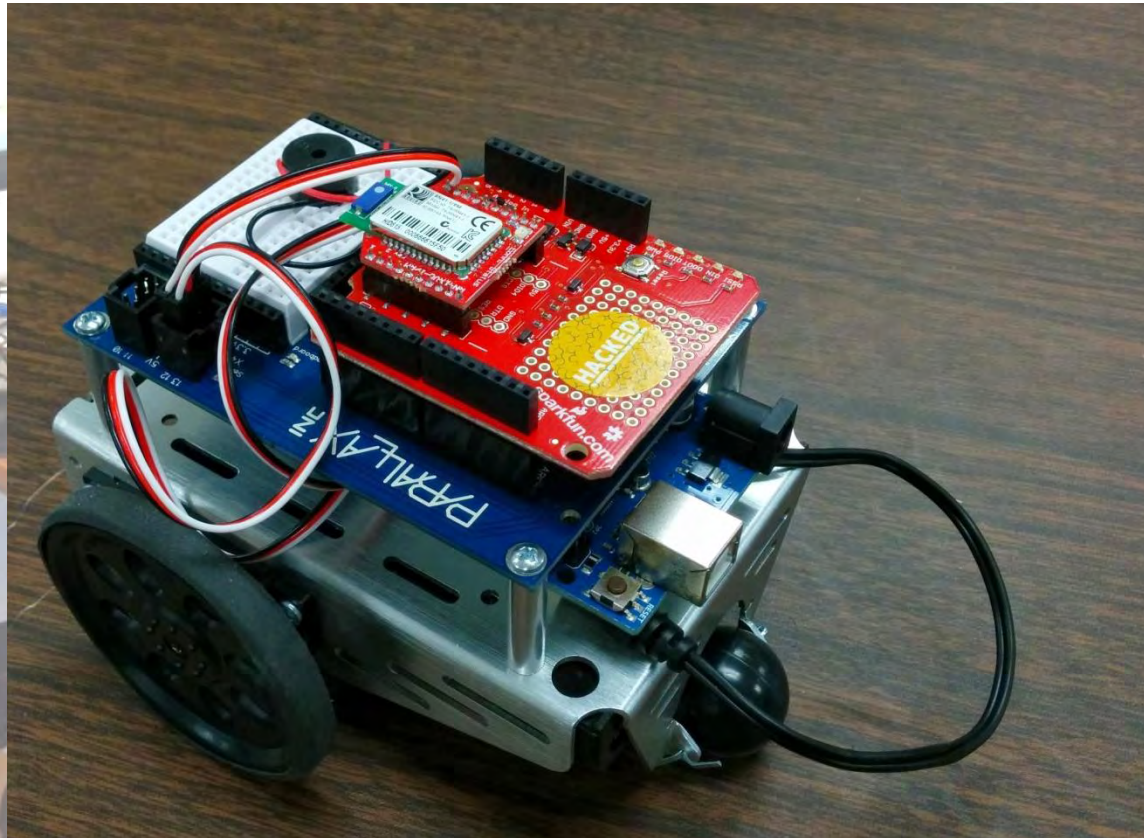
VEX ClawBot

Robotic Devices



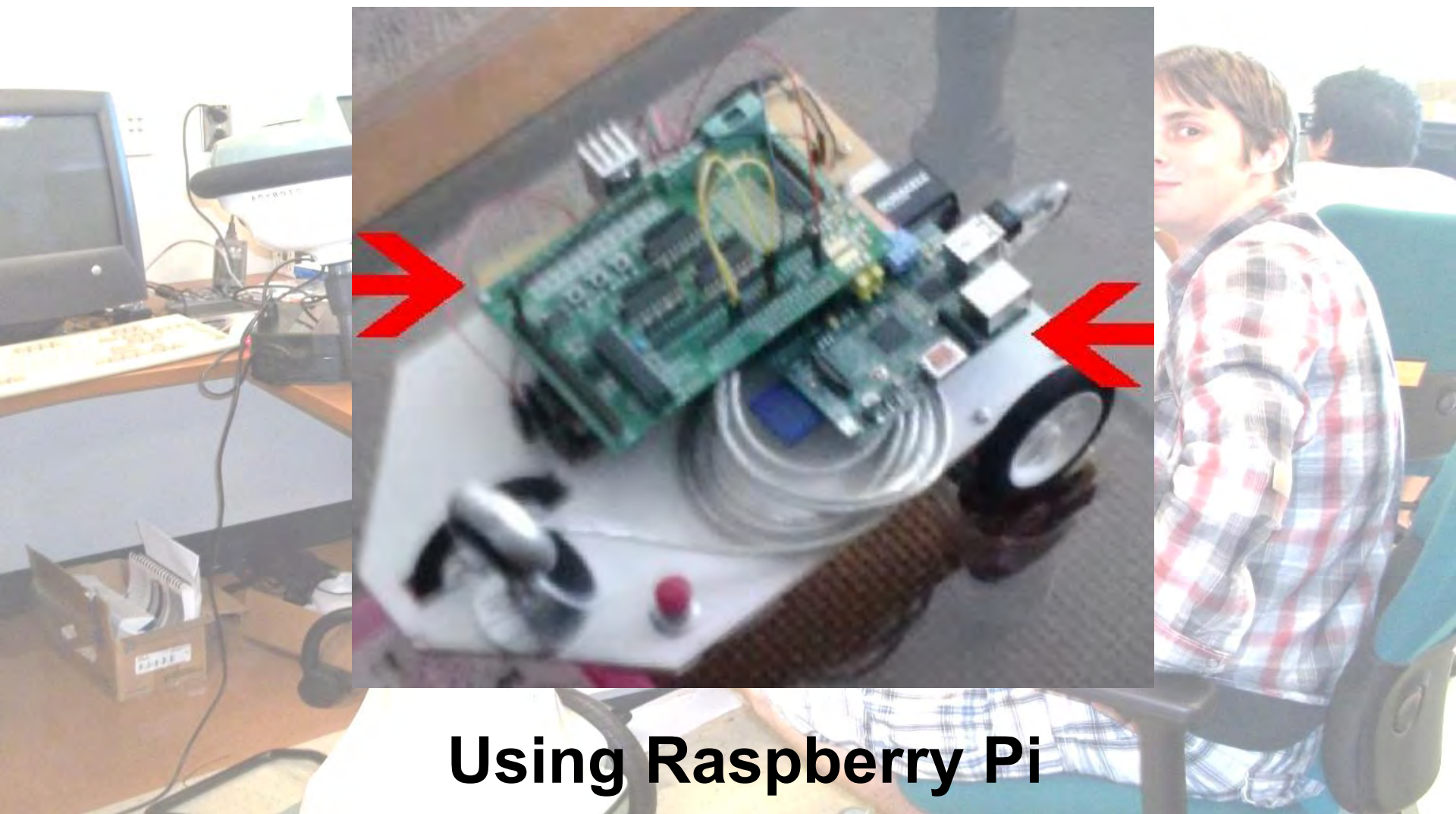
LEGO Robots

Robotic Devices



Using Arduino

Robotic Devices



Using Raspberry Pi

Robotic Devices



Multicopter



Conclusion



Conclusion

Tendency in Education to Offer Dynamic Course Contents

- Graphics
- Animation
- Interaction
- Simulations
- Online Labs

Conclusion

- ***New Disruptive Technology***

Technology that has a potential to disrupt markets, because they have not been prepared for its introduction.

[Bowen & Christensen, 1995]

Conclusion

- ***New Disruptive Technology***
... the clock is not merely a means of keeping track of hours but of synchronizing the actions of men [...] one ate not upon feeling hungry but when prompted [...]; one slept not when one was tired... [Lewis Mumford, 1936]

Conclusion

Marshall McLuhan (1960's)

the medium is the message

“after more than a century of electric technology, we have extended our central nervous system into global embrace”

Conclusion

Some Facts

- Glasses are extending our vision
- Vehicles extend our legs
- Printing extended our speech
- Electronic media extend our consciousness

All of these are/were DISRUPTIVE

Conclusion

Is this all successful in education?

Was I well educated? If education is defined as what is left after one has forgotten most of what one has learned in school, then I guess the answer is yes.

Mark Kac, p. 19, Enigmas of Chance

Acknowledgments

- **IEEE Education Society**
 - funding the standardization project
- **Florida Gulf Coast University**
 - funding my participation in P1876
- **National Science Foundation**
 - Awarding Web-based Real-Time Lab
- **Gdansk University of Technology**
 - funding this trip

eTEE 2019, Gdańsk, Poland, September 19, 2019 – Janusz Zalewski



Waiting for Questions