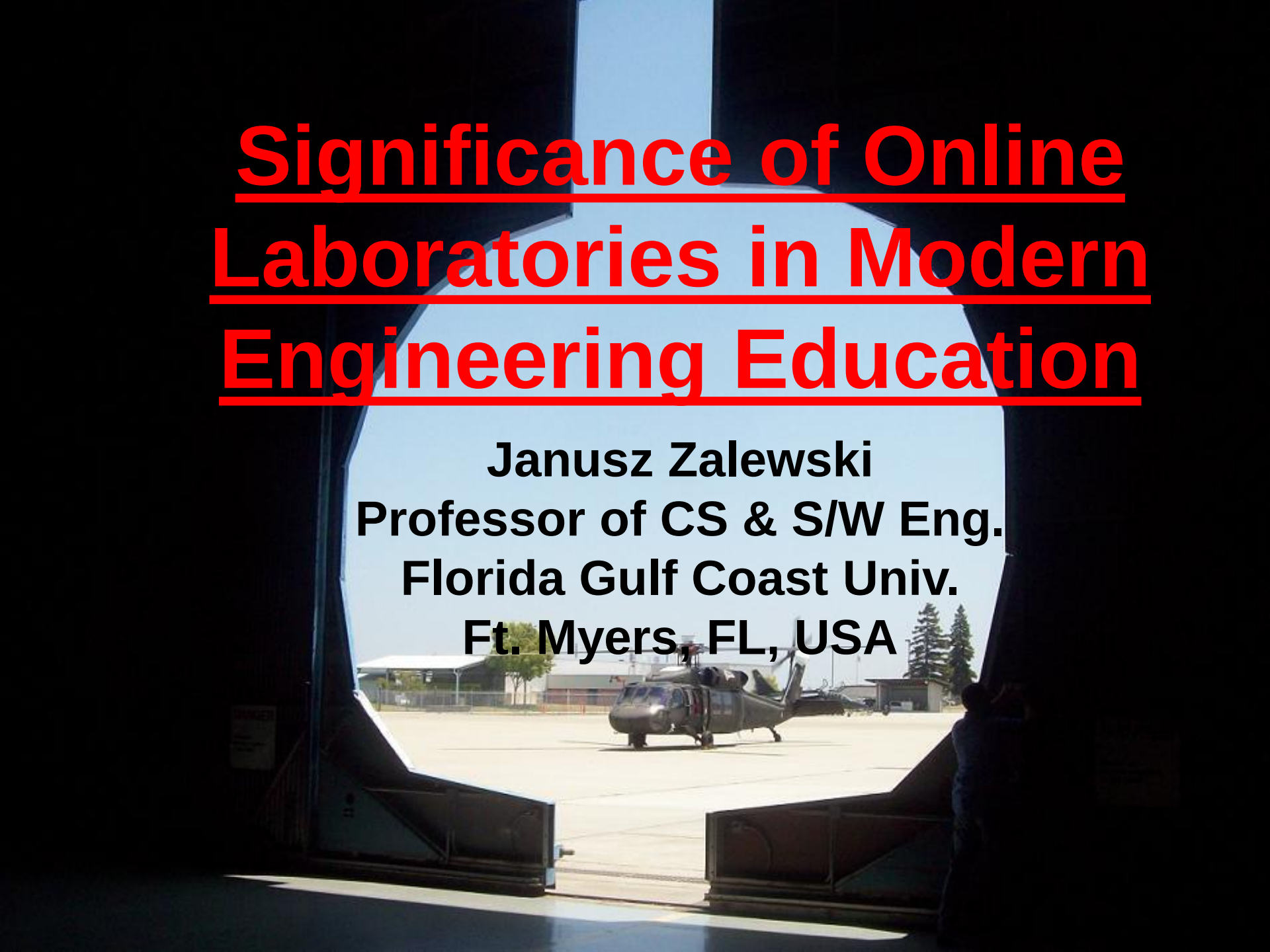
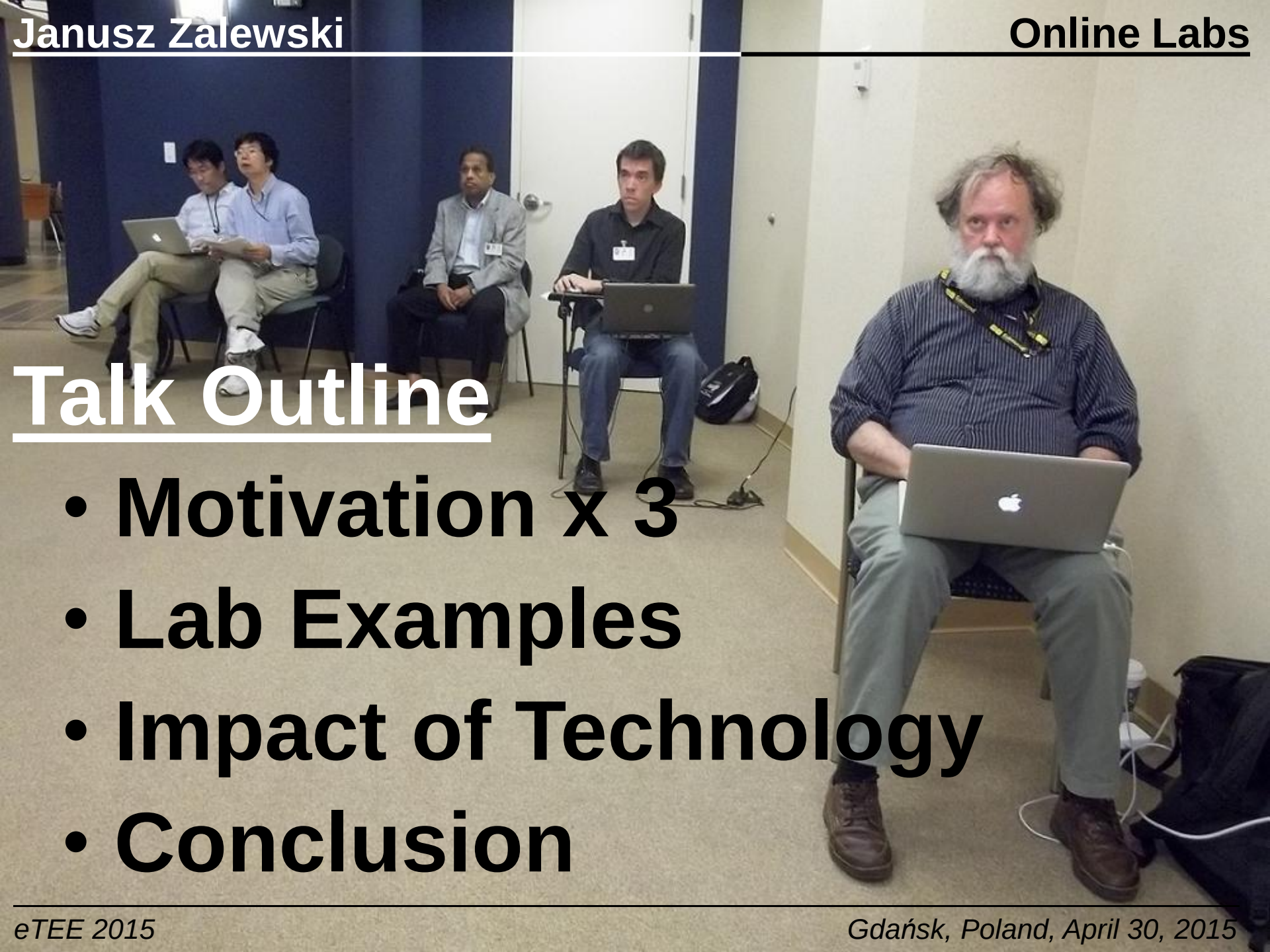
Significance of Online Laboratories in Modern Engineering Education



Janusz Zalewski
Professor of CS & S/W Eng.
Florida Gulf Coast Univ.
Ft. Myers, FL, USA

Online Labs



Talk Outline

- Motivation x 3
- Lab Examples
- Impact of Technology
- Conclusion

Motivation x 3

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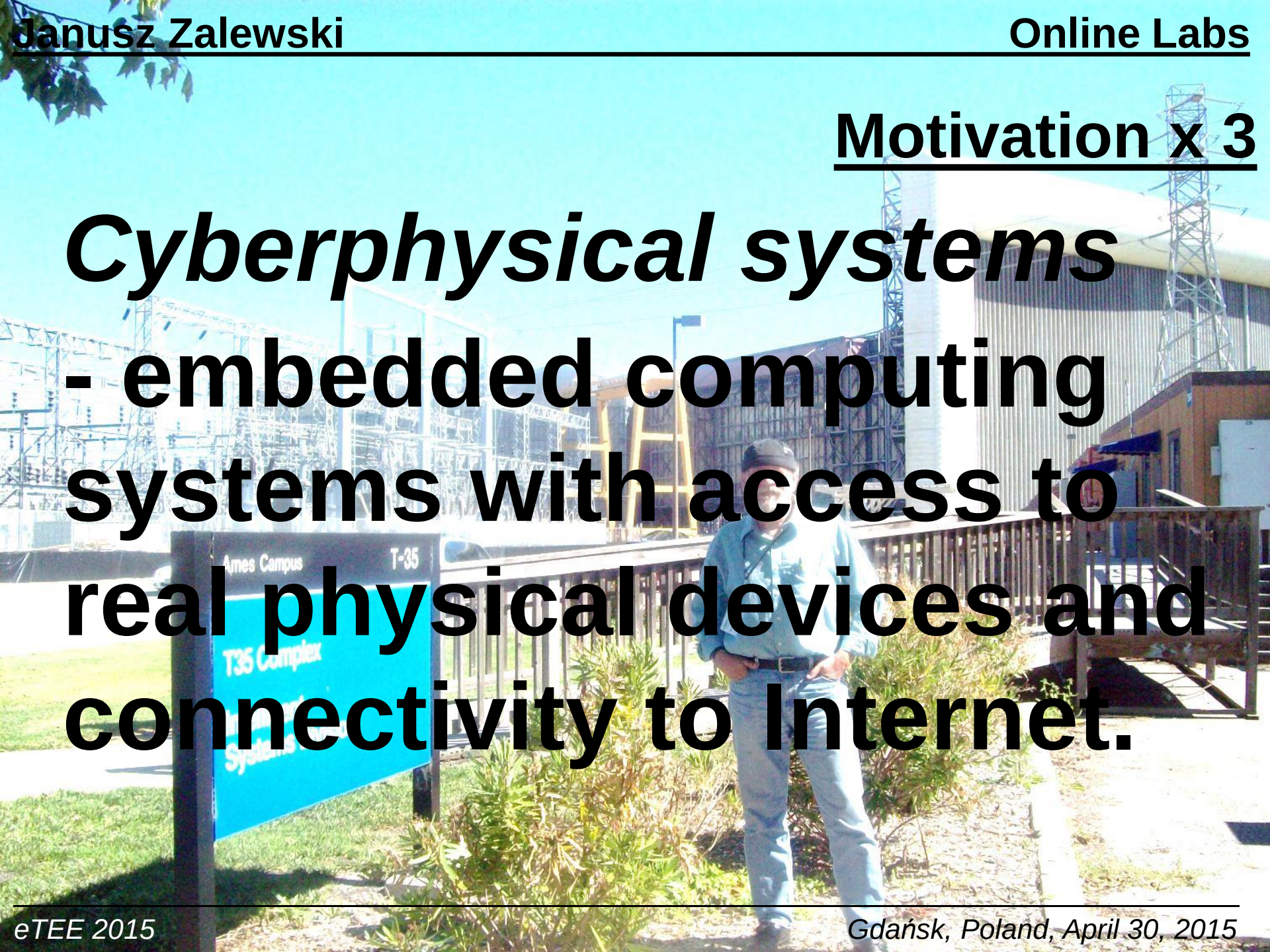


Cyberphysical systems

- embedded computing systems with access to real physical devices and connectivity to Internet.

Motivation x 3

1) Professional

2) Societal

3) Innovational

[… Educational …]

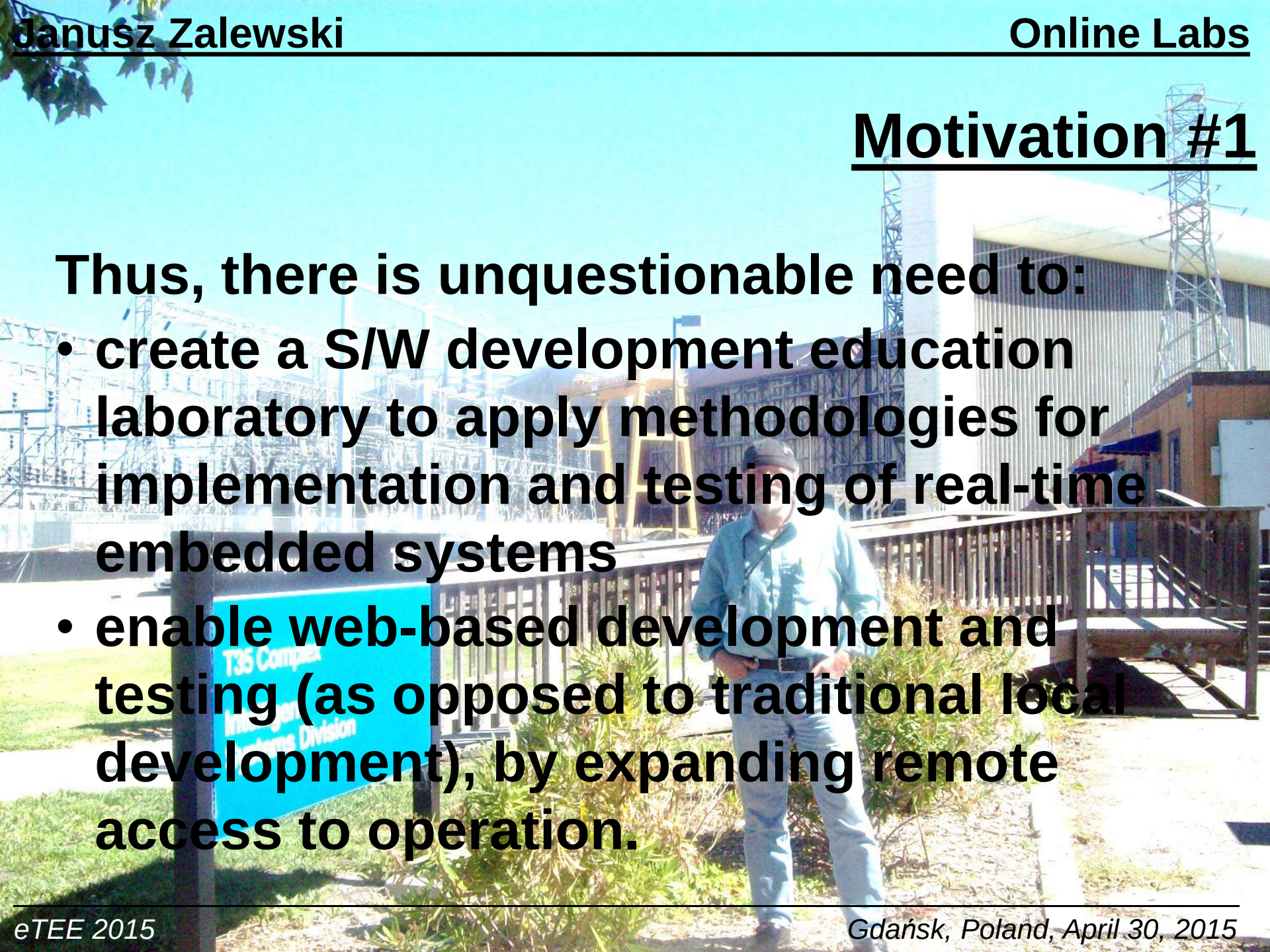
Motivation #1

Modern cyberphysical systems involve the most demanding real-time safety-critical applications, such as:

- flight control systems
- accelerator control
- sensor networks
- navigation, road vehicle control, etc.

They are all distributed and for proper operation require very different programming techniques than traditional systems.

Motivation #1



Thus, there is unquestionable need to:

- **create a S/W development education laboratory to apply methodologies for implementation and testing of real-time embedded systems**
- **enable web-based development and testing (as opposed to traditional local development), by expanding remote access to operation.**

Motivation #2

T. Berners-Lee, R. Cailliau, Motivation #2

World Wide Web:

Proposal for a Hypertext Project: CERN

- Nov. 12, 1990, Geneva, Switzerland
- Operation: "A link is specified as an ASCII string from which the browser can deduce a suitable method of contacting an appropriate server. When a link is followed, the browser addresses the request for the node to the server."

Motivation #3

Top Tech 2012 Special Report

IEEE Spectrum, January 2012

- Bye, Wheelchair, Hello Exoskeleton
- 3-D Chips Grop up
- Birth of the Bionic Eye
- China's Homegrown Supercomputers
- Plug-in Vehicles Proliferate
- 3-D Printing Takes Shape
- 4G LTE (Long Term Evolution) networks

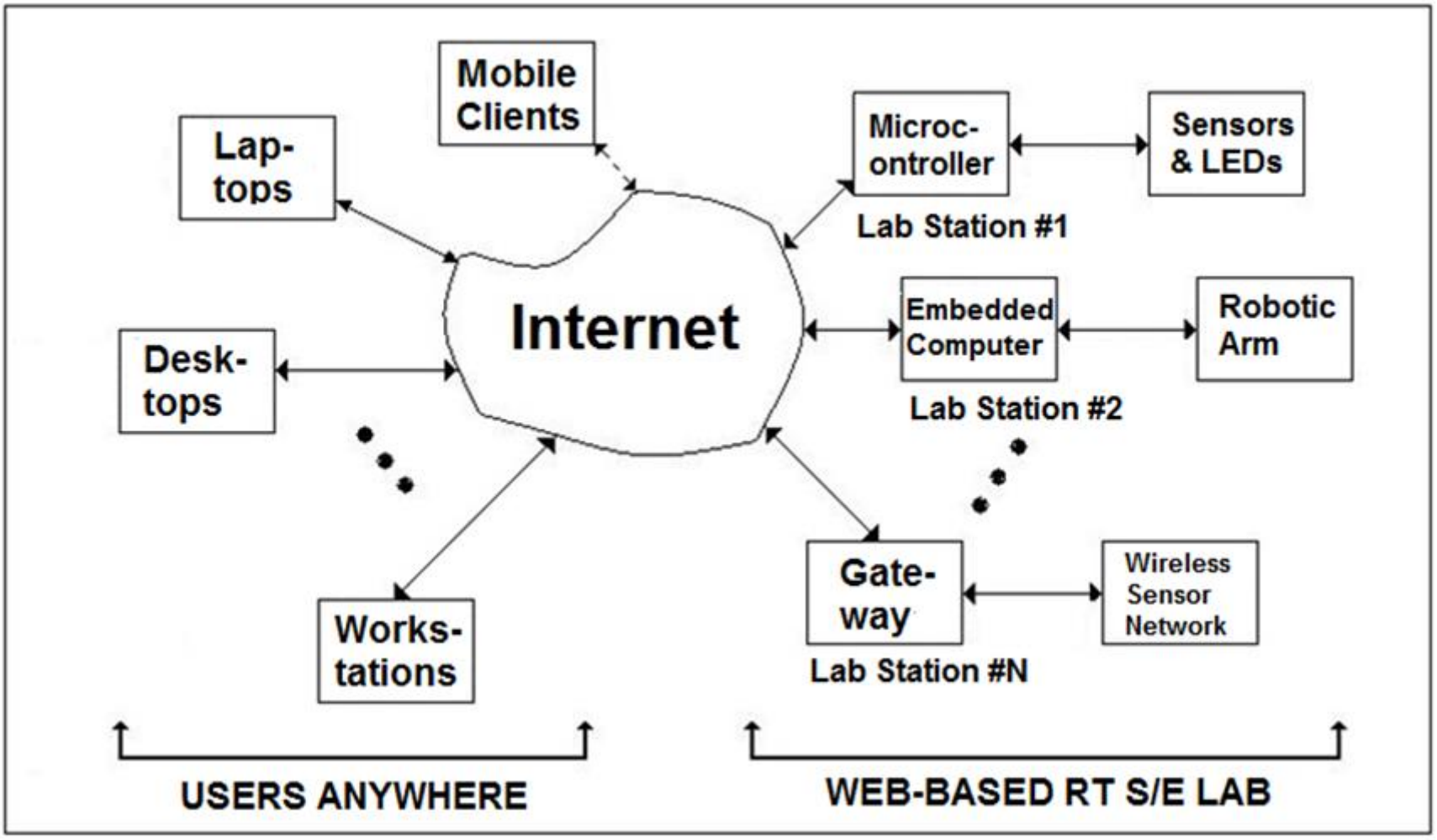
2014 Top Tech To Watch

IEEE Spectrum, January 2014

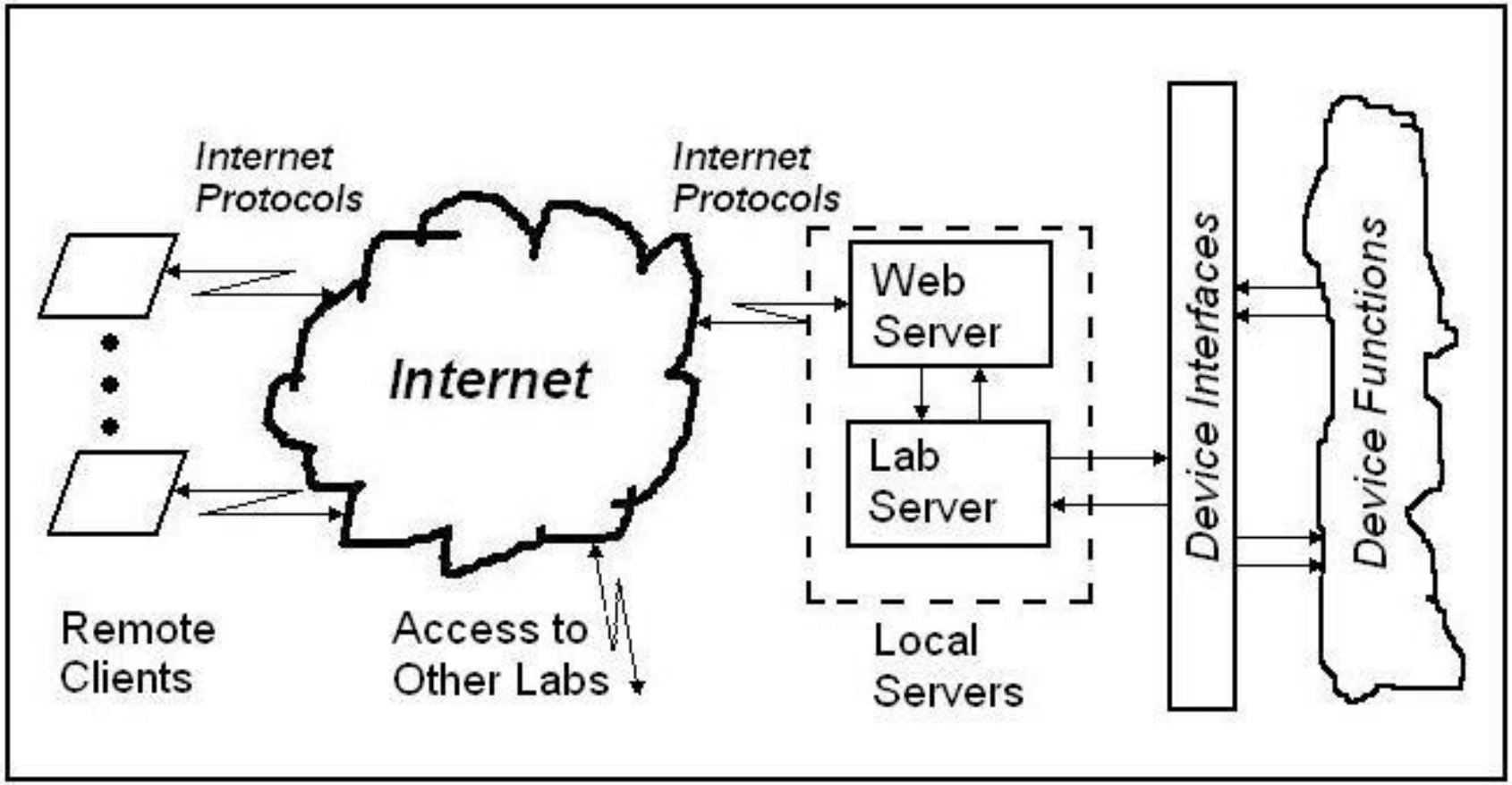
- Would You Shoot Neighbor's Drone?
- Oculus Virtual Reality
- LTE Advanced: Real 4G
- Formula E Cars
- U.S. Brain Initiative
- China: Next Space Superpower

Lab Architecture & Stations

Lab Architecture & Stations



Lab Architecture & Stations



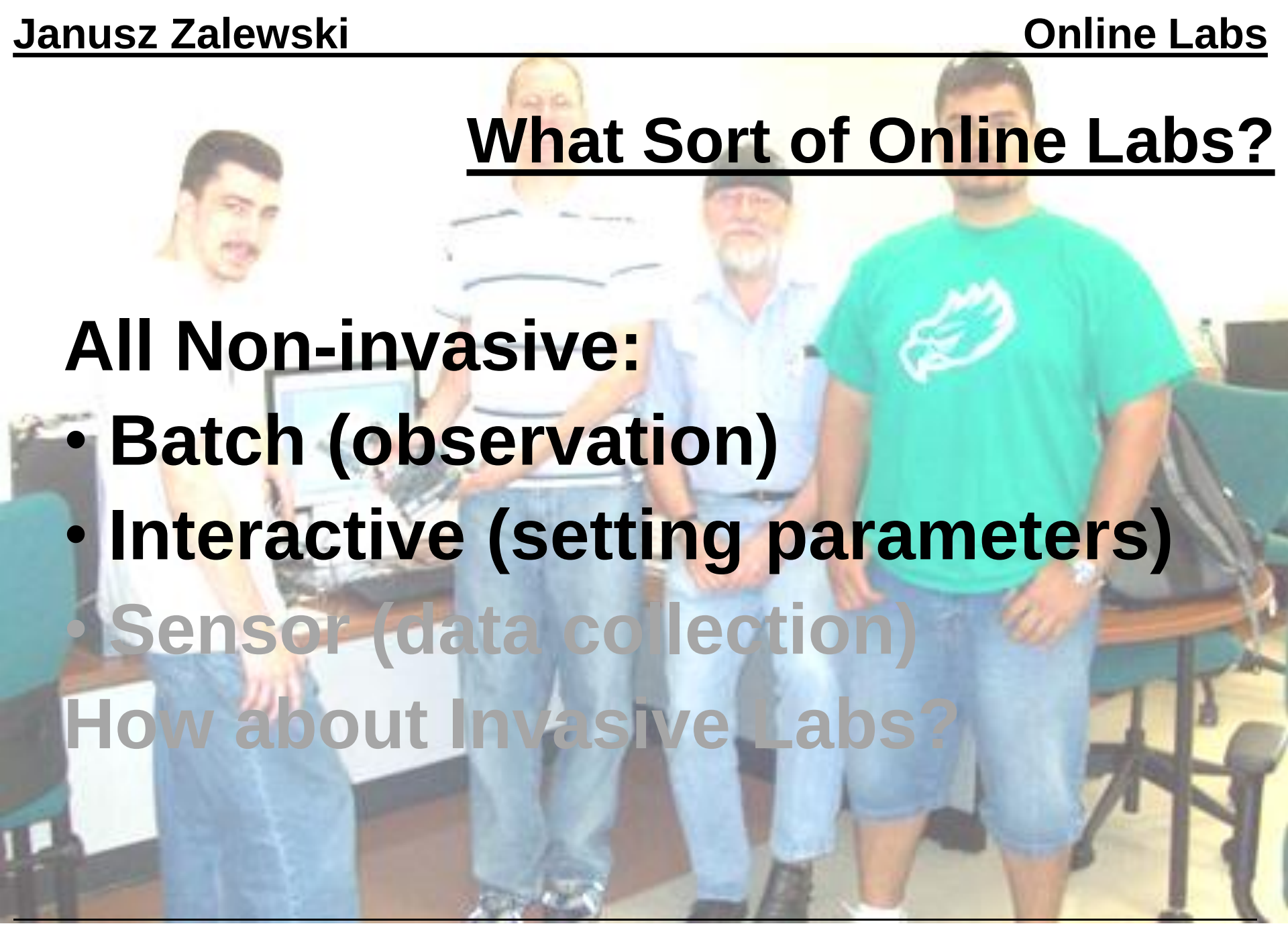
What Sort of Online Labs?

All Non-invasive:

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

How about Invasive Labs?

What Sort of Online Labs?



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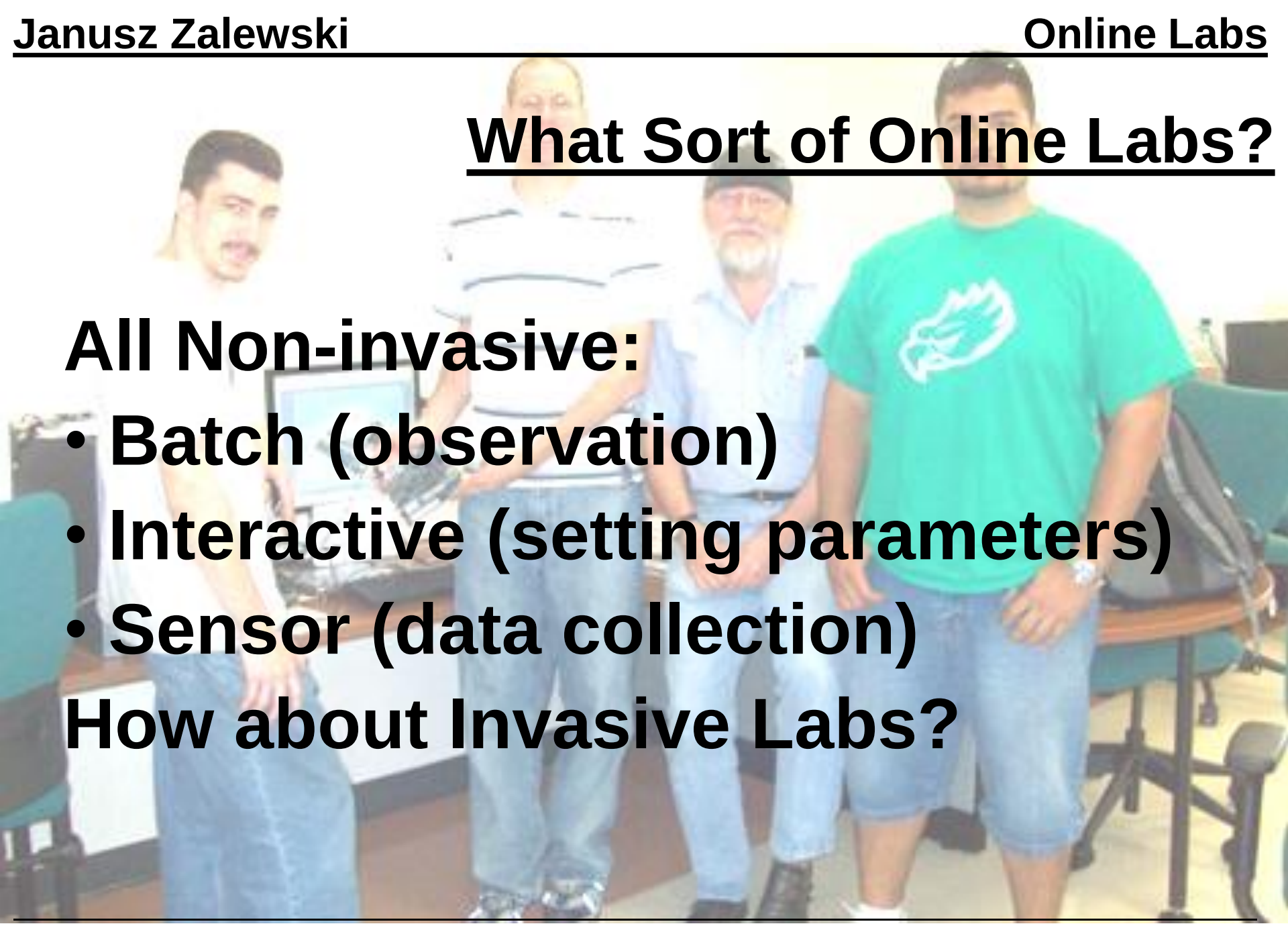

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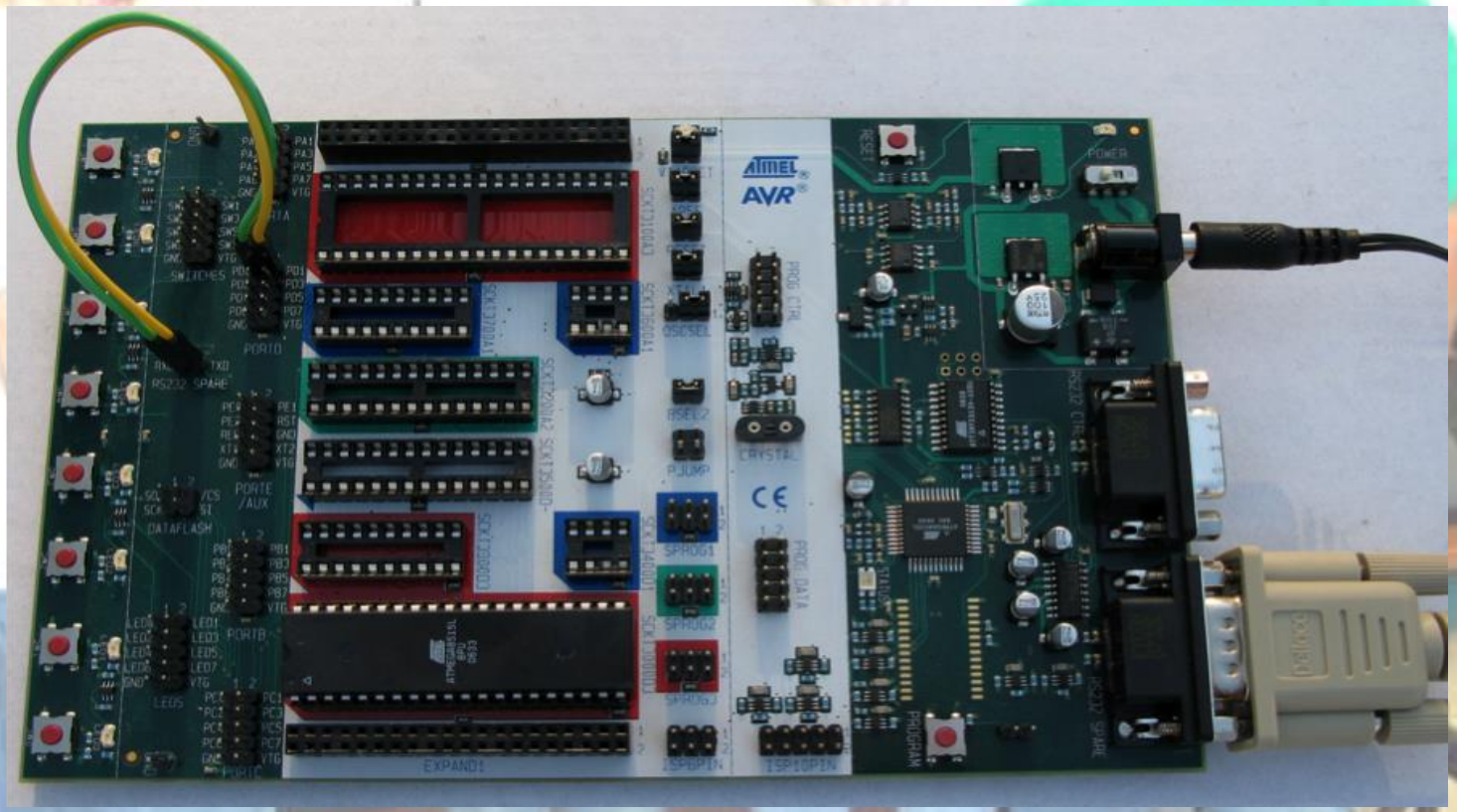
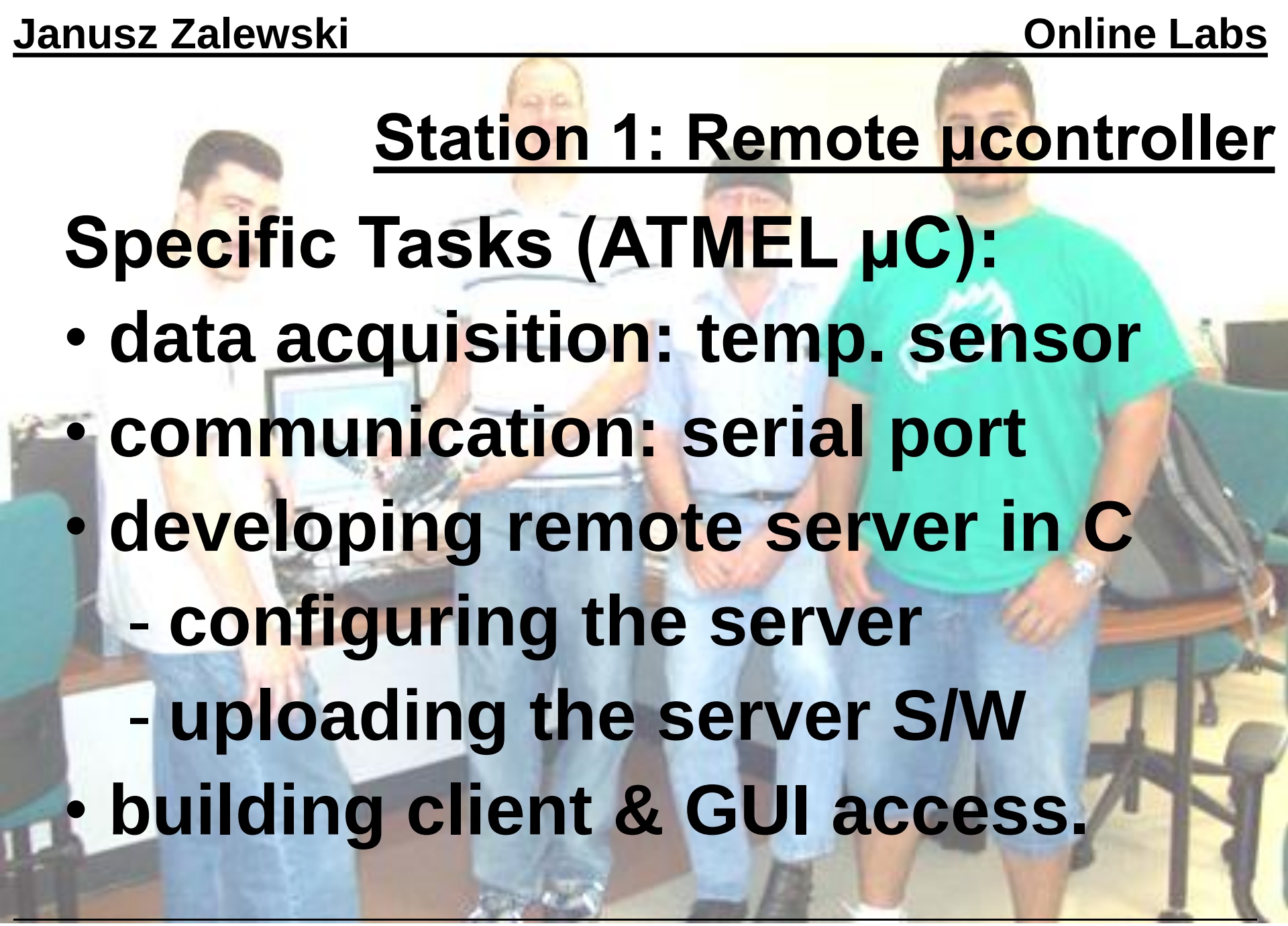
How about Invasive Labs?

Station 1: Remote µcontroller





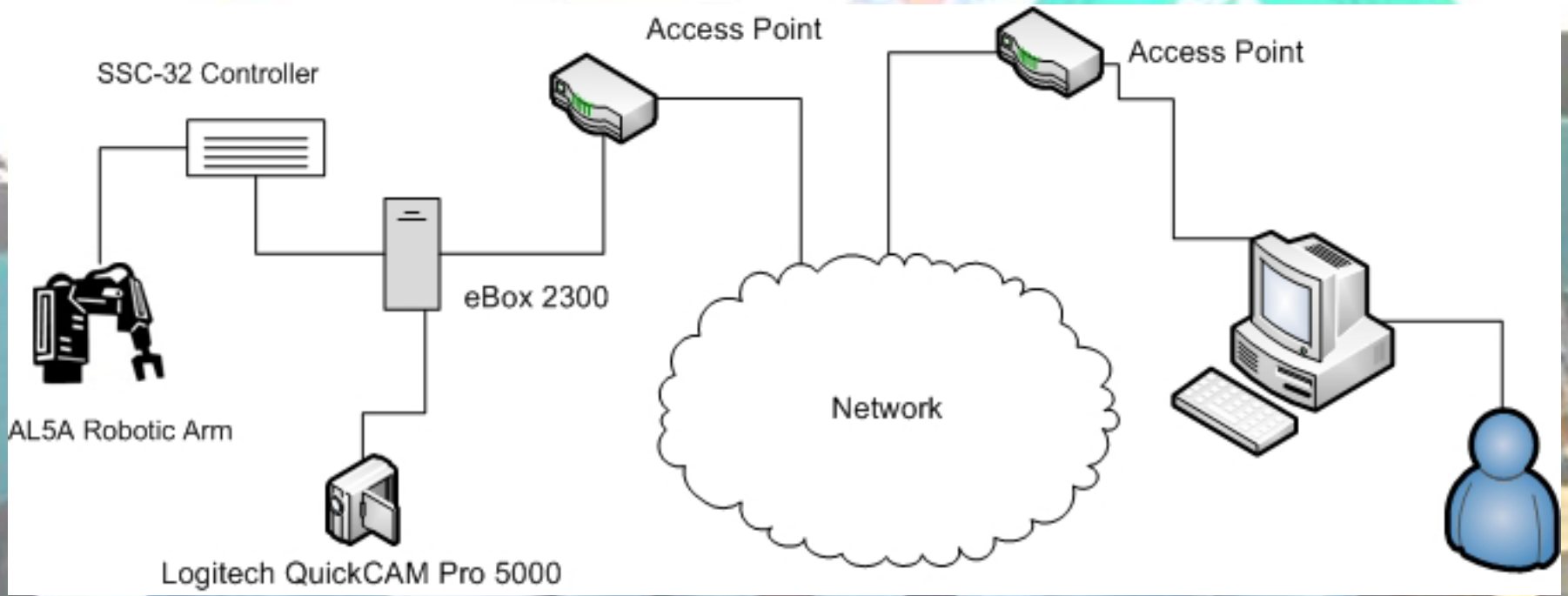
Station 1: Remote µcontroller

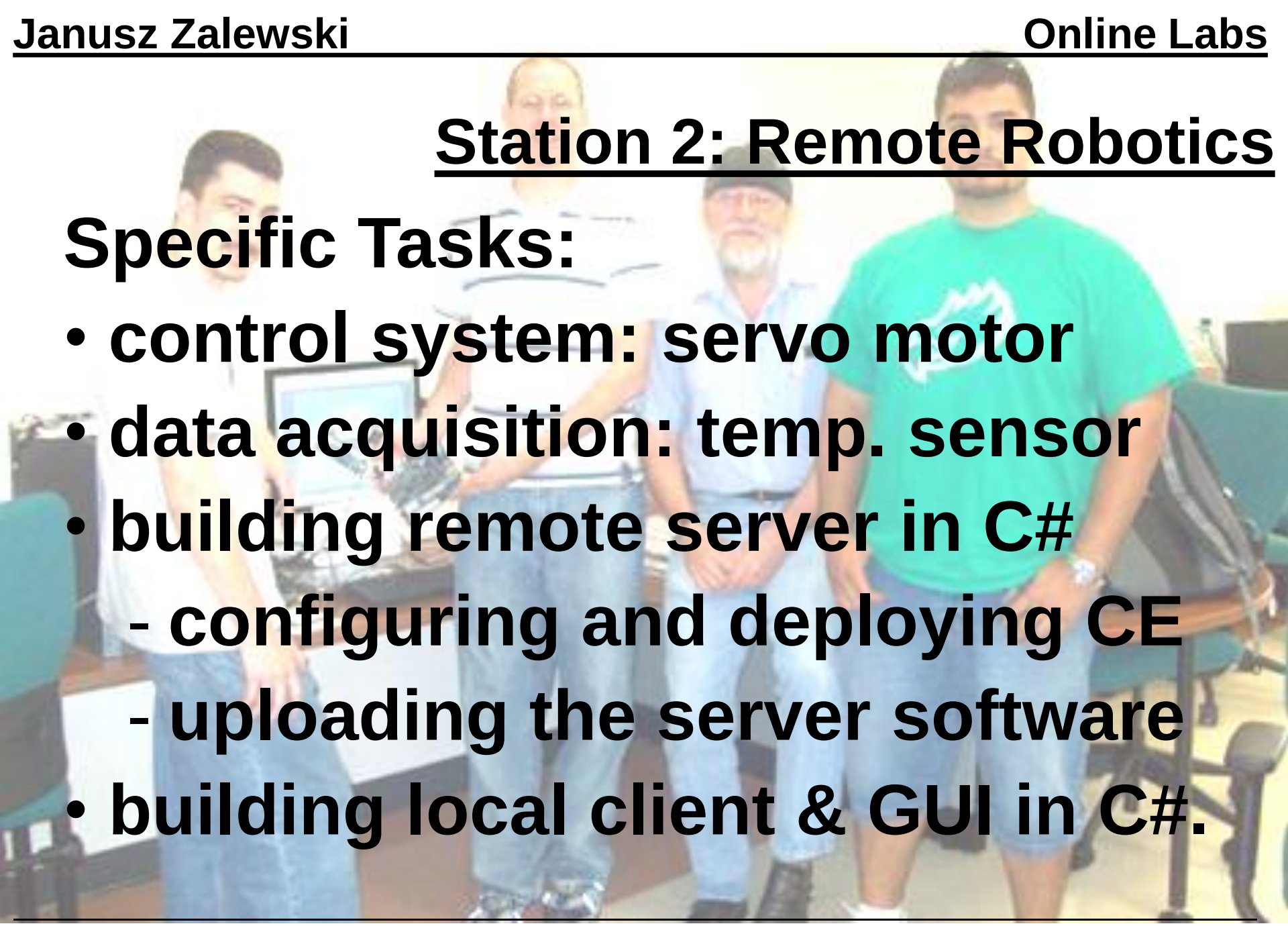
Specific Tasks (ATMEL µC):

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

Station 1: Remote µcontroller

Station 2: Remote Robotics



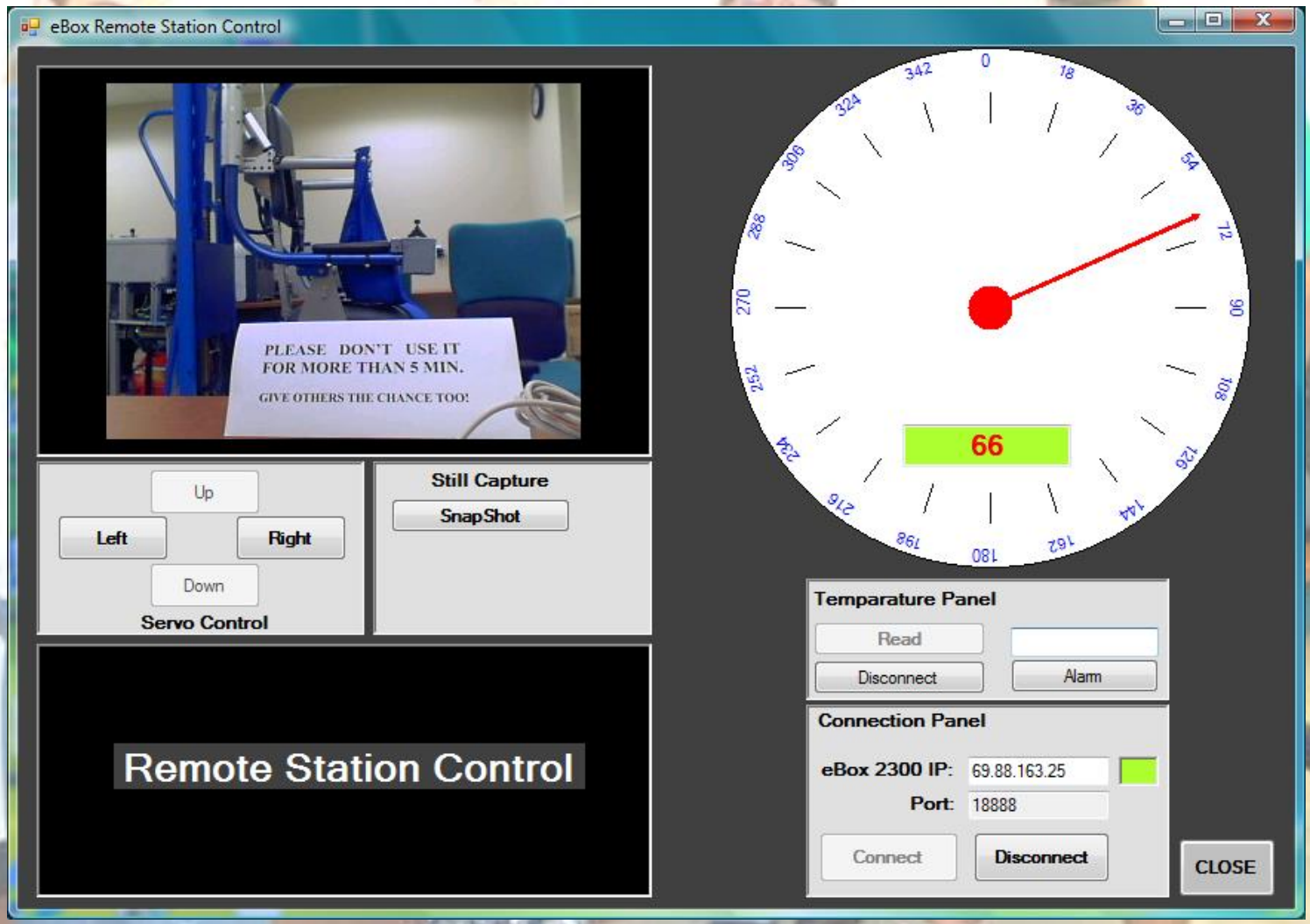


Station 2: Remote Robotics

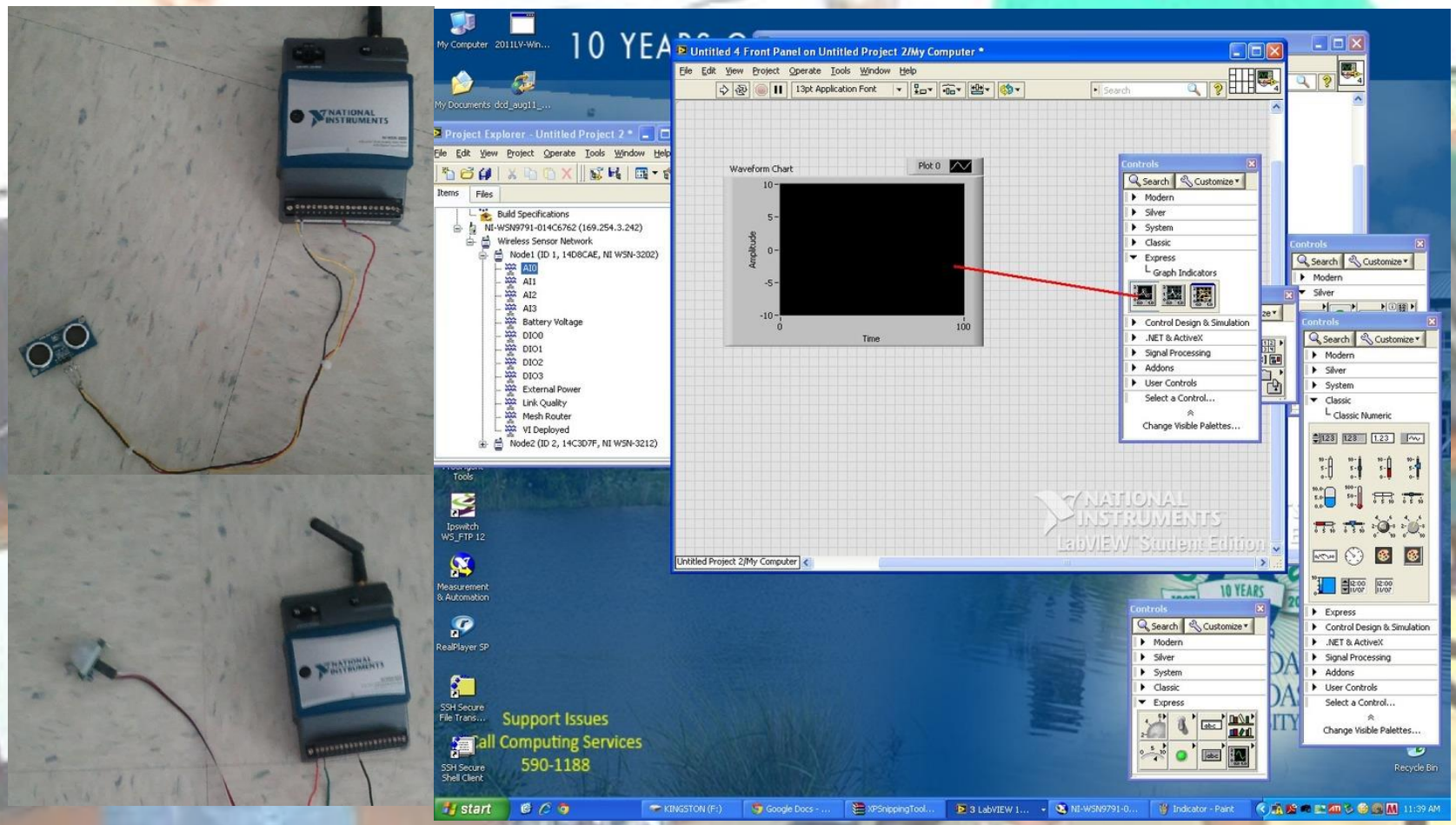
Specific Tasks:

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

Station 2: Remote Robotics



Station 3: Sensor Network



Station 3: Sensor Network

Specific Tasks:

- Zigbee/IEEE Std 802.15.4
- communication: sockets
- double role of the project
  - programming in LabVIEW
  - web access for testing.

Station 4: Remote FPGA

Please Logout when you are finished.

Station 4: Remote FPGA

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 display/LED's.

Station 5: Web Game

HydraNet 3 Player

The game controls are:

- A: Left
- D: Right
- W: Up
- S: Down
- J: Action

To play, you must first click within the screen area.

Game uploader

To upload a game for the HydraNet 3 system, three files are required:

- Compiled game file.
- Zipped images file.
- Game manual file.

Select the files and then click the "Upload Files" button:

Compiled game file (.eeprom)
Browse...

Zipped images file (.zip)
Browse...

Game manual file (.txt)
Browse...

Upload Files

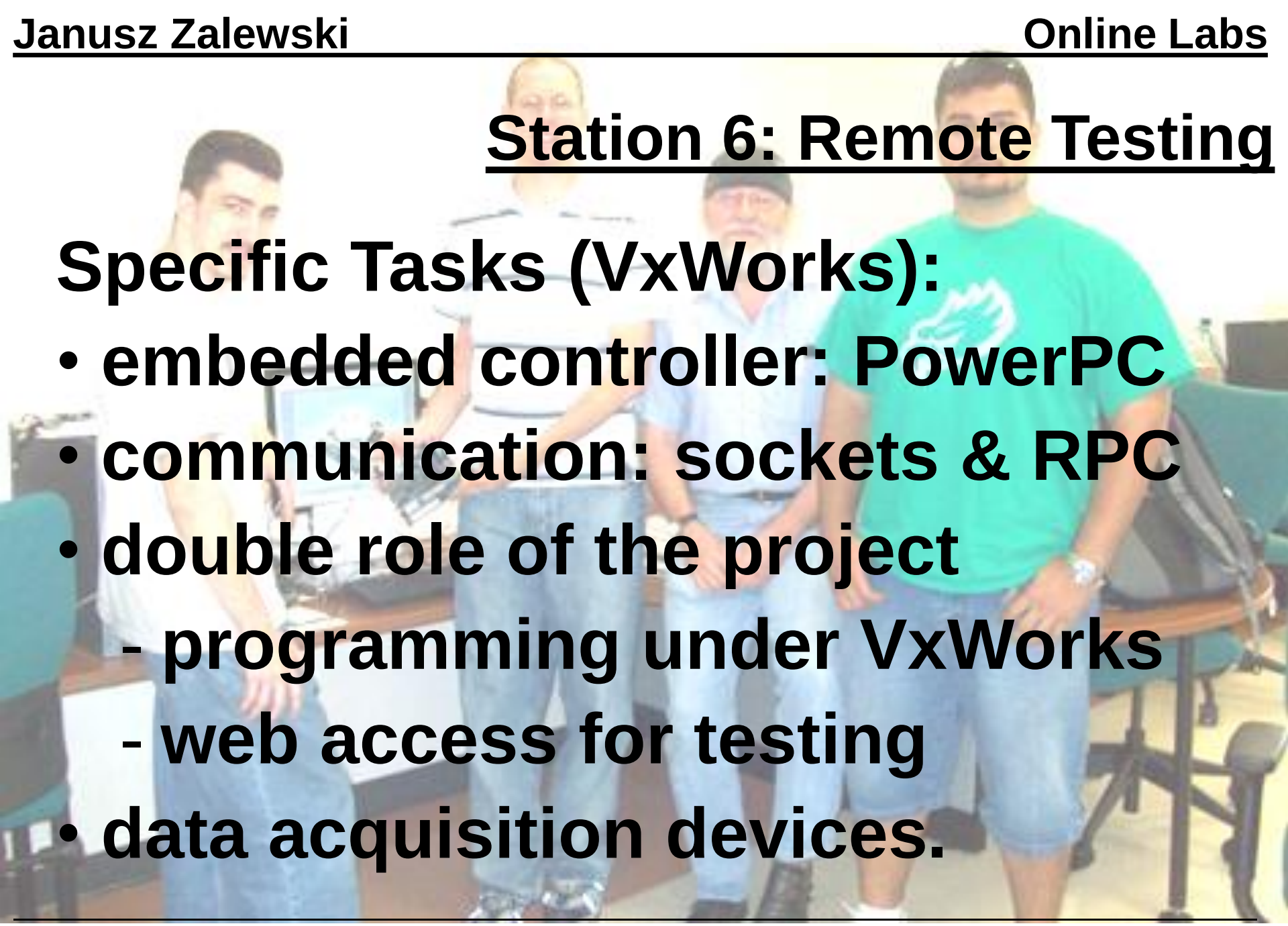
Station 5: Web Game

Specific Tasks:

- 8-core Parallax Processor
- communication: HTTP
- double role of the project
  - programming the game
  - web access for testing.

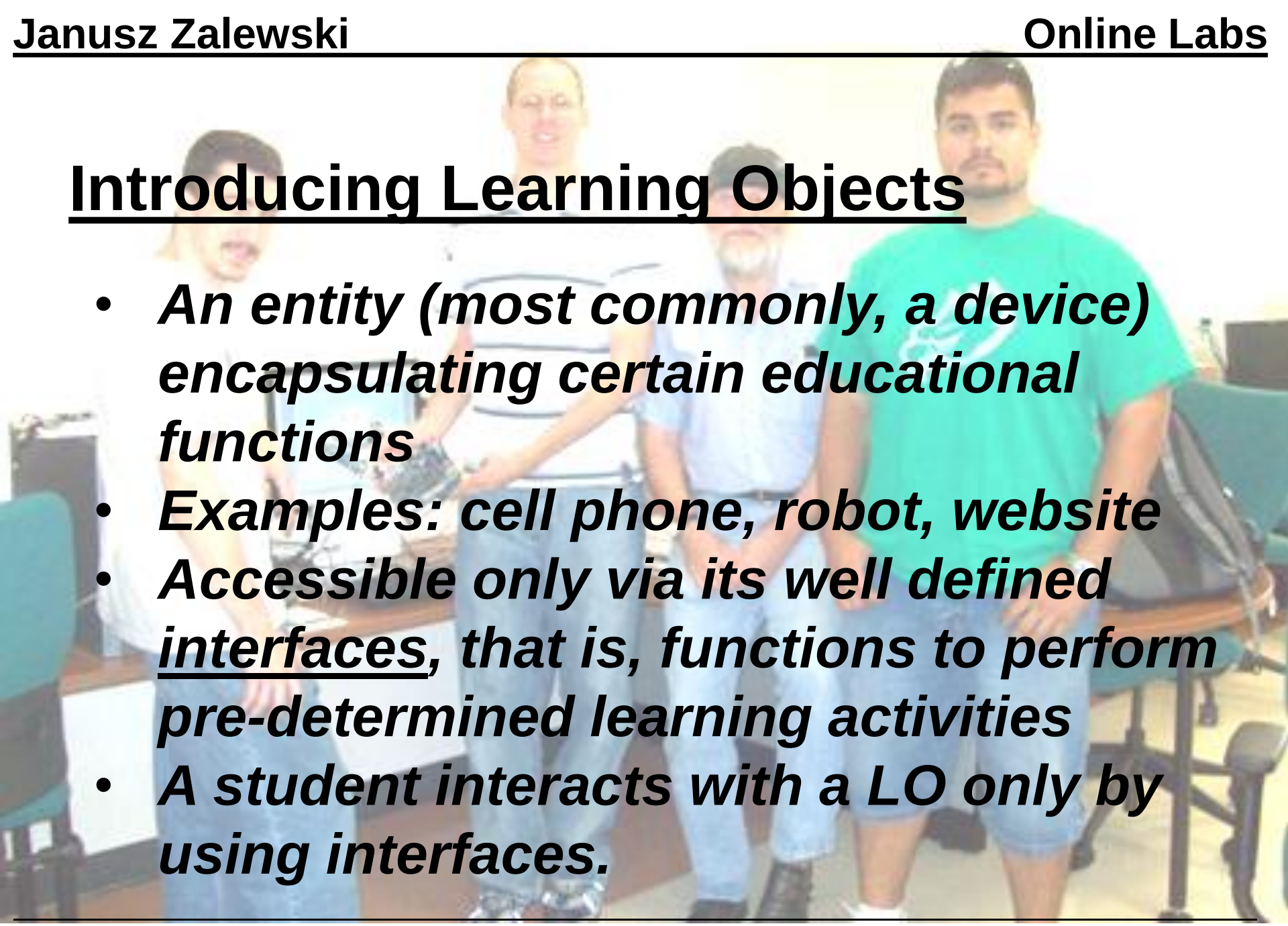
Station 6: Remote Testing

Station 6: Remote Testing



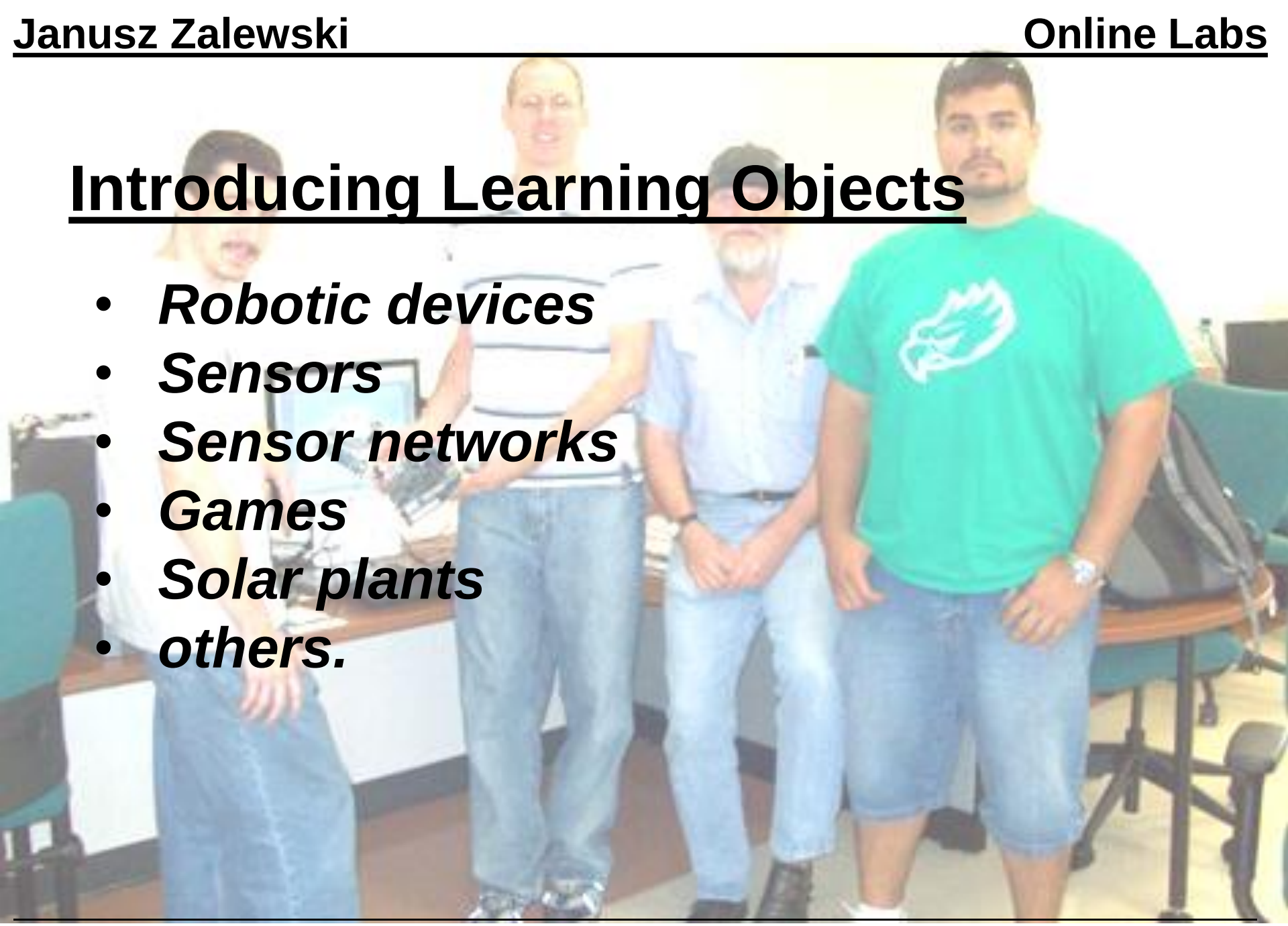
Specific Tasks (VxWorks):

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



Introducing Learning Objects

- *An entity (most commonly, a device) encapsulating certain educational functions*
- *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 a LO only by using interfaces.*



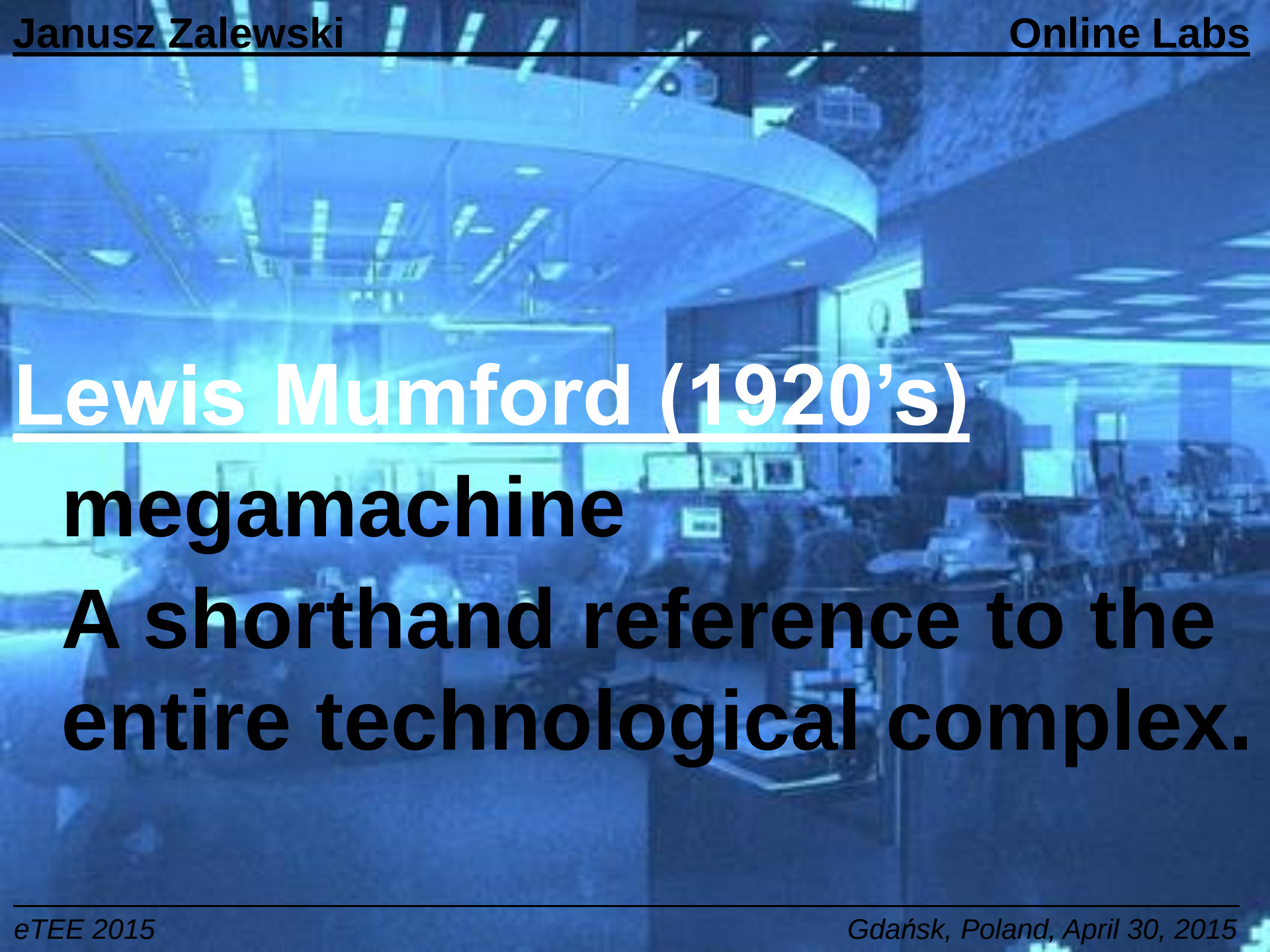
Introducing Learning Objects

- *Robotic devices*
- *Sensors*
- *Sensor networks*
- *Games*
- *Solar plants*
- *others.*

Remote Learning Objects

- *IEEE Standards Association*
- *Working Group P1876*
  Networked Smart Learning Objects
  for Online Laboratories
- **http://ieee-sa.centraldesktop.com/1876public**

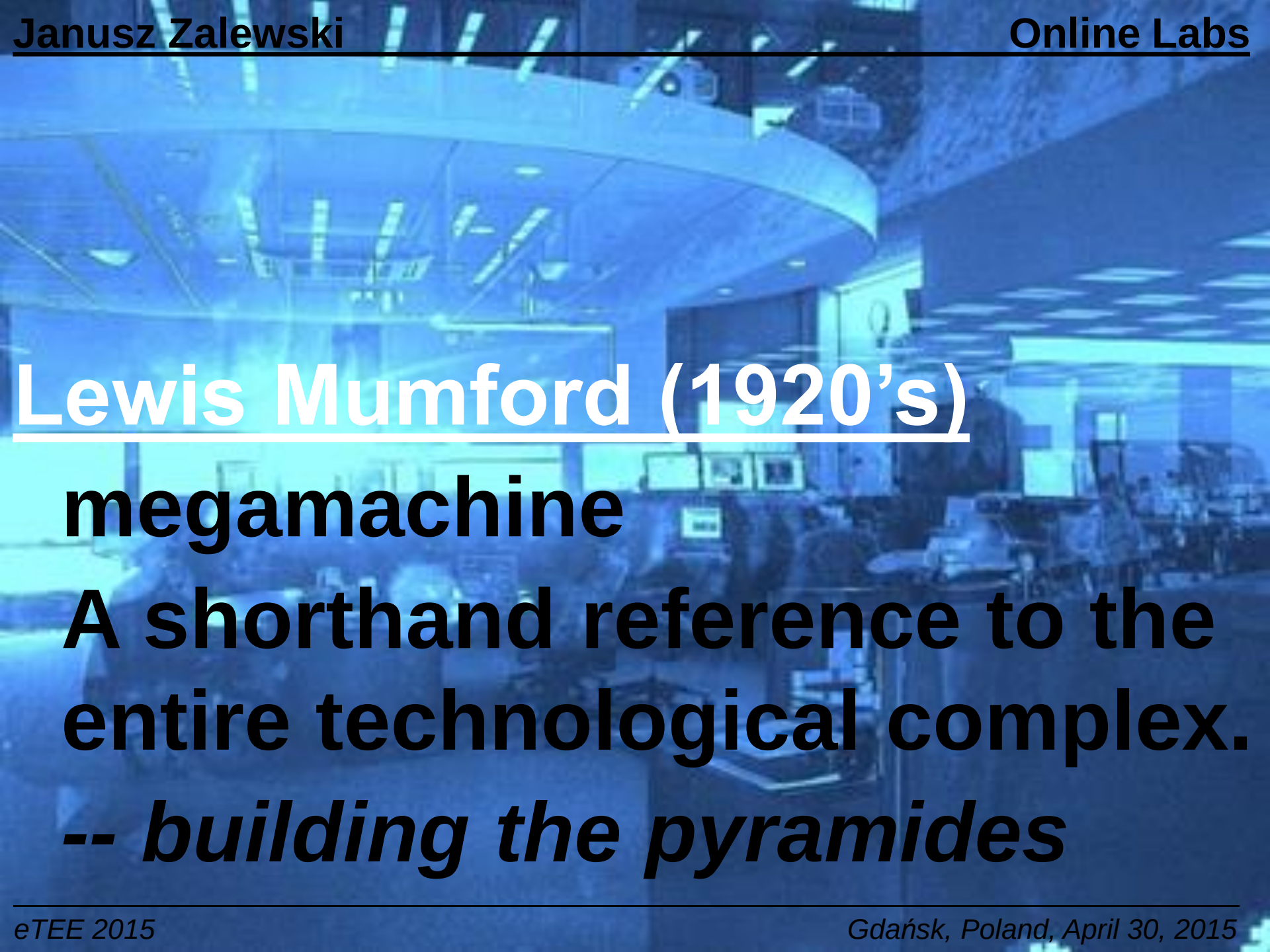

Fermilab
Managed by Fermi Research Alliance
For Office of Science/U.S. Department of Energy



Lewis Mumford (1920's)

megamachine

A shorthand reference to the entire technological complex.



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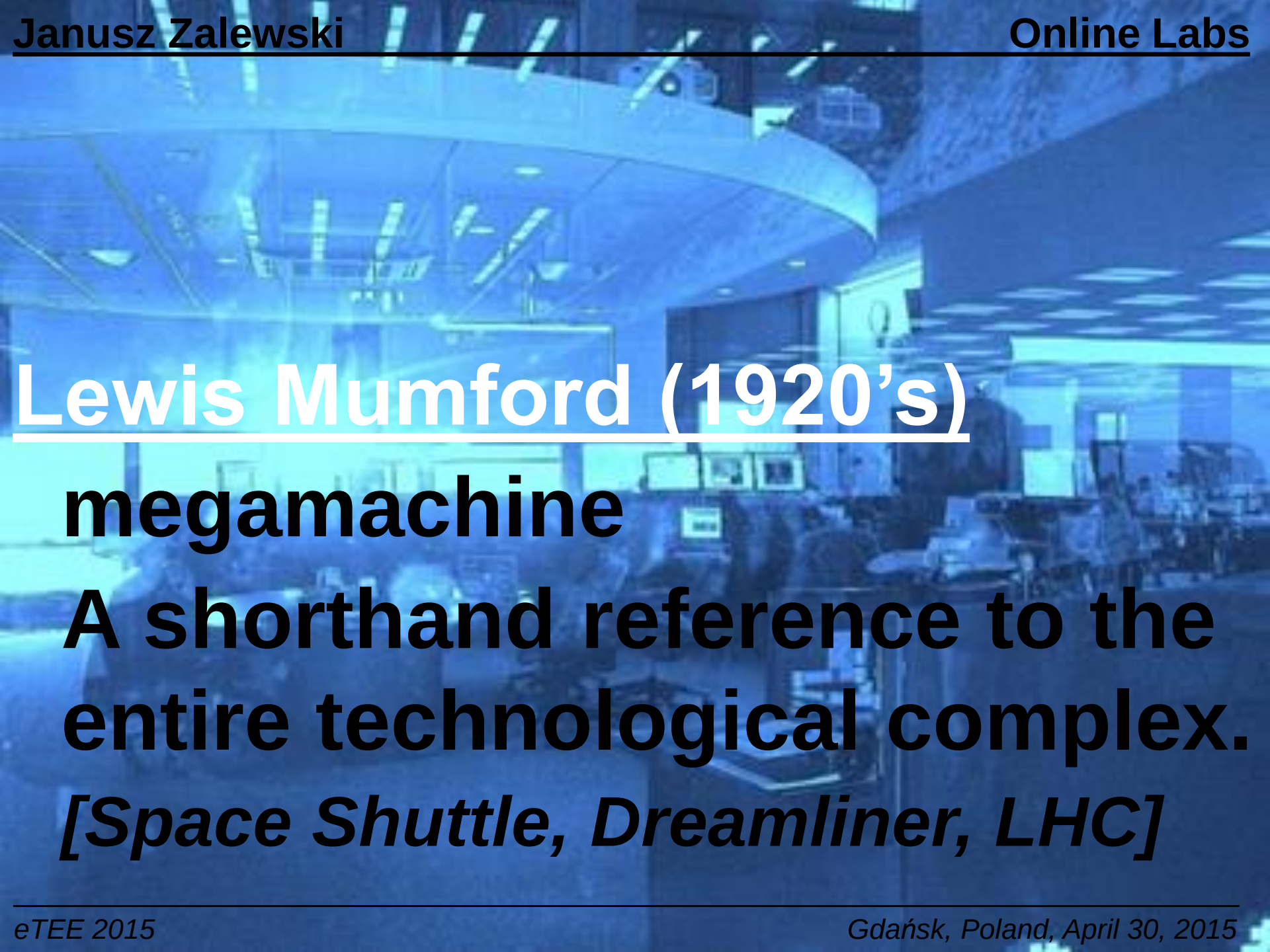
-- building the pyramides



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A shorthand reference to the entire technological complex.

[Space Shuttle, Dreamliner, LHC]

Some Data

- Facebook, March 2013 – 665 million users per day
- In 2014 – 7.4 billion of active mobile phones
- In 2025 – 7 trillion IP enabled devices

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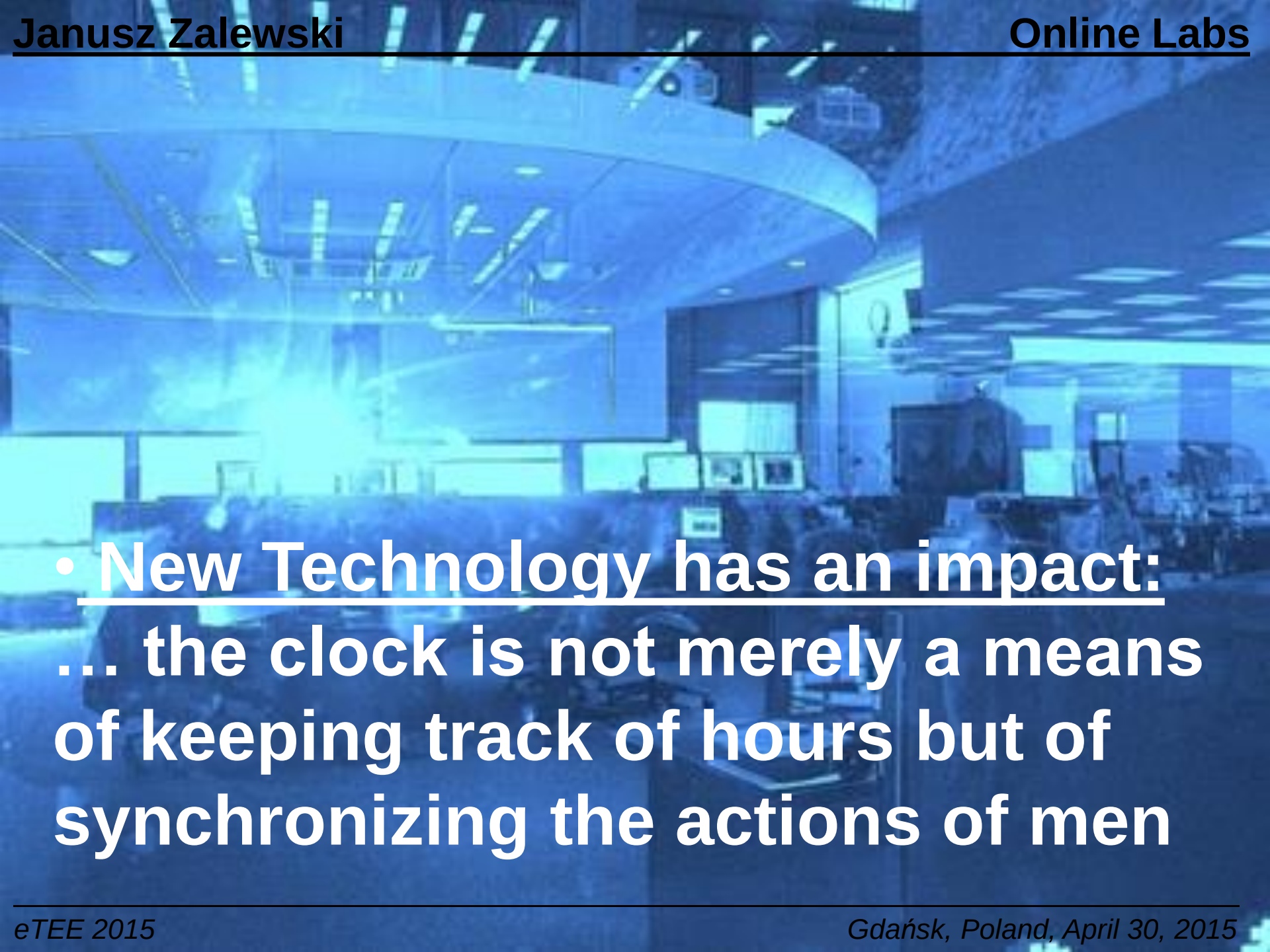
More Data

- Typical Japanese aircraft involves 200,000 parts, 10 times more than a car, which involves 20,000 parts
- In 1900's it took 700 parts for Ford to produce Model T
- In 1990 at Super Collider the plan was to have particles collide every 10-100 ns producing 1 MB of data each time



- New Technology has an impact:

… the clock is not merely a means of keeping track of hours but of synchronizing the actions of men

- **New Technology has an impact:**

… 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]

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"

Some Facts

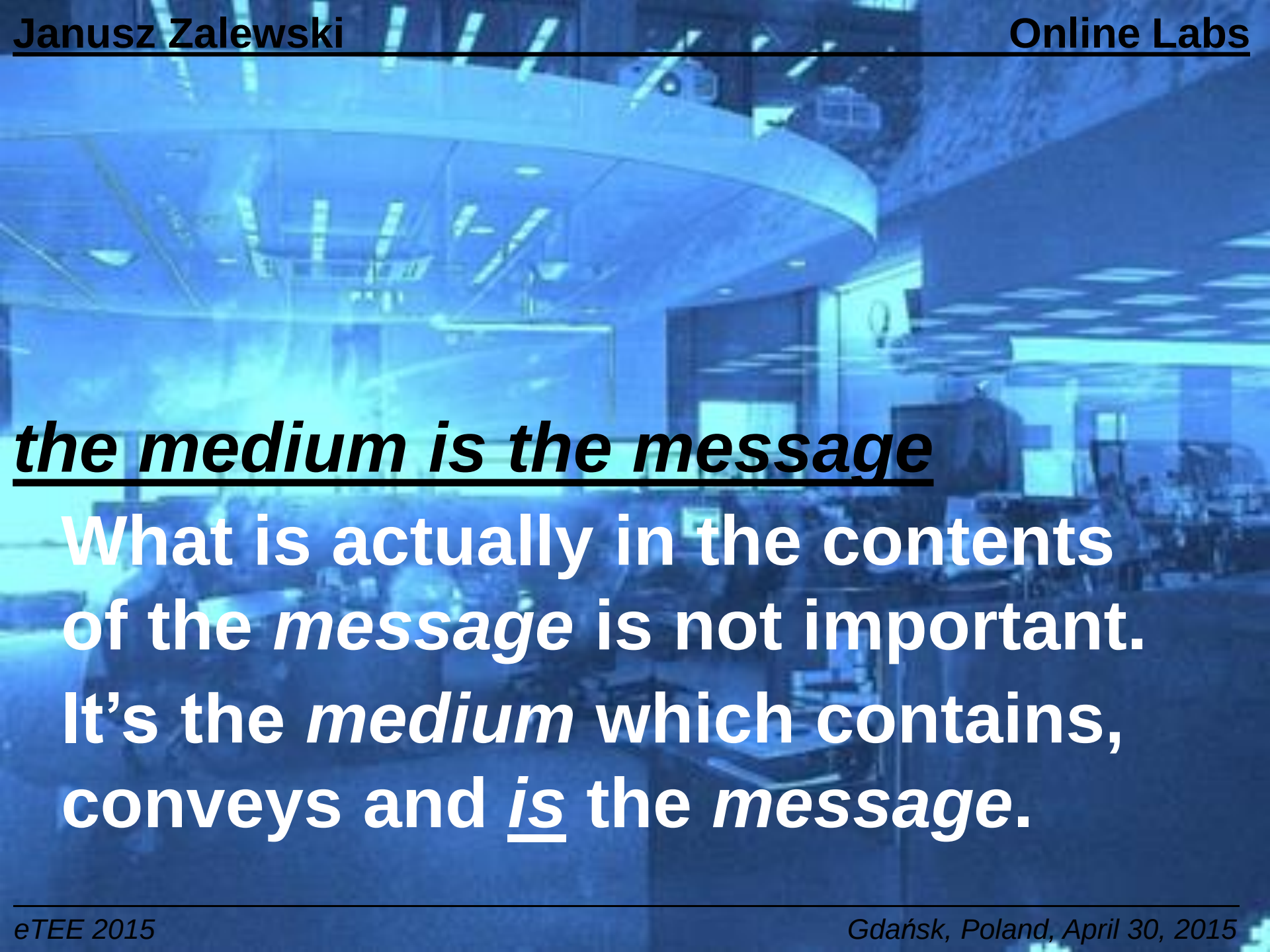
- Wheels extend our legs
- Glasses are extending our vision
- Printing extended our speech

Some Facts

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

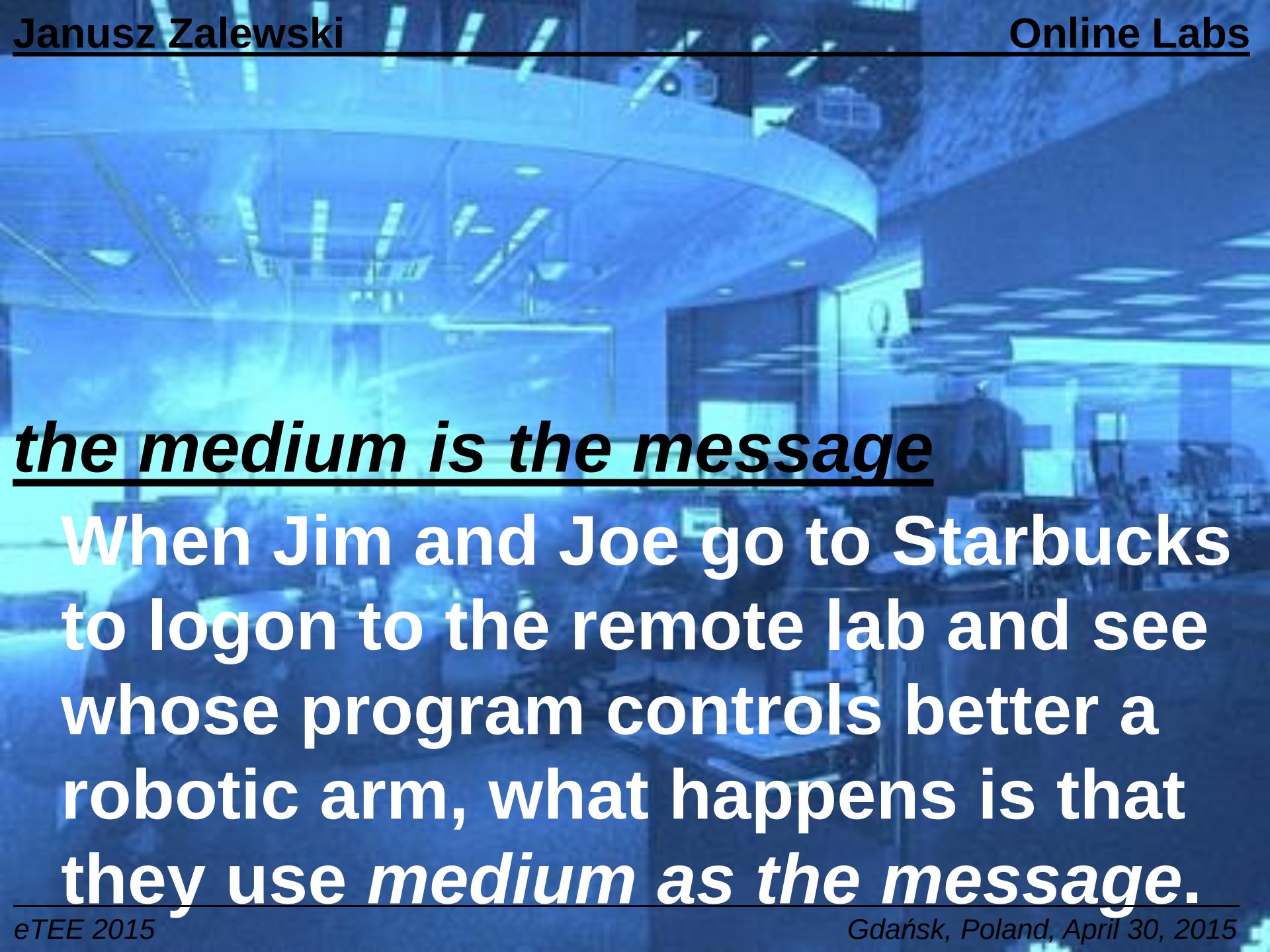
More Facts

- Printing press gave rise to revolution in communication - as a consequence, the emergence of rational thought in Enlightenment was actually due to the printing press
- Telegraph, telephone extend our nervous system
- Electronic media extend our consciousness



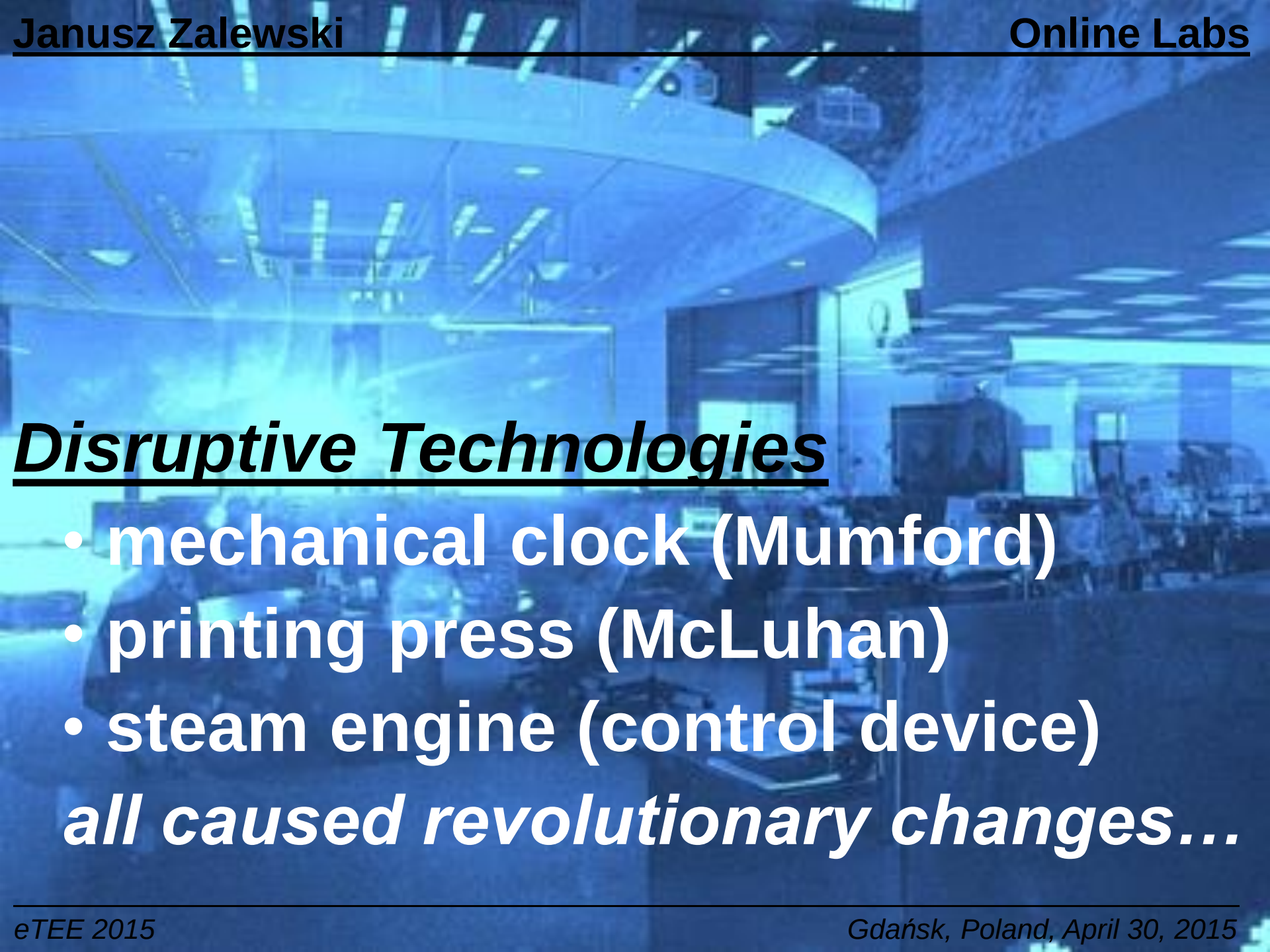
the medium is the message

What is actually in the contents of the *message* is not important. It's the *medium* which contains, conveys and *is* the *message*.



the medium is the message

When Jim and Joe go to Starbucks to logon to the remote lab and see whose program controls better a robotic arm, what happens is that they use *medium as the message*.



Disruptive Technologies

- mechanical clock (Mumford)
- printing press (McLuhan)
- steam engine (control device)

all caused revolutionary changes…

Disruptive Technologies

Cause failures of industries

- **Sears gave way to Walmart**
- **Blockbuster gave way to Netflix**

due to revolutionary changes…

Disruptive Technologies

Cause failures of industries

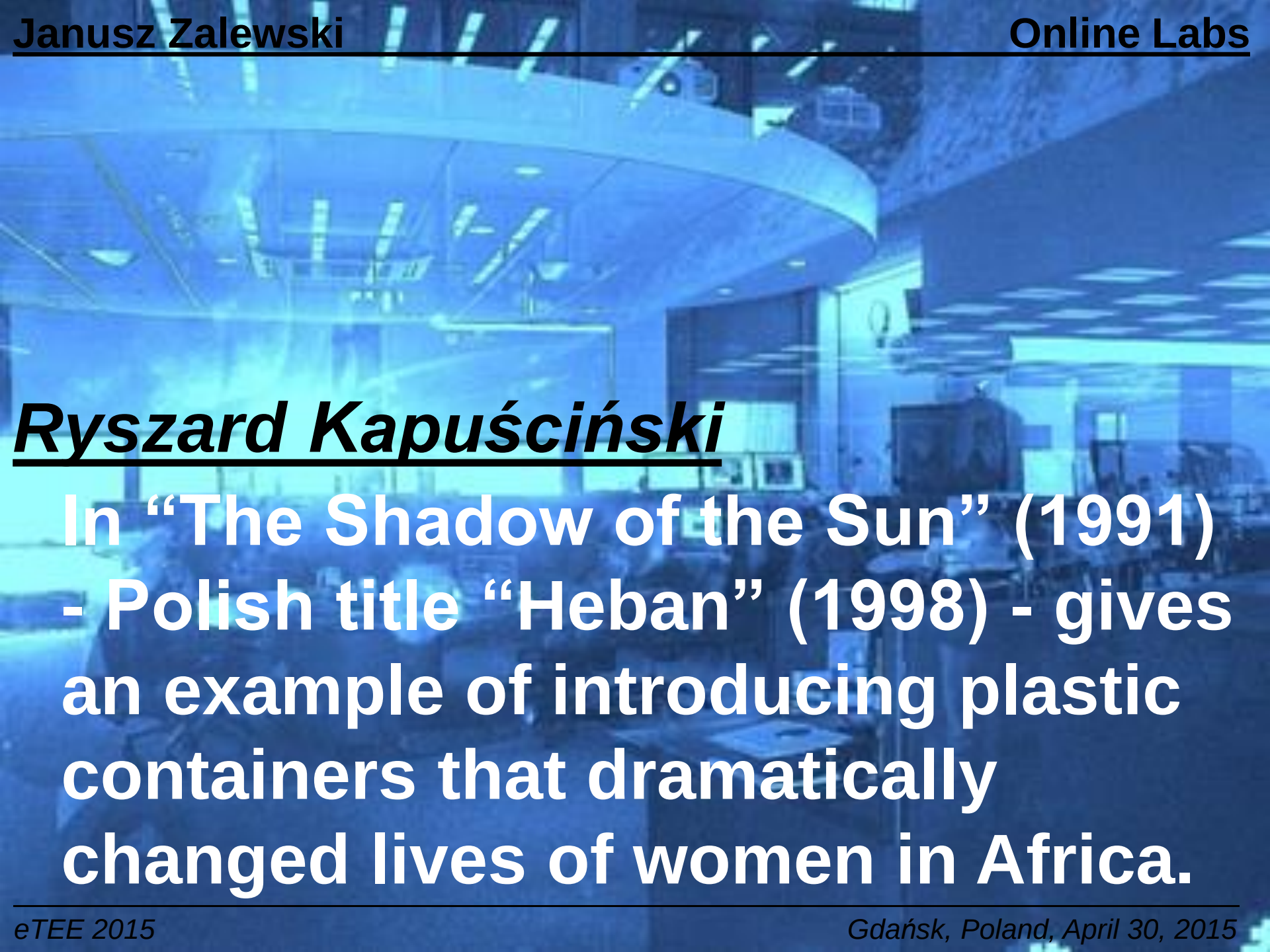
- **IBM missed the minicomputers**
- **DEC missed the microcmputers**

due to revolutionary changes…

C.M. Christensen

disruptive technology

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



Ryszard Kapuściński

In “The Shadow of the Sun” (1991) - Polish title “Heban” (1998) - gives an example of introducing plastic containers that dramatically changed lives of women in Africa.

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

- New Disruptive Technology
- Tremendous job advantage for student developers
- Great experience for faculty
- Significant technical problems
- Major administrative problems
- Course on Embedded Systems Programming in Spring 2013

Waiting for Questions