Applications of Wireless Sensor Networks and Mobile Devices

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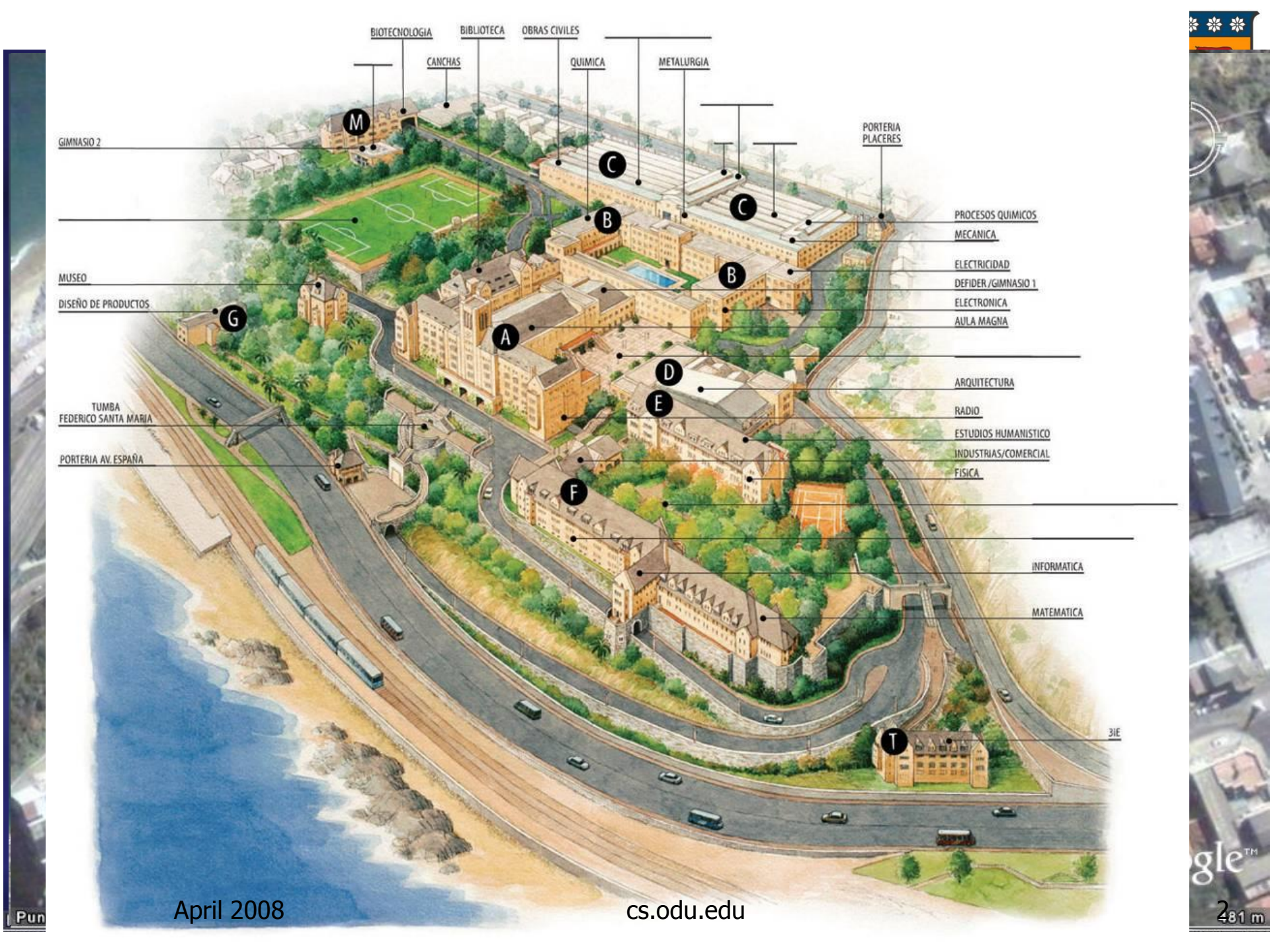
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BIBLIOTECA
OBRAS CIVILES
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DISEÑO DE PRODUCTOS
ELECTRONICA
AULA MAGNA
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Department of Electronics

- 5 areas of specialization, two of those are Computers and Telecommunications
- 21 faculty members
- Undergraduate programs
  - **Electrical Engineering**
  - Telematic
- Master's and Doctoral programs

Outline

- Mobile and Multihop ad hoc networks
- Wireless sensor networks
  - Hardware and Standards
- Applications
  - Precision Agriculture application
  - Monitoring Off the Road Mining Trucks
- Mobile devices
  - Hardware
- Applications
  - Monitoring Student Learning in the classroom
  - Retail Store Assistant
  - Medical assistant application for skull surgery

Mobile and Multihop **Ad hoc Networks**

- Mobile ad hoc networks (MANET): in this paradigm mobile devices self-organize to create a network by exploiting their wireless network interfaces, without a requirement for a pre-deployed infrastructure.
- It assumes network use for large-scale general consumer applications, and nodes would be ubiquitous (dense and active)
- This has not happened yet.

Mobile and **Multihop** Ad hoc Networks (cont.)

- Multihop network refers to an end-to-end transmission paradigm. Here, packets are forwarded in ad hoc fashion by the network nodes from the source to the destination.
- Devices that are not directly connected can communicate by forwarding their traffic via a sequence of intermediate devices.
- This has been used in several commercial solutions.
- Examples: Mesh, opportunistic, vehicular, and sensor networks.

Wireless Sensor Networks

- The idea is to study, control, and monitor events and phenomena.
- A number of sensor nodes are deployed in a dense and possible random manner inside the monitoring area.
- Info collected by sensors is delivered to a sink node and through this to nodes connected to the Internet.
- Enabling technology: MOTE

WSN and Motes: Hardware platform

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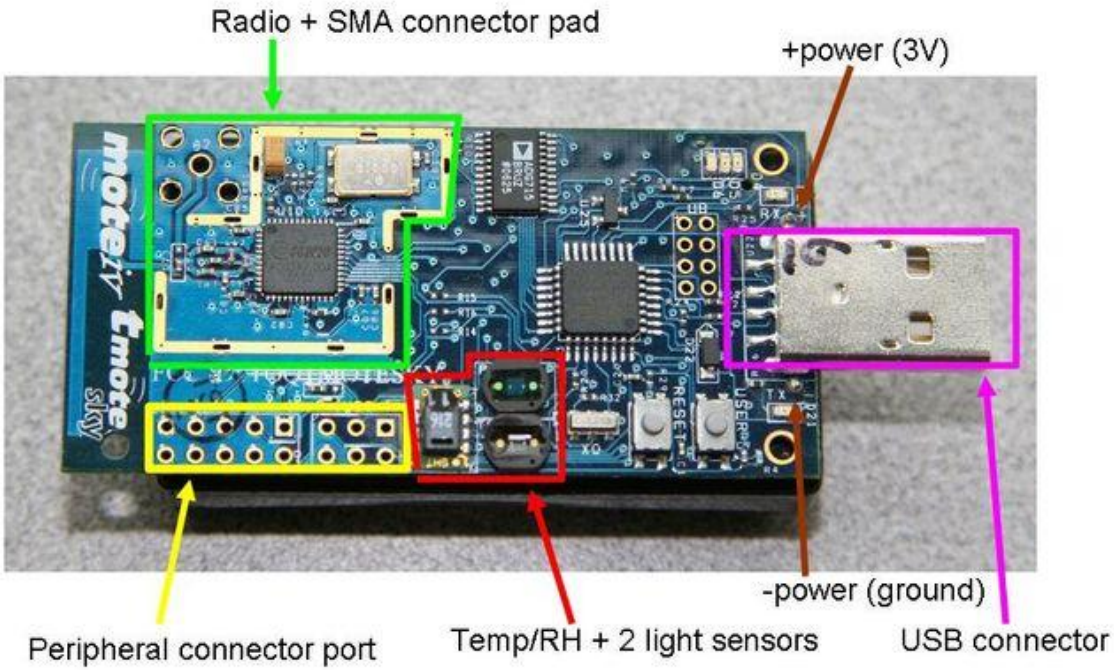
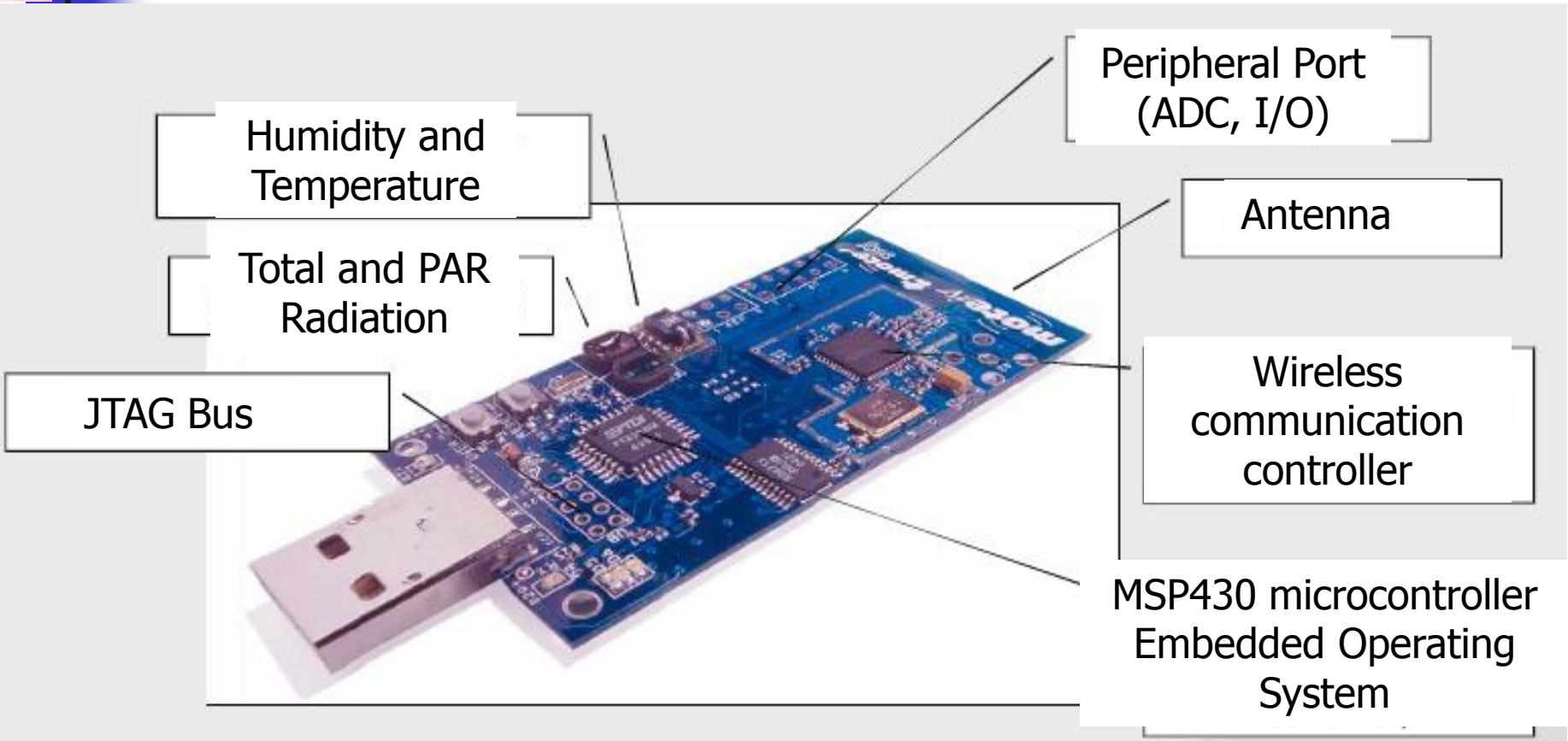


One platform: Tmote Sky



P.A.R. (Photosynthetically Active Radiation)

Another platform: SUN Spot

- 2G/6G 3-axis accelerometer
- Other sensors
- J2ME
- We have not used it in a project yet.

Standards

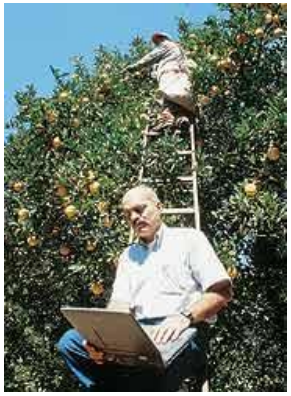
- Physical and MAC layers: IEEE 802.15.4: Optimized for low-cost, low-power, and robust RF performance.

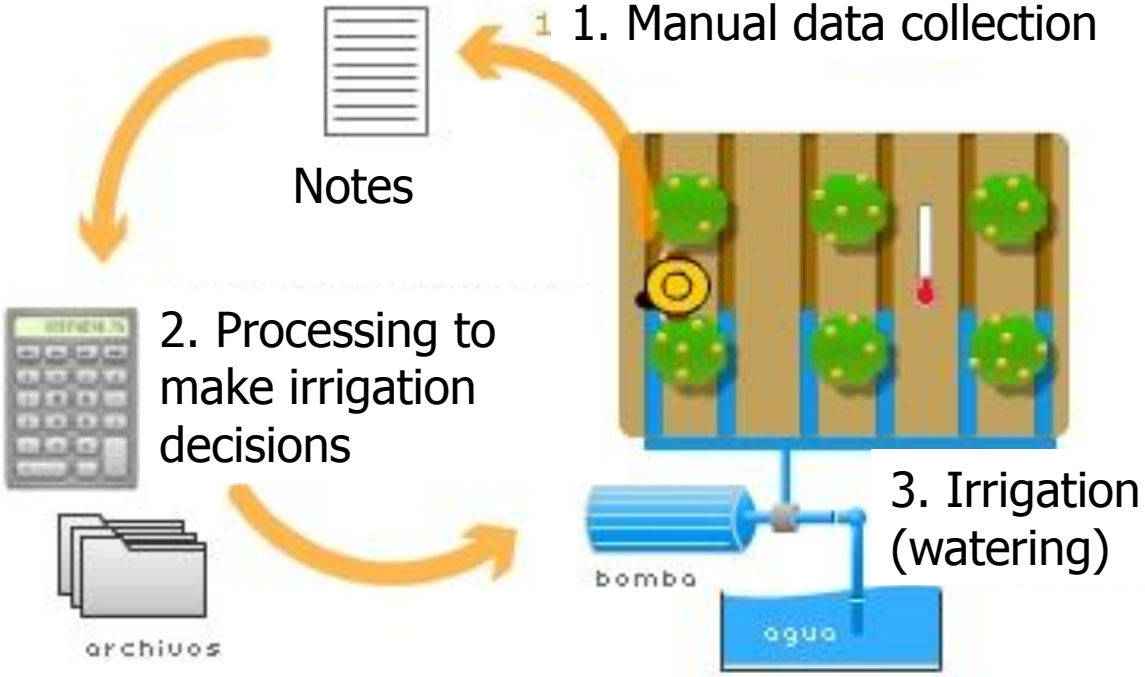
250 kb/s	2.4 GHz
40 kb/s and 20 kb/s	900 and 868 MHz

- ZigBee (2004) builds on top of 802.15.4 and encompasses a complete network stack for WSN focuses on sensor and control networks.
- ZigBee Pro (dec. 2007) improves addressing and routing algorithms

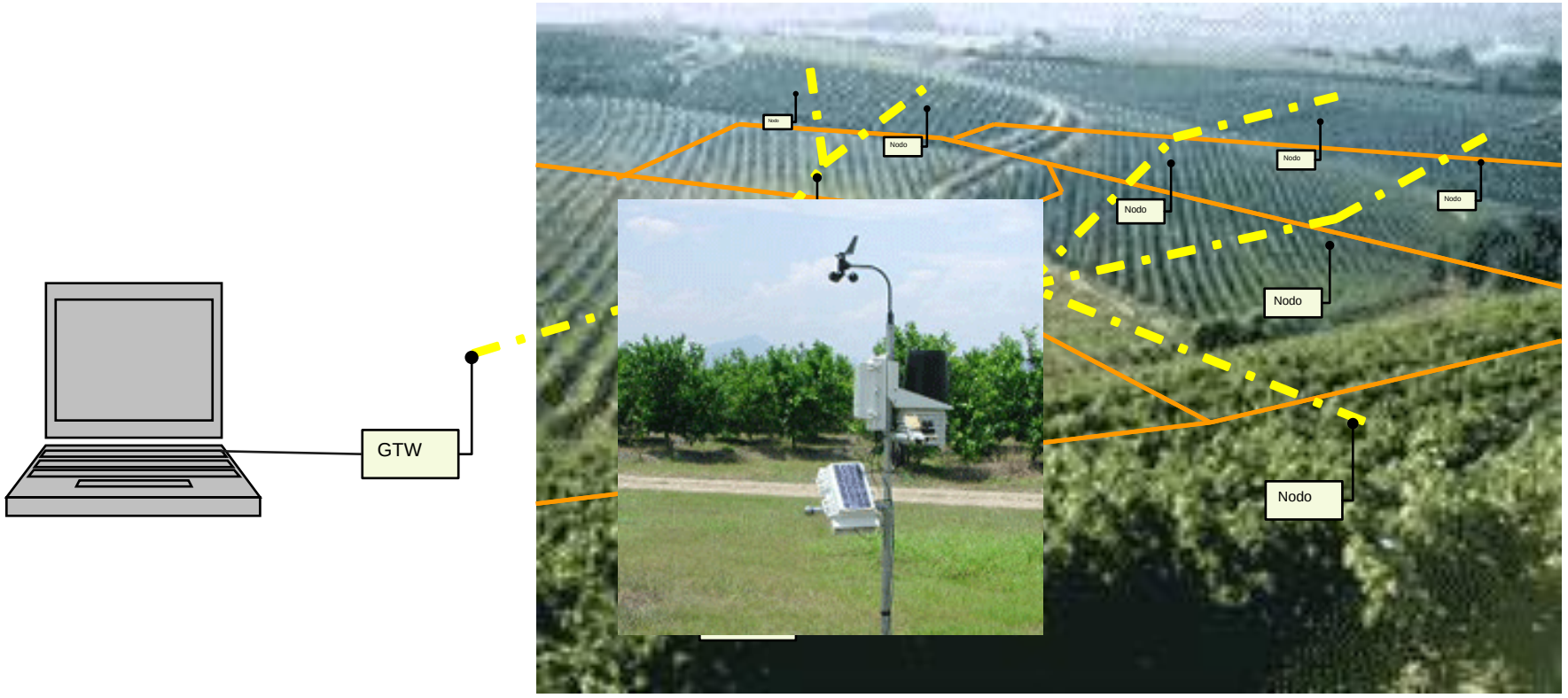
Precision Agriculture: the problem

Traditional
Manual data collection





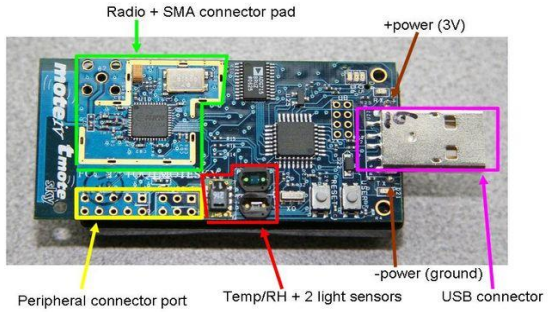
Precision Agriculture Application: Solutions



Meteorological Station

Issues we addressed

- Application driven by interaction with environment
- Limited resources
- Reliability (long-lived application)
- Soft real-time requirements
- RF Signal propagation and interference



Mote platform

+ Tiny OS + NesC

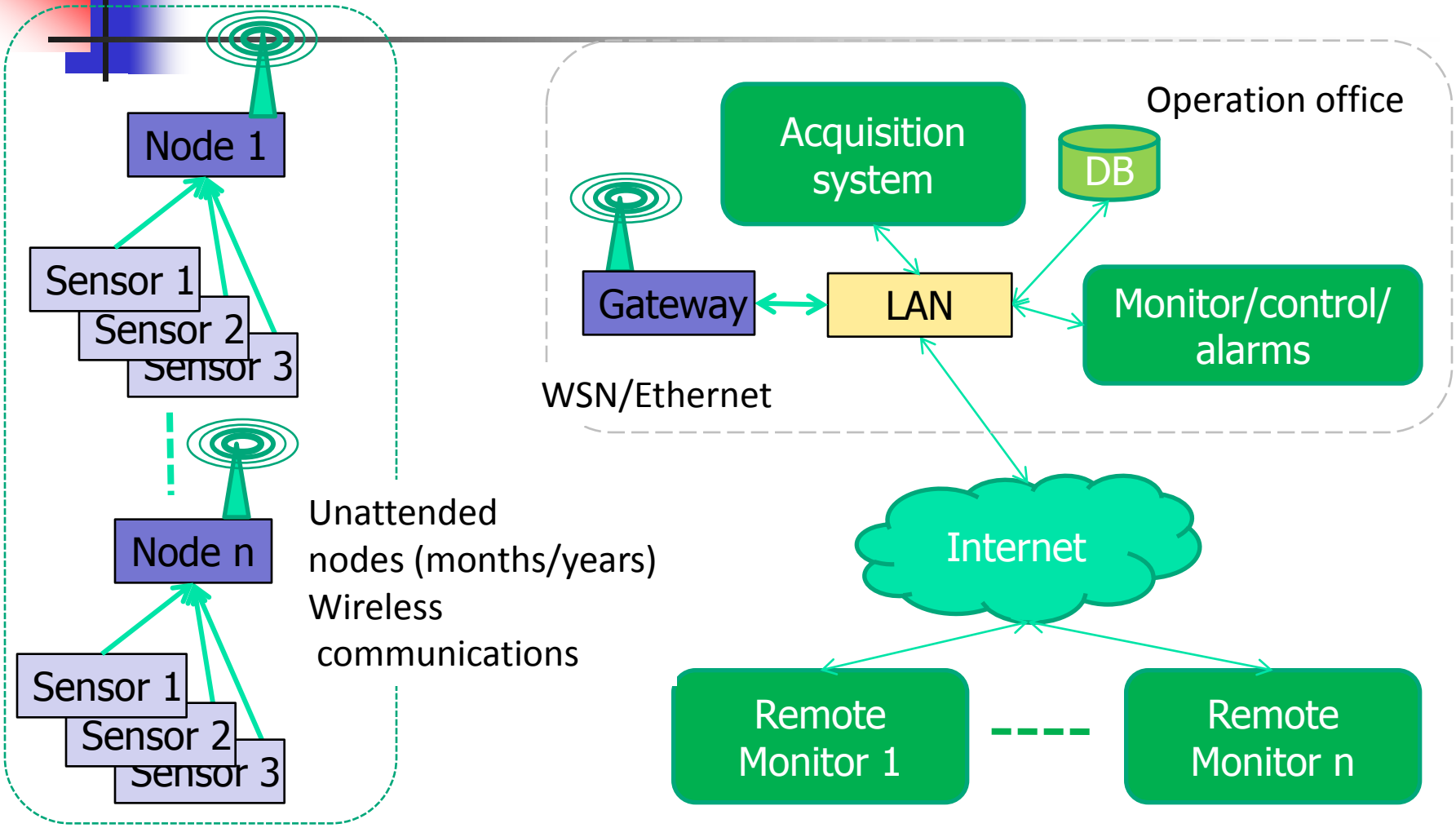
= Application

Result

- José Ulloa's Final Project
- Data acquisition application

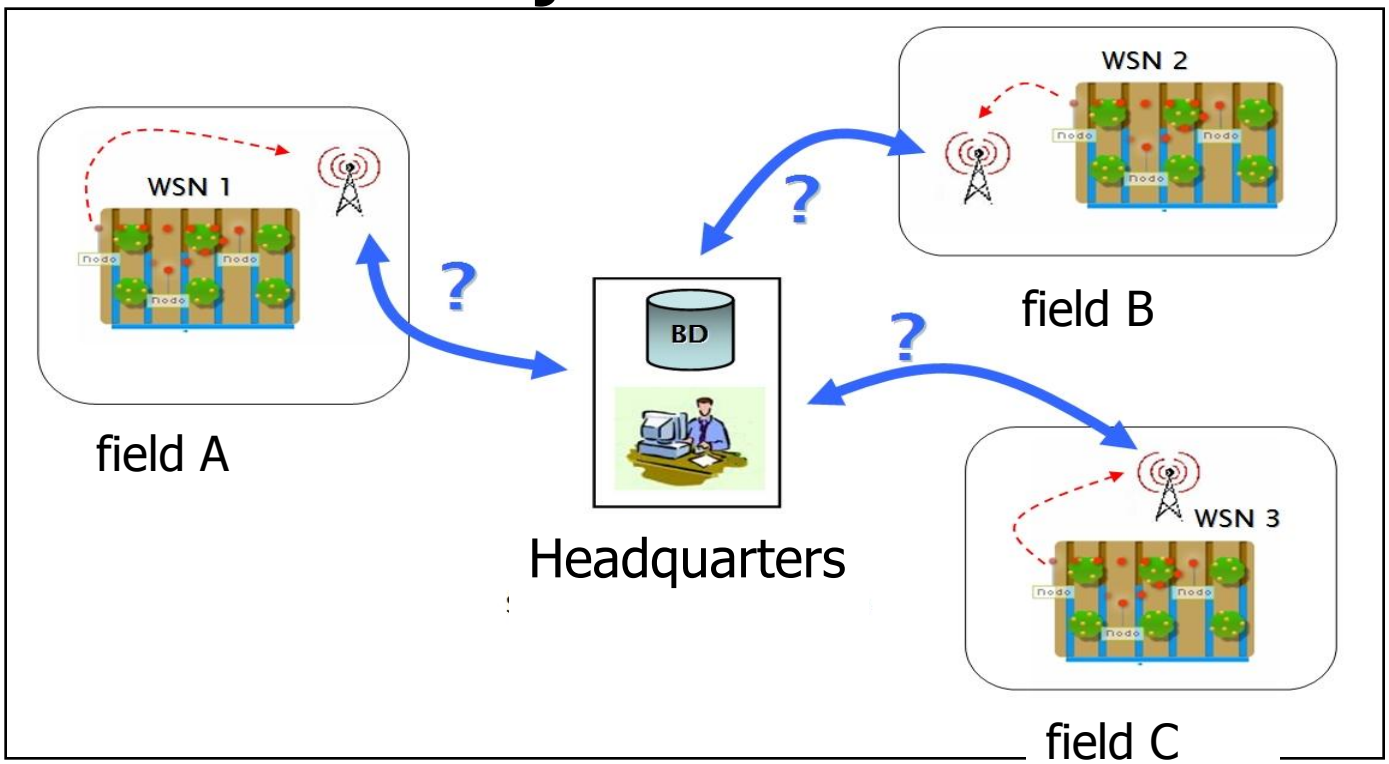
- In collaboration with Wiseconn
- Product: WiseField

General Architecture



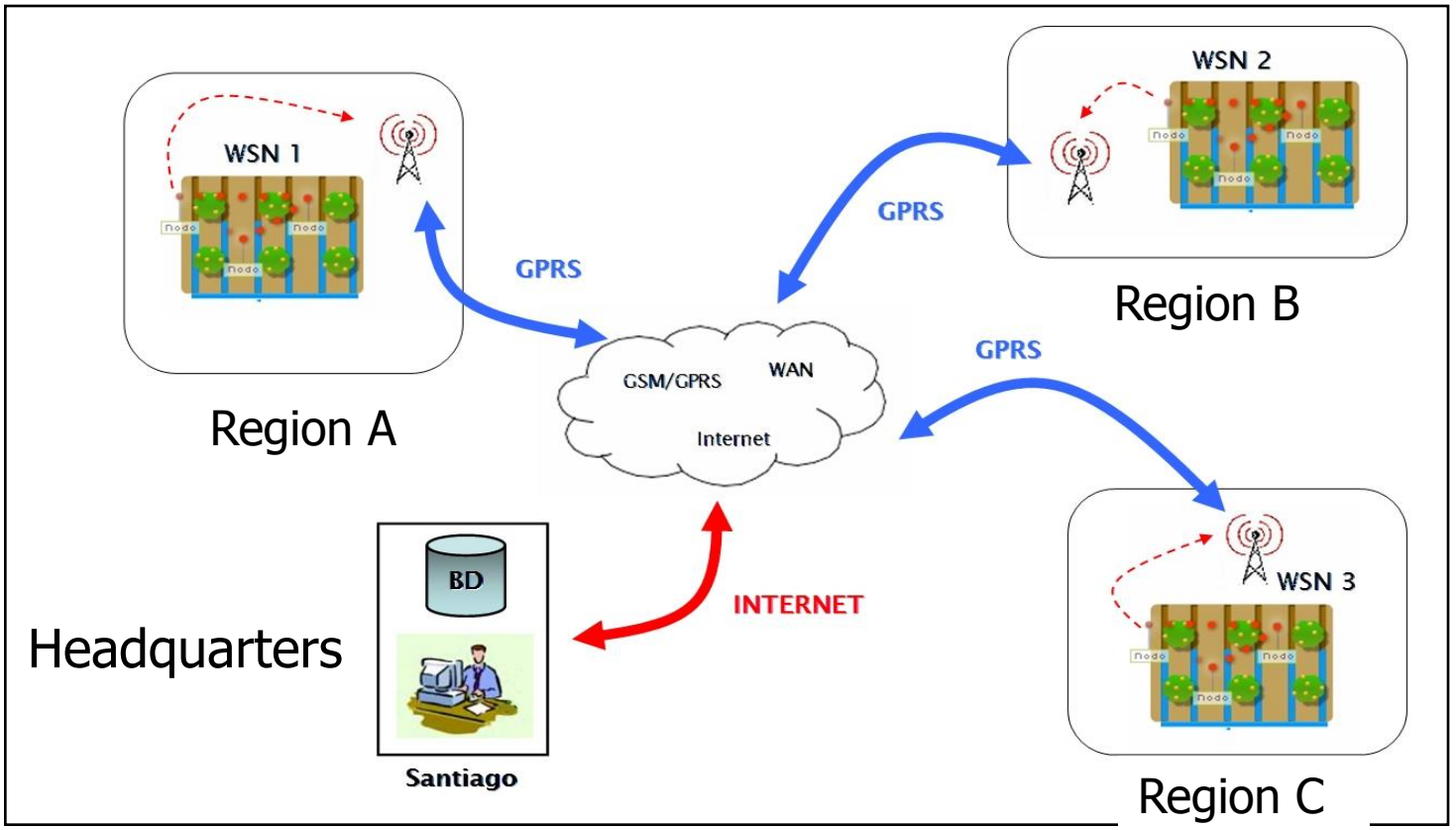
Client's new Requirement

What if the client owns several disjoint fields?



Precision agriculture: Extension

Using a WSN-GPRS gateway in each field



Architecture

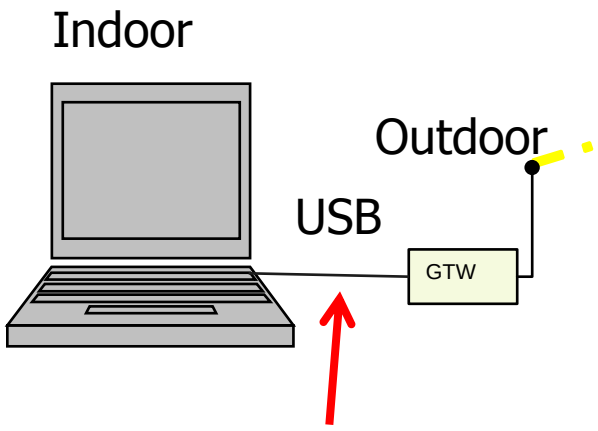
We used a GSM/GPRS standalone modem

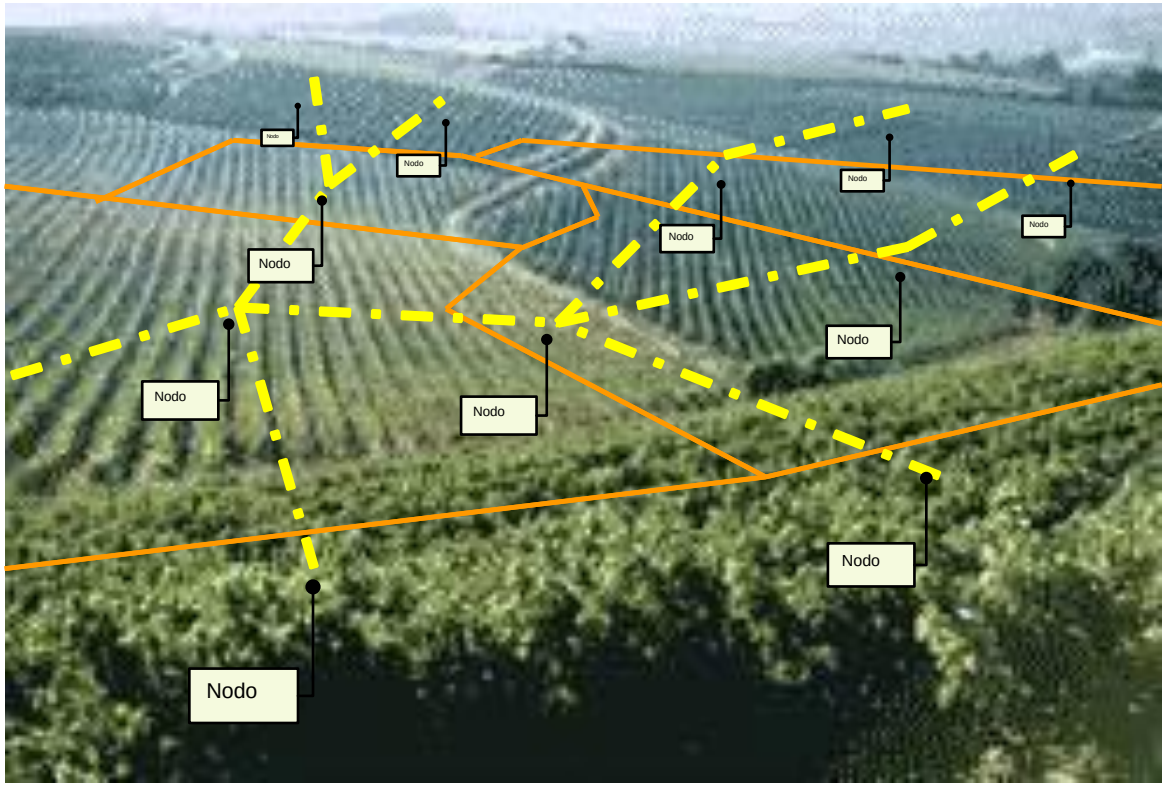
Result

- César Leon´s Final project
- Enhanced version of WiseField
- Main issue: reliability of GPRS link
  => He figured out a way to overcome rejected connections and packet size constraints
- In collaboration with Wiseconn

Need for WSN/Ethernet Gateway

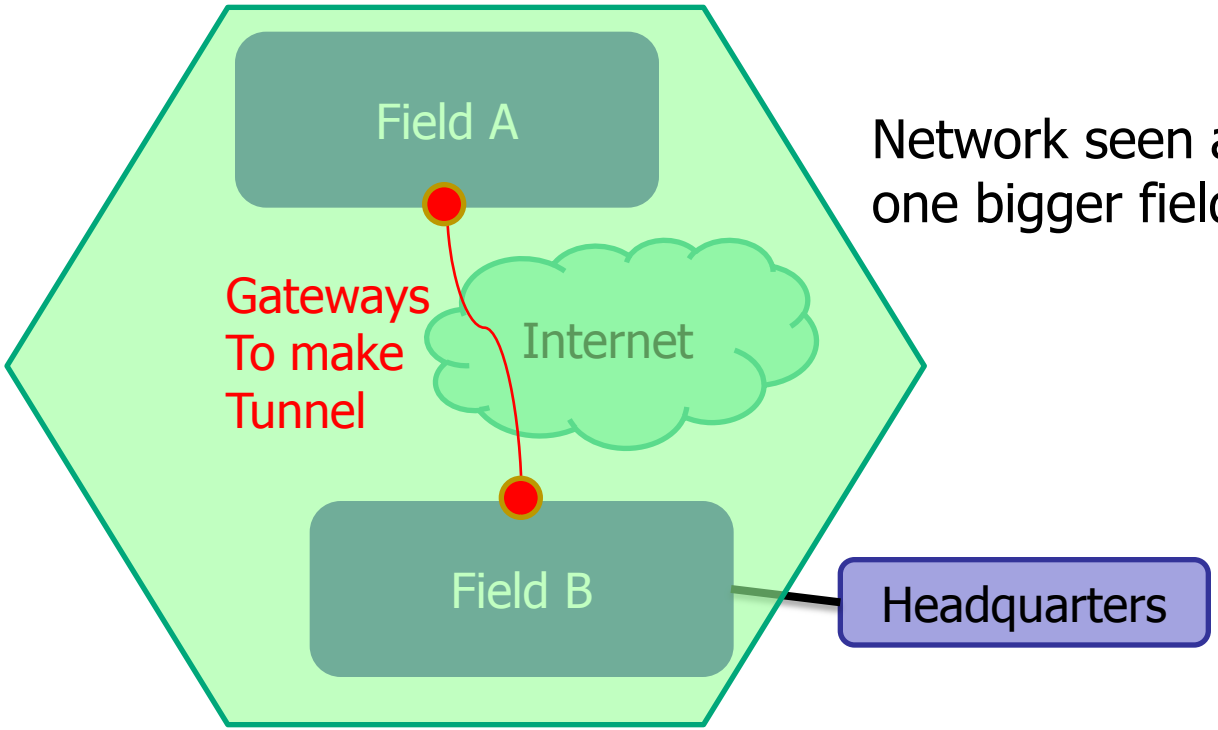
- Scenario 1:





Need for WSN/Ethernet Gateway

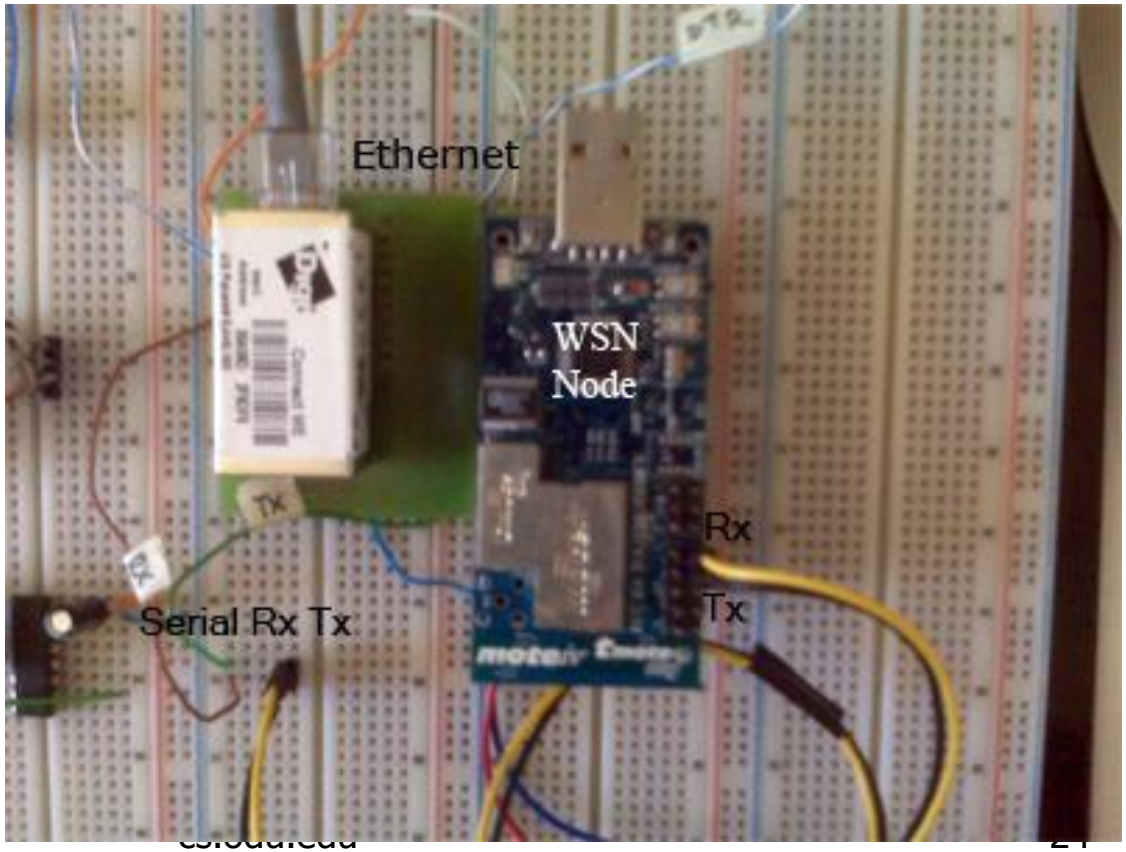
- Scenario 2:



Solution: WSN/Ethernet Gateway:

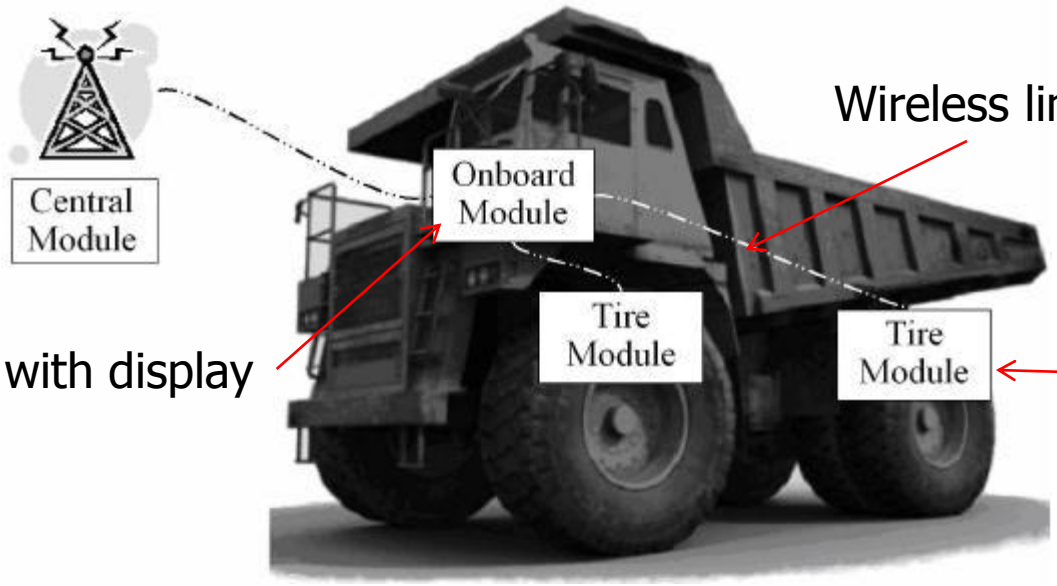
- Guillermo Bustos' Project

Ethernet/Serial gateway OEM System Implements a client/server model



Pressure and Temperature Monitoring System of Mining Truck Tires

- Alejandro Alviña's project
- Tires are among the highest-cost supplies
- He integrated the hardware and protocol

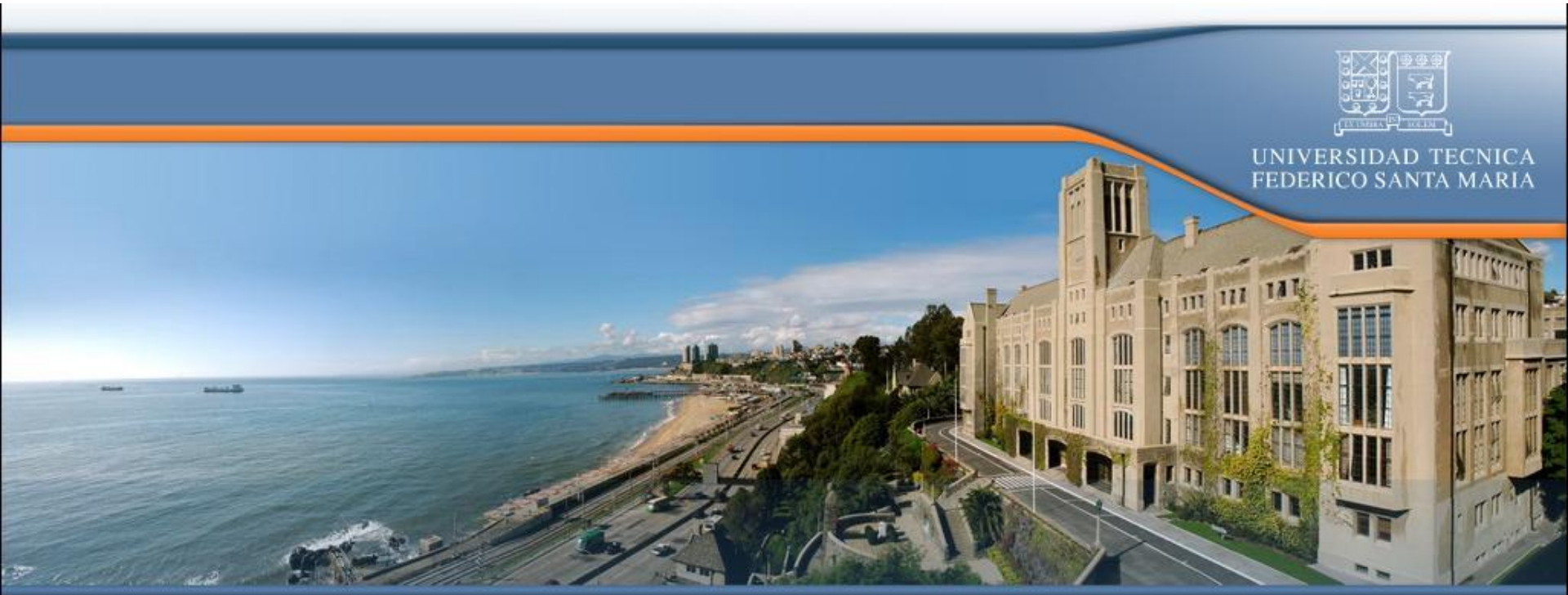


It's also a Wireless Sensor Network

- Sensors: OEM from Freescale
- Microcontroller TI
- RF Module OEM from Aerocomm

Applications using Mobile Devices

Agustín J. González



Mobile devices over time: Yesterday's

Cell phone

PDA

Mobile devices over time: Today's

- We can't tell the difference

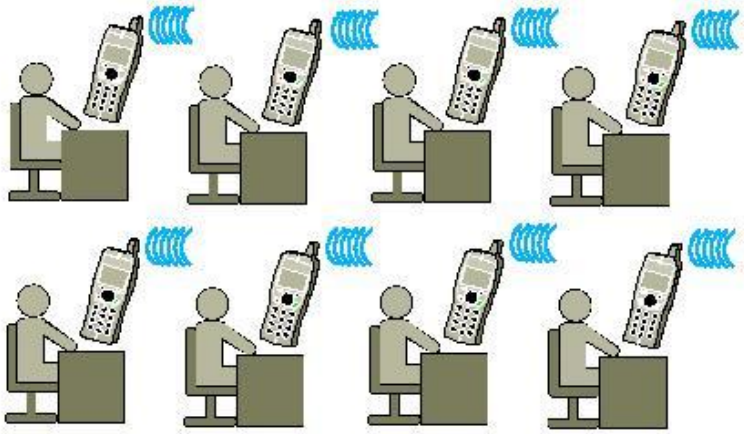
Many available resources

- Not only microphone and speaker
- But also:
  Camera, display, communication (Bluetooth, WiFi, GPRS, …)
- You, we can program them …
- For portability, we are using J2ME.

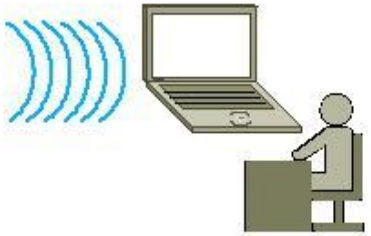
Monitoring Student Learning in the classroom

- Bruno Mundaca's project
- In situ Measurement of students understanding using mobile devices
- Scenario: Teachers normally ask for a brief response.
- Let's use the technology.

Architecture



Students

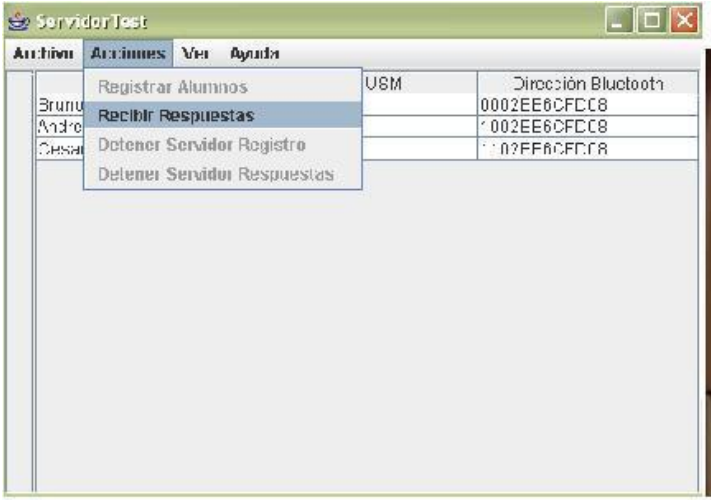


Teacher

- In client side we use:
- Java 2 MicroEdition
- Requires: Java support and bluetooth

- In server side we use:
- Bluecove API for Windows OS
- Avetana API for Linux OS

Result



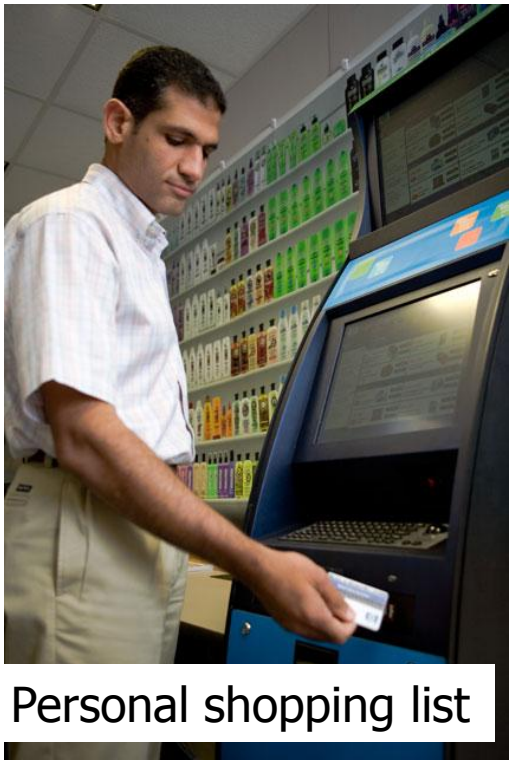
"Learning probe"
Teacher asks for
a brief response

Students' answers

Teacher gets statistics

Retail Store Assistant

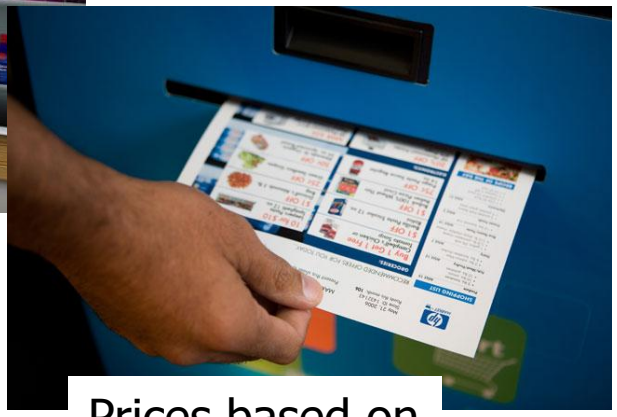
- The PH SmartShopping system (May 2007)



Personal shopping list

Map with item location

Let's use our phones!



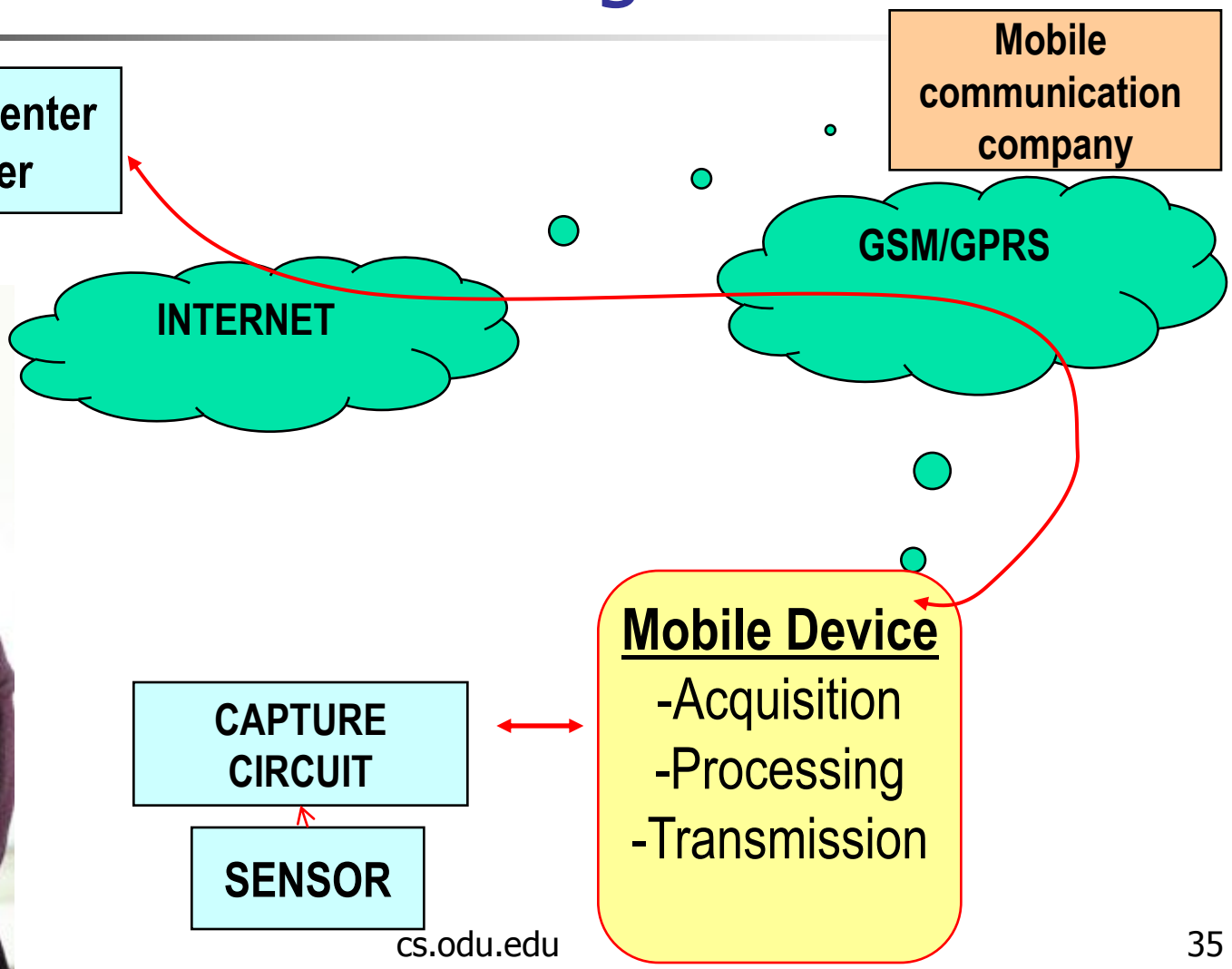
Prices based on client's records

Our Shopping assistant

- Network infrastructure deploy in the store.
- Cell phones connect to it and exchange info, e.g. mobile previous products.
- Use cases:
  - A customer can request a product price by capturing its barcode.
  - Shopping list can be sorted to suggest a route through corridors
- Demo barcode decoder

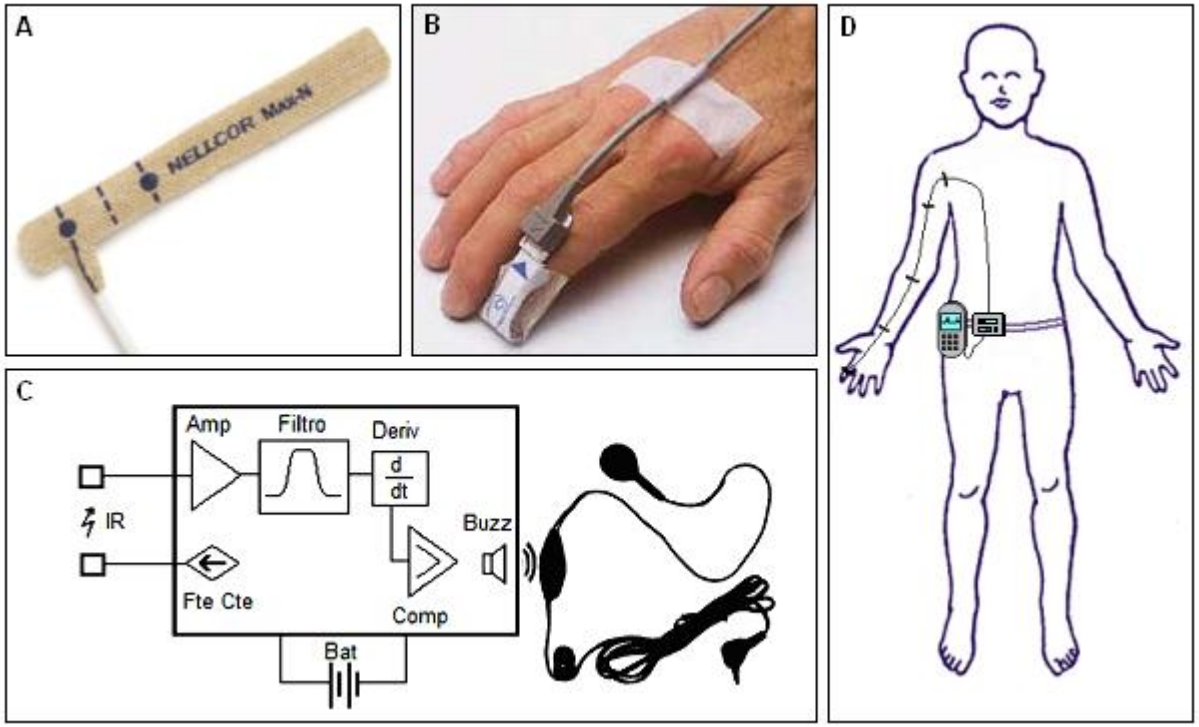
Another Application: Patient Telemonitoring

Pablo Roncagliolo:
Ph.D. Student



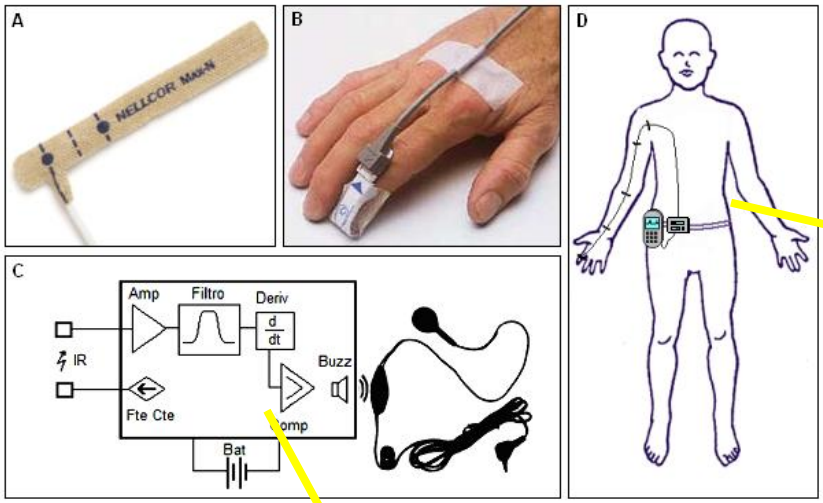
First prototype

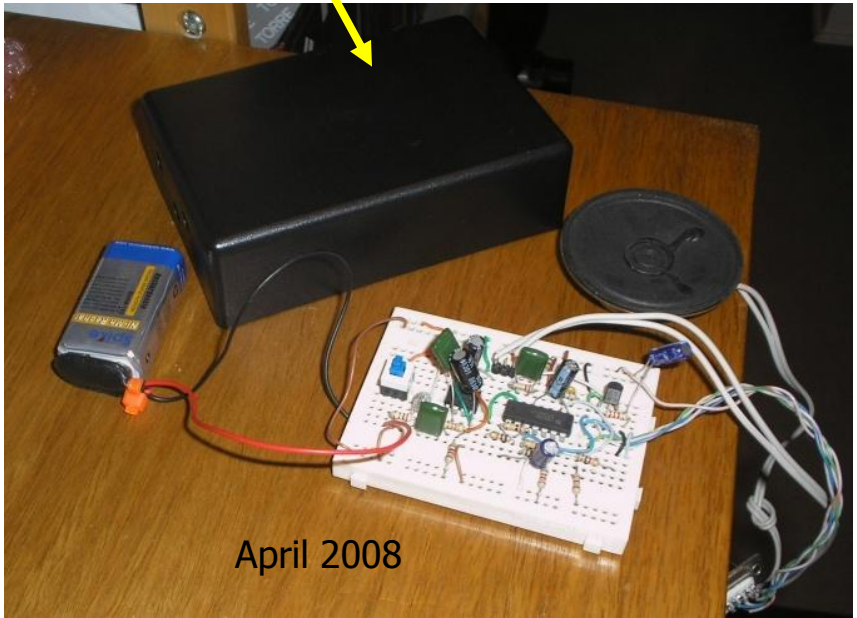
Sensor



Adaptation Circuit

System prototype



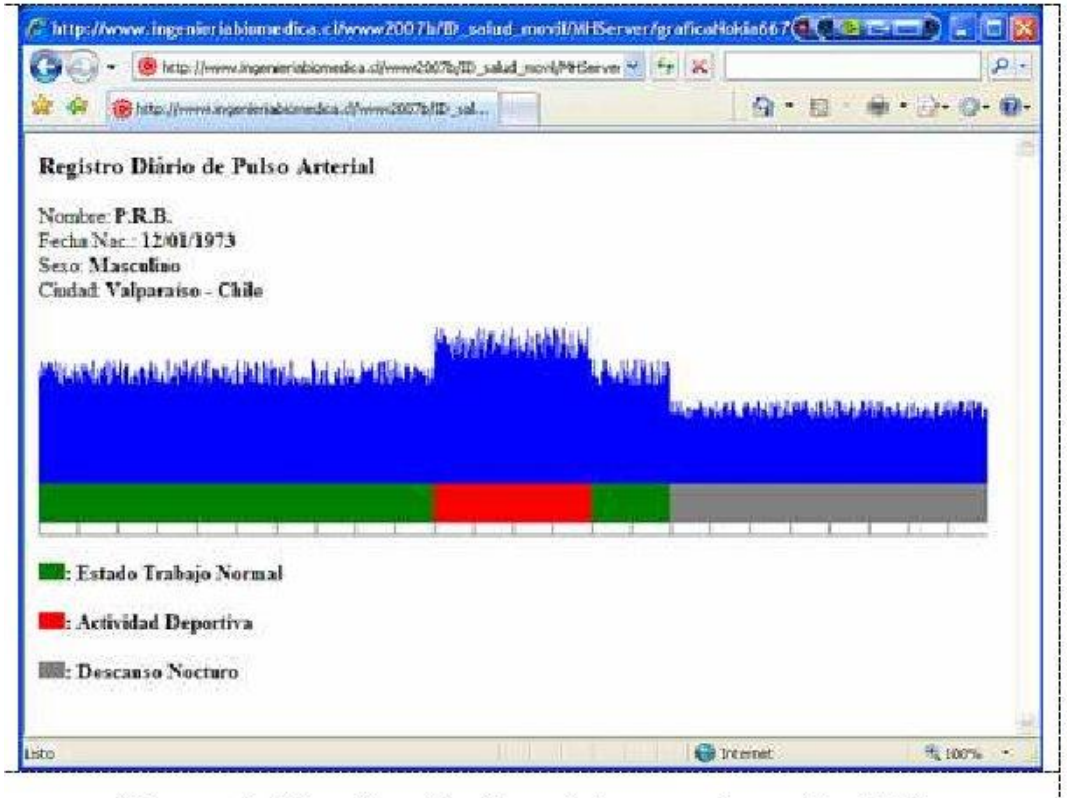


Portability tests

Results

- Capturing and displaying Pulse (heart rate)

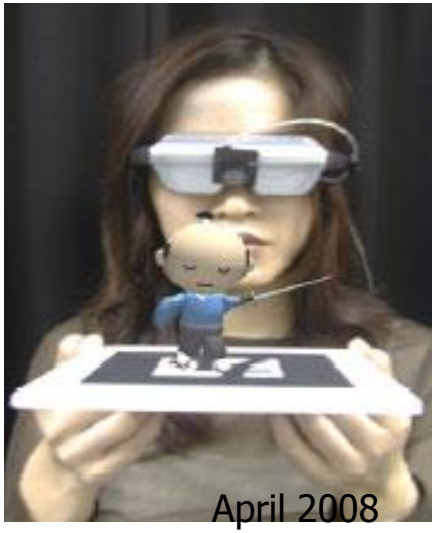
Signal in the cell phone



- Remote monitoring

Augmented Reality with mobile devices

- Augmented Reality: to add info to what you see through a video camera.
- Examples:



Now with mobile devices

2000

2004 Austria

Augmented Reality Applications

Remaining of an old church

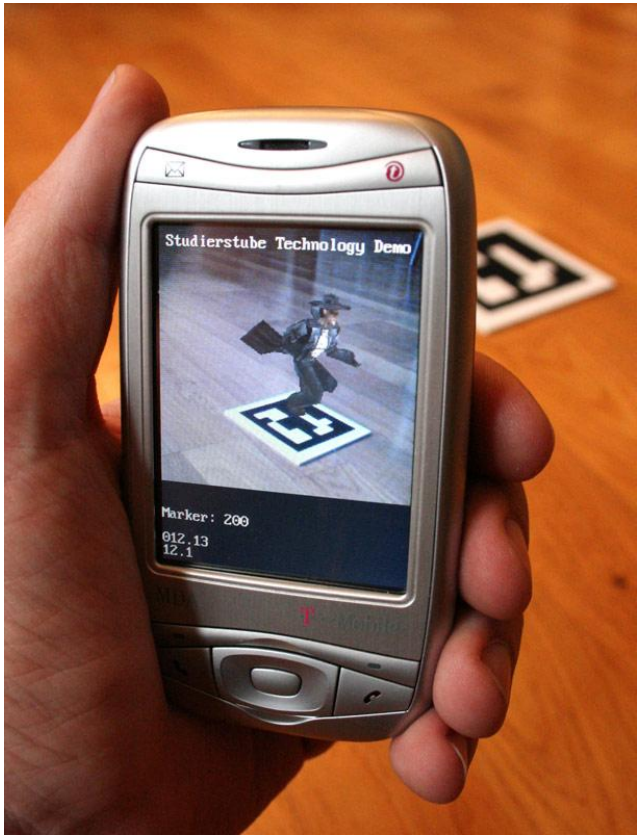
can be seen like this

Museum

Museum

Games


SIEMENS


Studierstube Technology Demo
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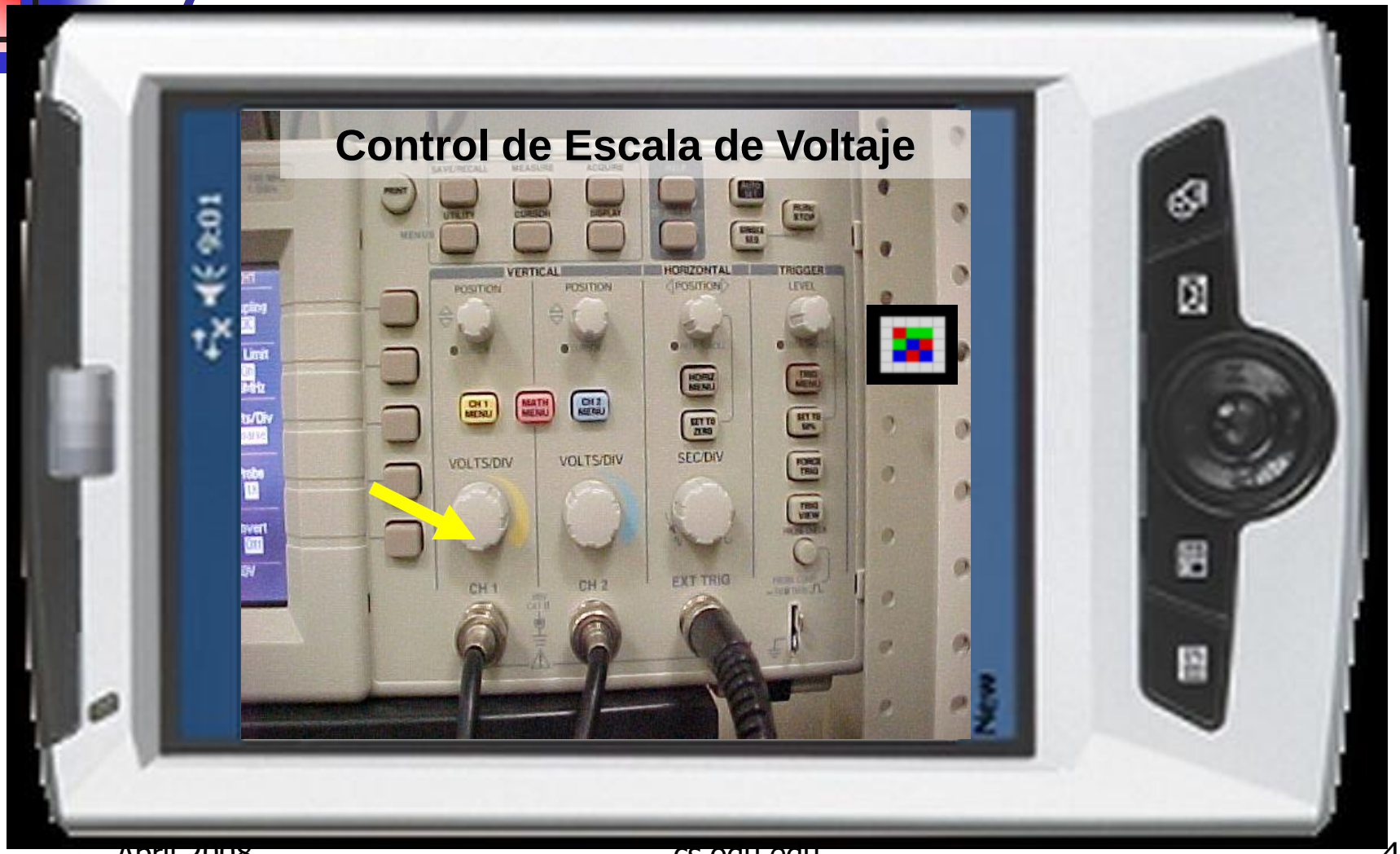
Training example By Pablo



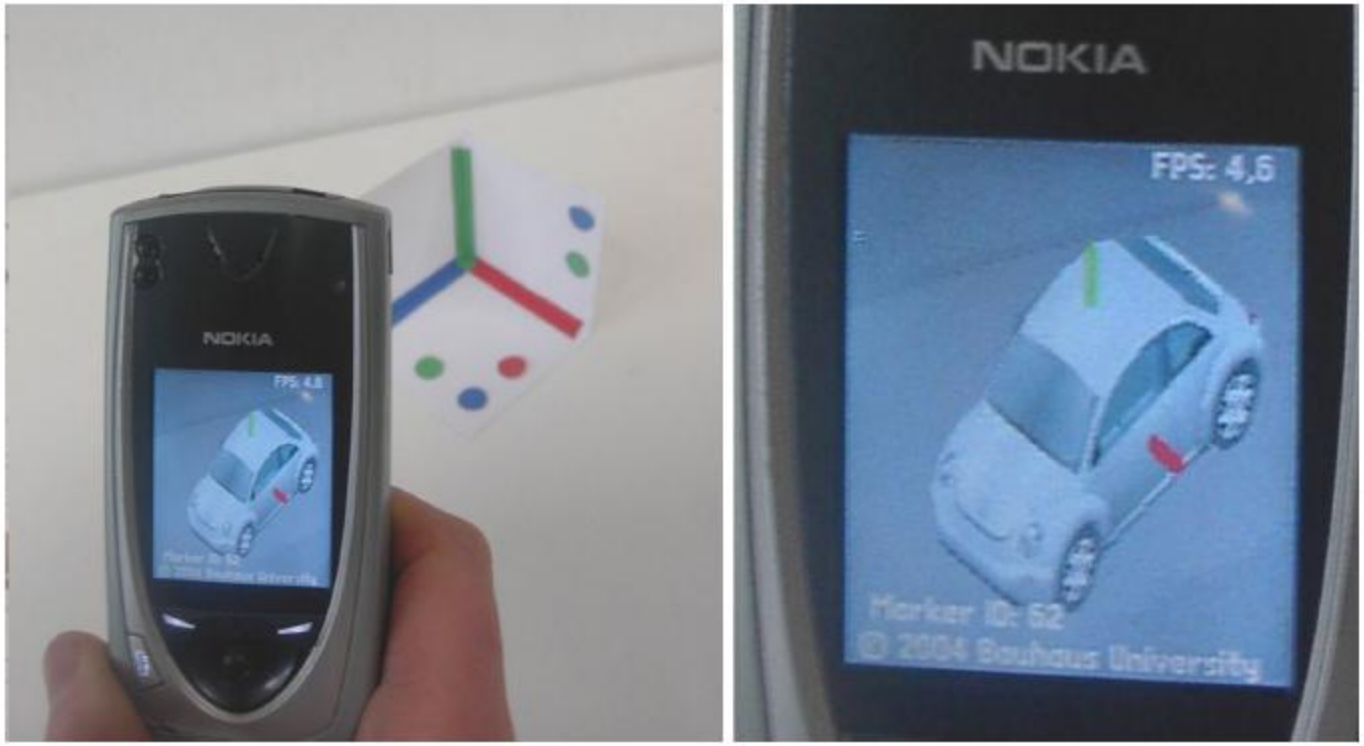
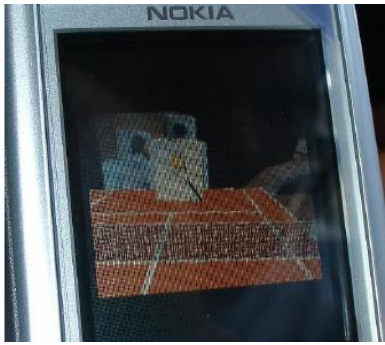


Figure 1: Video see-through example on a consumer cell-phone.

Möhring 2004, Bauhaus University

Figure 5: Face to Face condition

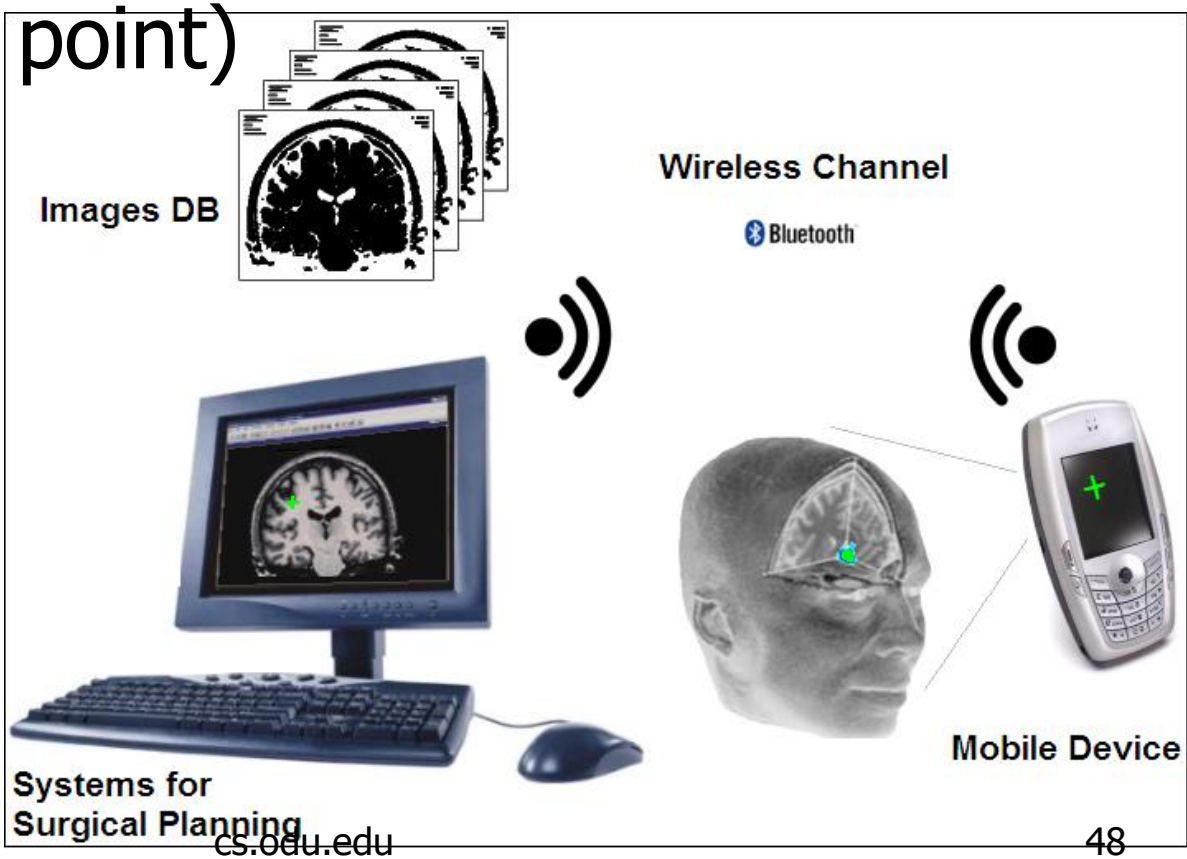


- J2ME based
- Nokia 6600
- Bluetooth link

Henrysson 2005, Linköping University, Suecia

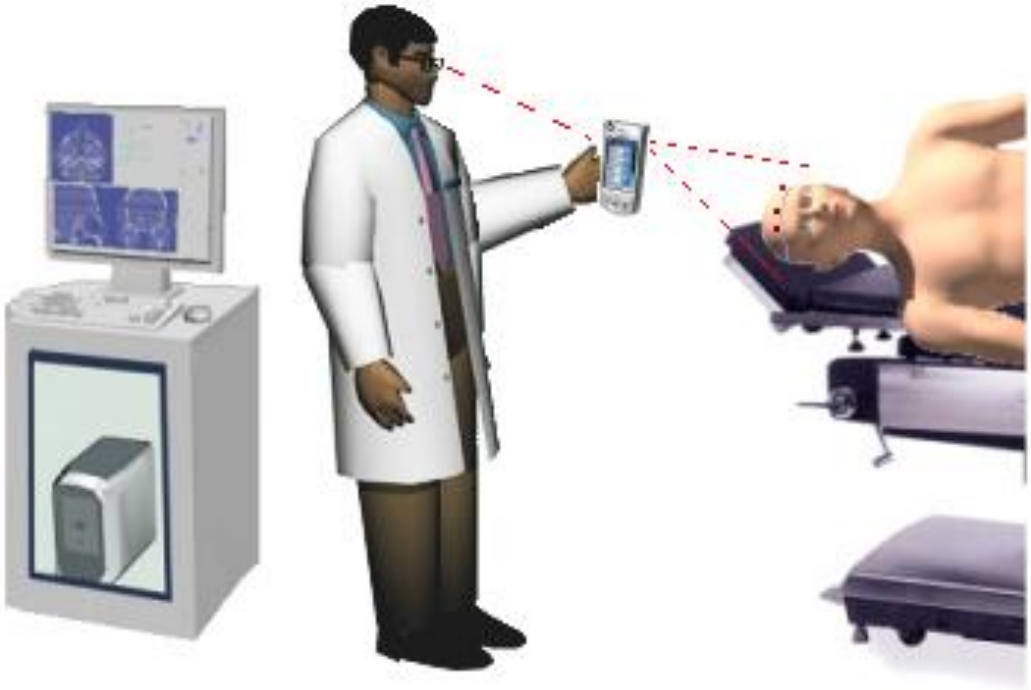
Application: Skull Surgery (Craniotomy)

- Objective: To help surgeon to find attach point (opening point)

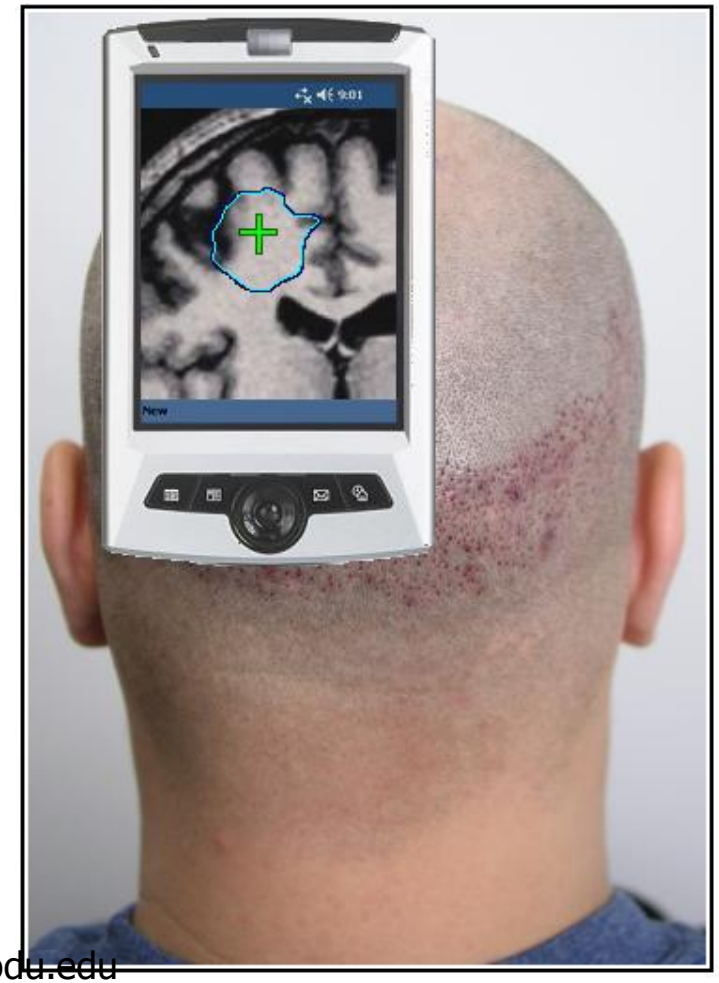


Propose system

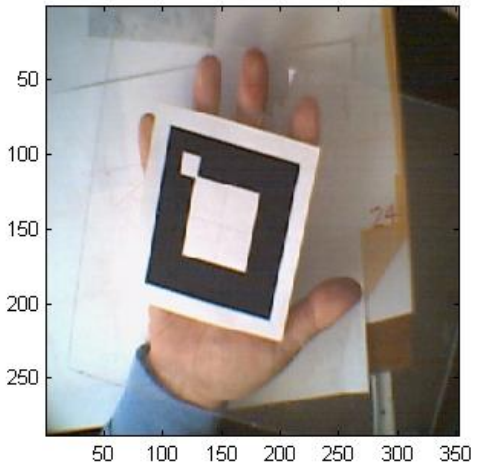
Use scenario

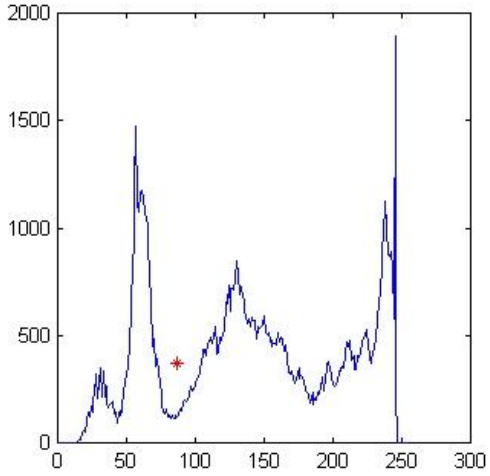


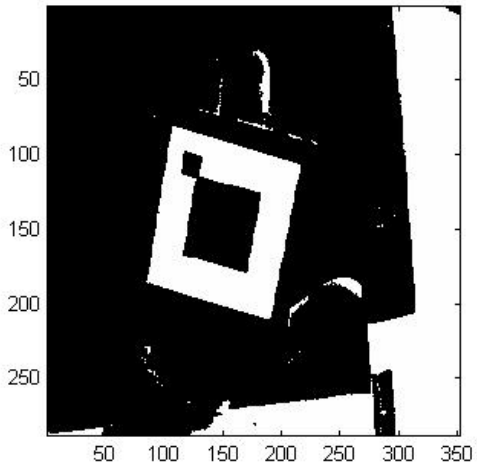
Expected result



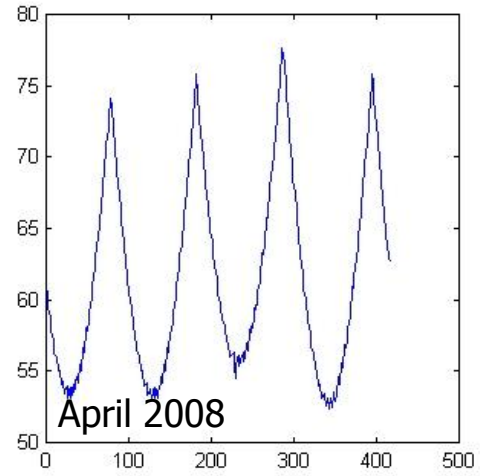
Some Results: Image projection over a 2D pattern

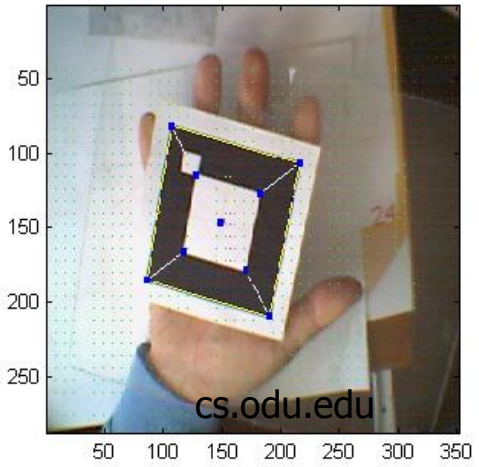


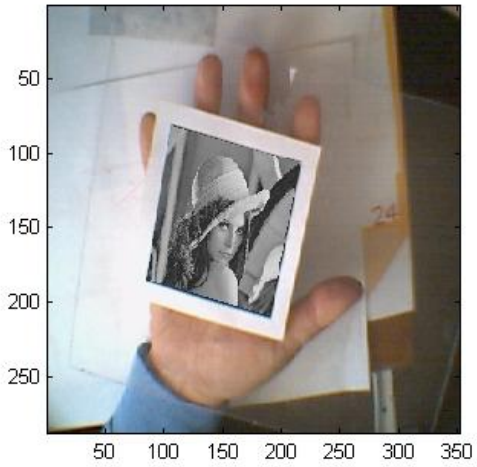


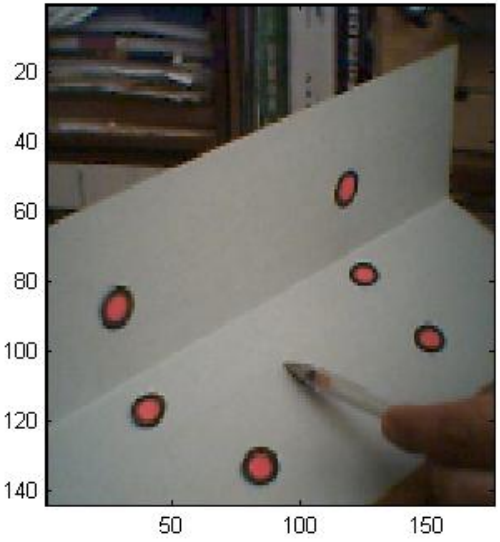


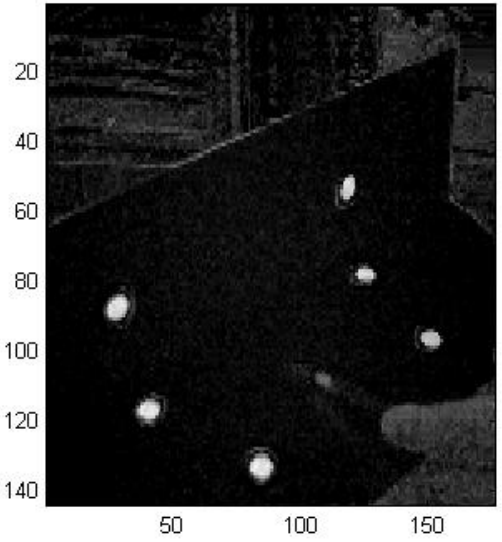
Let's see a demo ....



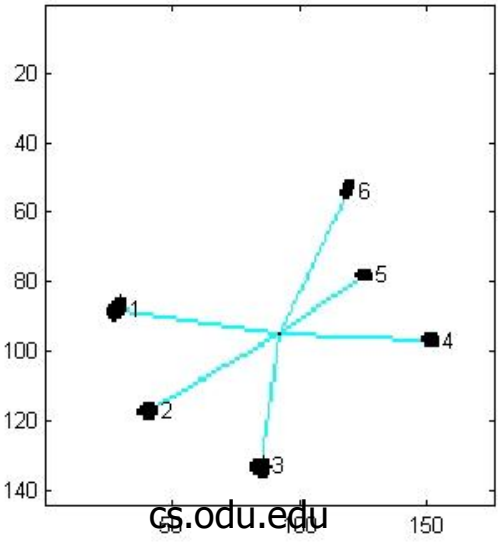


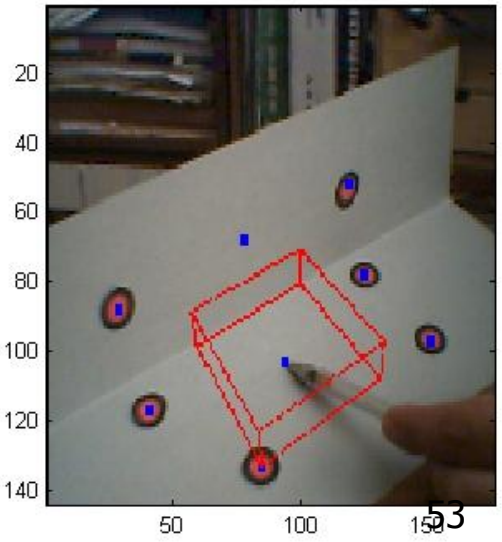


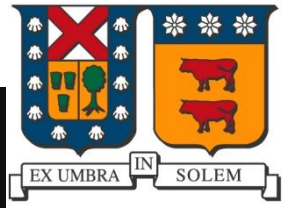




Now 3D projection







Feasibility test

8. Normal View

Thanks for your attention

Agustín J. González

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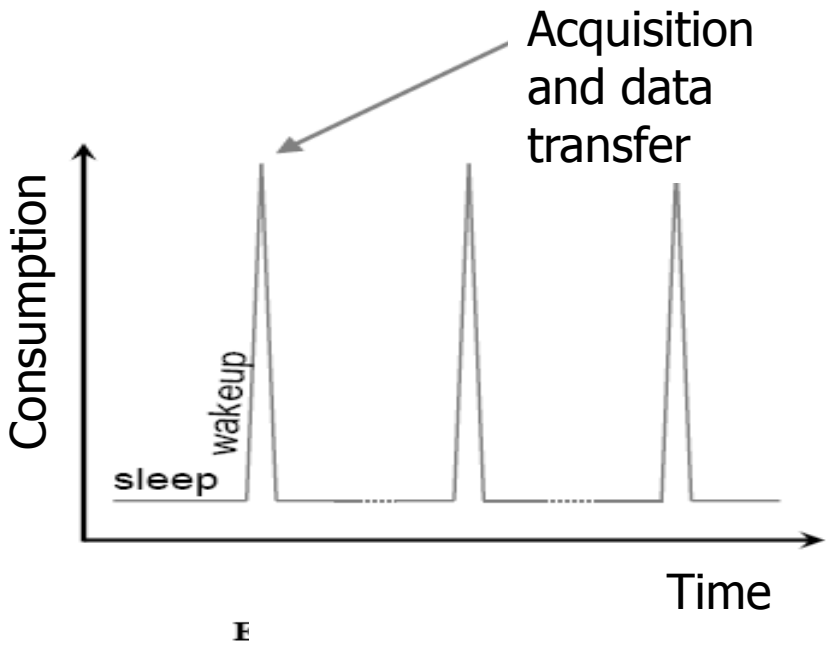
Two keys for low-power operation



Node states:
- Sleep: most of the time
- Active: Get the task done and sleep again
  This includes processing and retransmission functions

- Switch between active and sleep mode
- Done at Component granularity

Need for time synchronization