Wireless Sensor Networks

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Wireless Sensor Networks (WSNs)

- A sensor network is a wireless network that consists of thousands of very small nodes called *sensors*.

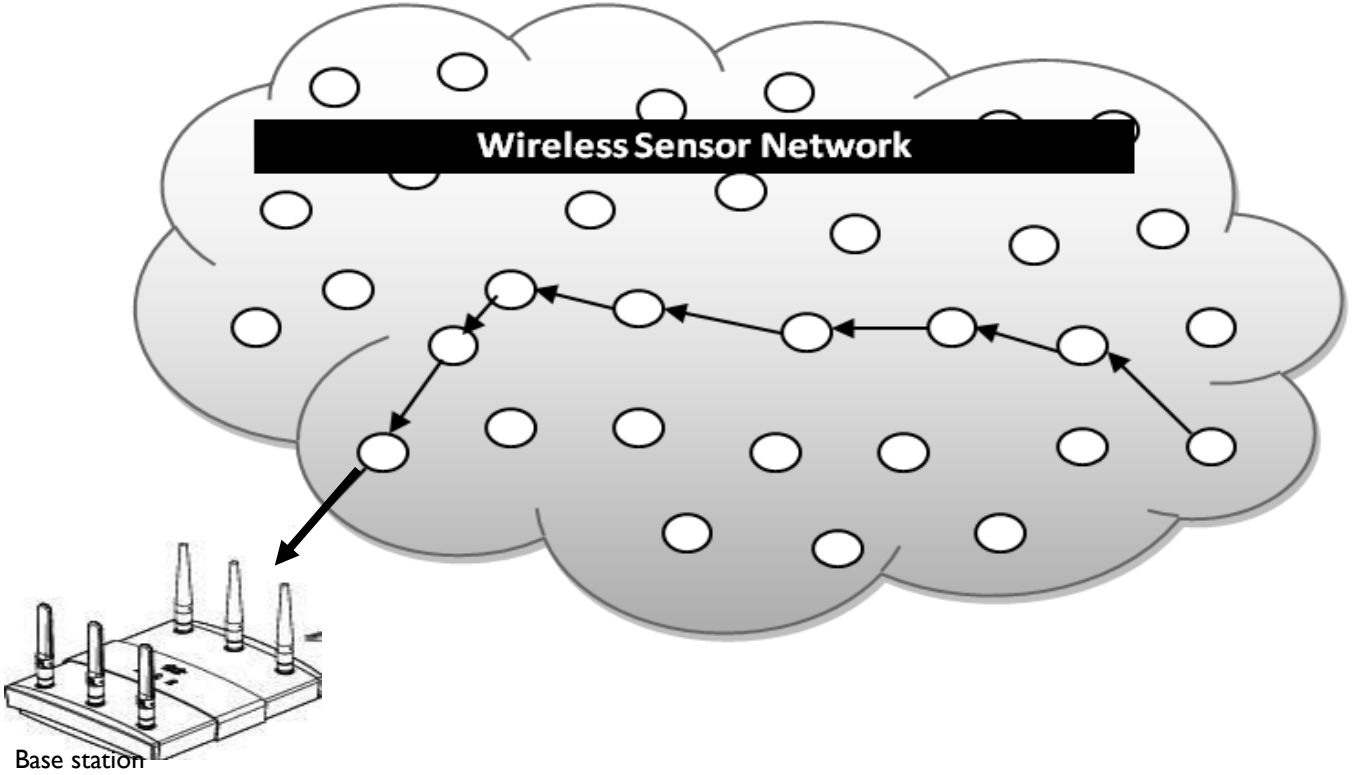


Figure 1: Architecture of wireless sensor networks

Wireless Sensor Networks (cont.)

- WSN **Sensors** are equipped with sensing, limited computation, and wireless communication capabilities.

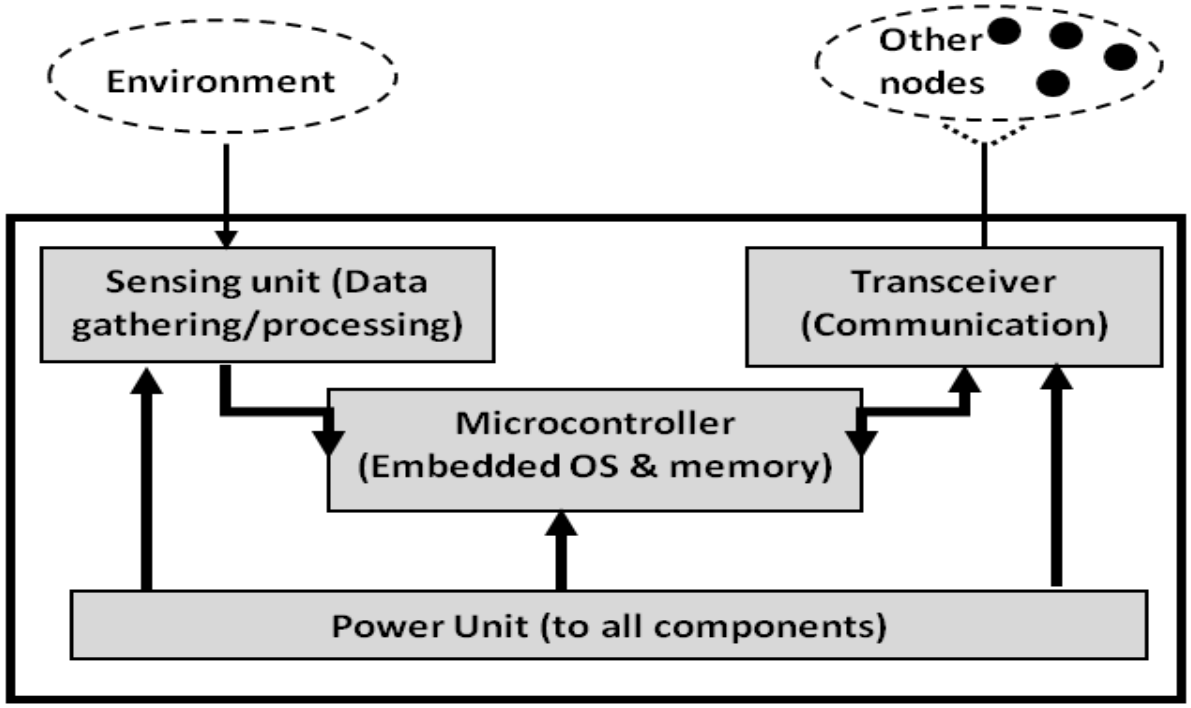


Figure 2: Typical hardware components of a sensor node in wireless sensor networks

Introduction

- Wireless Sensor Networks are networks that consists of sensors which are distributed in an ad hoc manner.
- These sensors work with each other to sense some physical phenomenon and then the information gathered is processed to get relevant results.
- Wireless sensor networks consists of protocols and algorithms with self-organizing capabilities.

Comparison with ad hoc networks

- Wireless sensor networks mainly use **broadcast** communication while ad hoc networks use **point-to-point** communication.
- Unlike ad hoc networks wireless sensor networks are **limited by sensors** limited power, energy and computational capability.
- Sensor nodes may **not have global ID** because of the large amount of overhead and large number of sensors.

WSNs Applications

- WSNs have many advantages over traditional networking techniques.

- They have an ever-increasing number of applications, such as infrastructure protection and security, surveillance, health-care, environment monitoring, food safety, intelligent transportation, and smart energy.

WSNs Applications

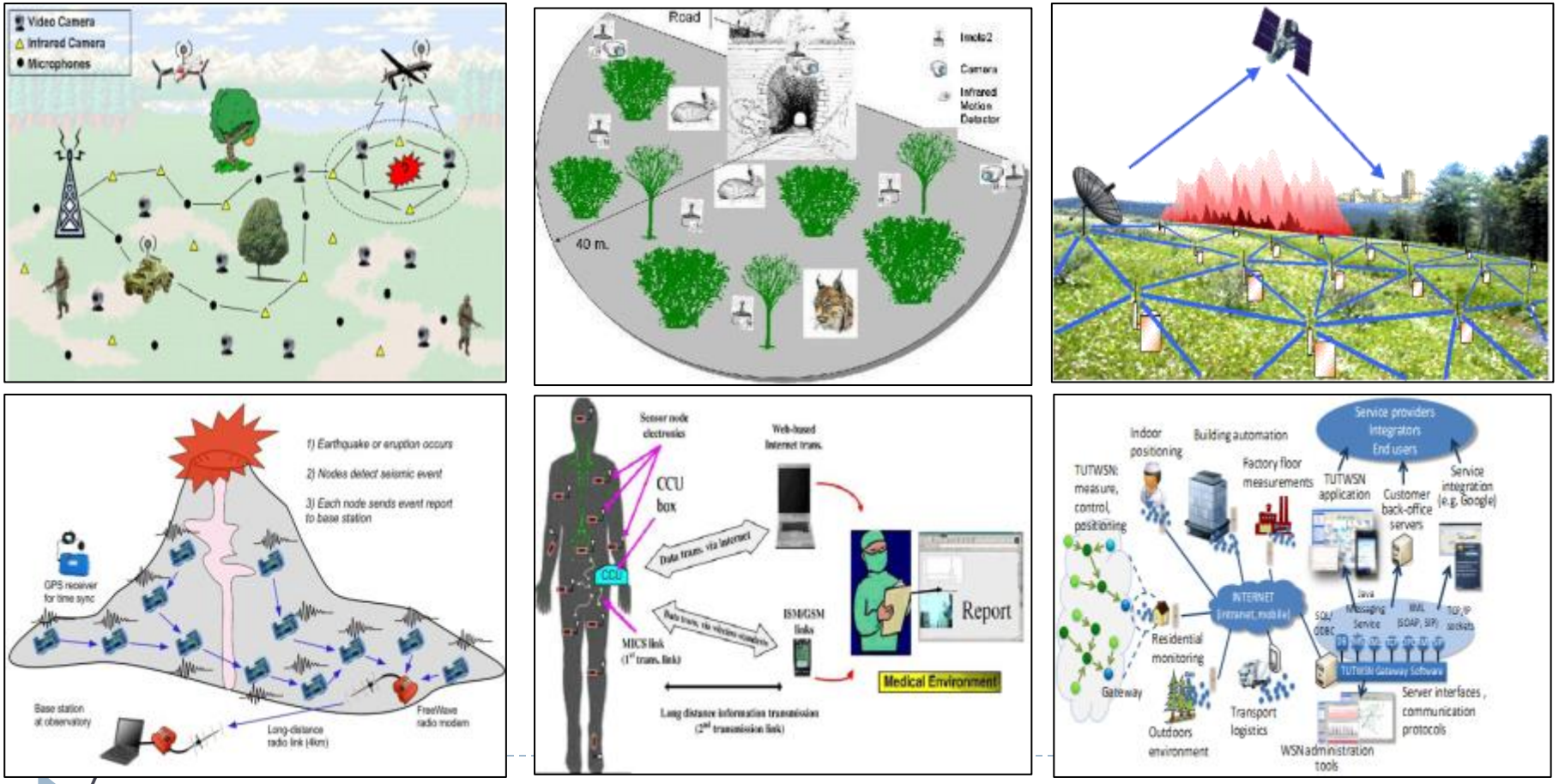
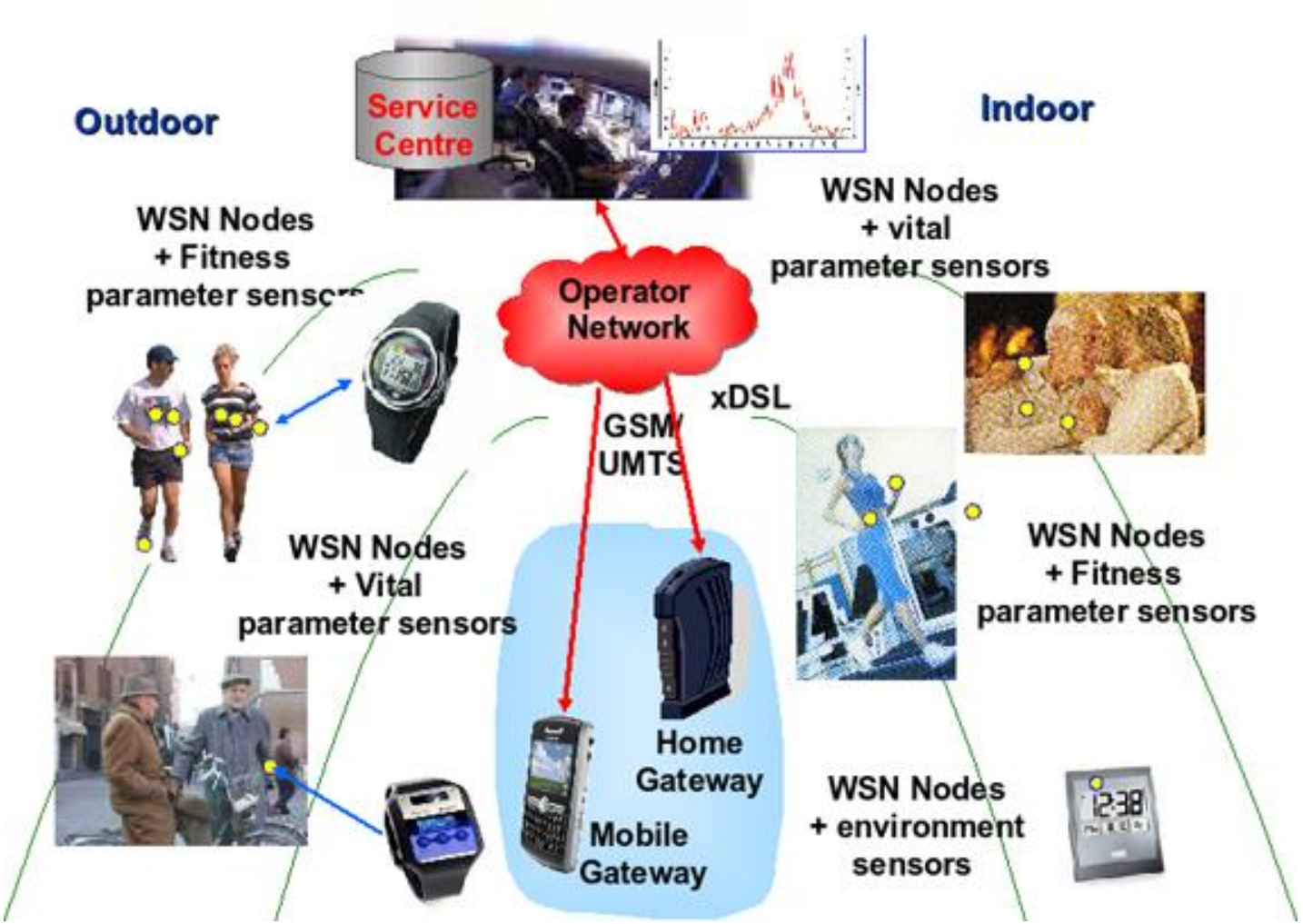


Figure 3: WSNs Applications

Example of WSN



Ref:http://esd.sci.univr.it/images/wsn-example.png

Applications of Wireless Sensor networks

The applications can be divided in three categories:

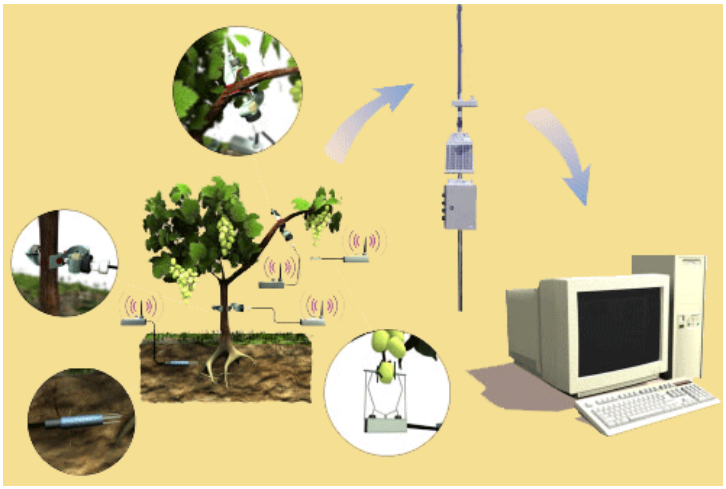
1. Monitoring of objects.
2. Monitoring of an area.
3. Monitoring of both area and objects.

Monitoring Area

- Environmental and Habitat Monitoring
- Precision Agriculture
- Indoor Climate Control
- Military Surveillance
- Intelligent Alarms

Example: Precision Agriculture

- Precision agriculture aims at making cultural operations more efficient, while reducing environmental impact.
- The information collected from sensors is used to evaluate optimum sowing density, estimate fertilizers and other inputs needs, and to more accurately predict crop yields.



Monitoring Objects

- Structural Monitoring
- Eco-physiology
- Condition-based Maintenance
- Medical Diagnostics
- Urban terrain mapping

Monitoring Interactions between Objects and Space

- Wildlife Habitats
- Disaster Management
- Emergency Response
- Ubiquitous Computing
- Asset Tracking
- Health Care

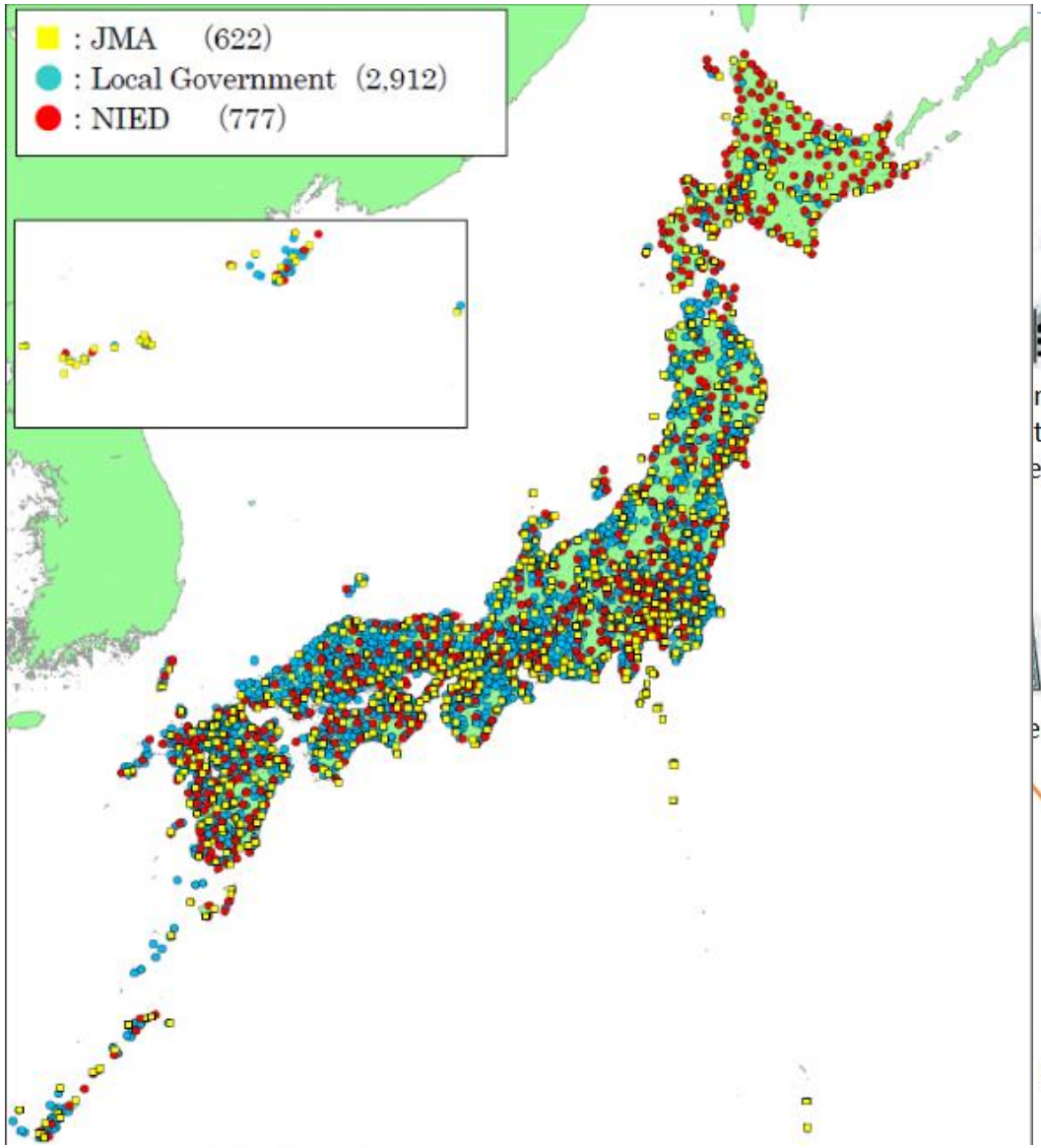
Example: Habitat Monitoring

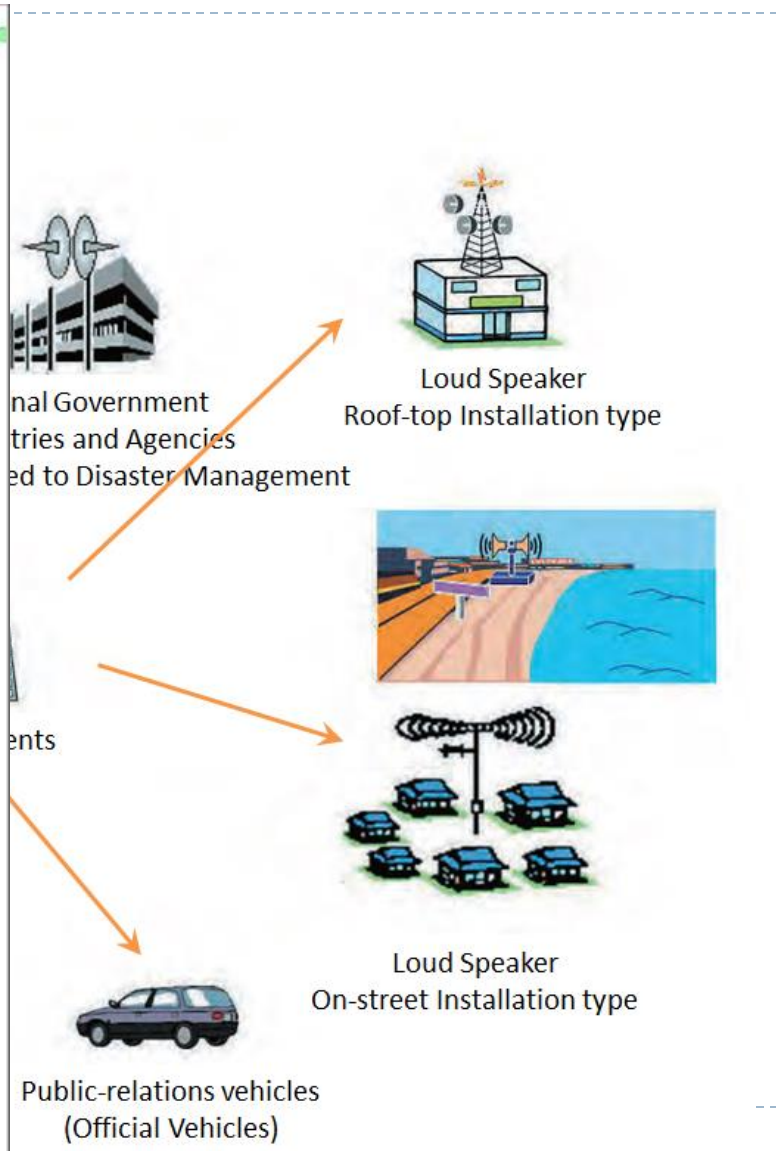
- The ZebraNet Project

  Collar-mounted sensors monitor zebra movement in Kenya

Source: Margaret Martonosi, Princeton University

Disaster Management





Source: Cabinet Office, *Disaster Management in Japan*

Characteristics of Wireless Sensor Networks

- Wireless Sensor Networks mainly consists of **sensors. Sensors** are **-**
  - low power
  - limited memory
  - energy constrained due to their small size.
- Wireless networks can also be deployed in **extreme environmental** conditions and may be prone to enemy attacks.
- Although deployed in an ad hoc manner they need to be **self organized** and **self healing** and can face constant reconfiguration.

Design Challenges

- **Heterogeneity**
  - The devices deployed maybe of various types and need to collaborate with each other.
- **Distributed Processing**
  - The algorithms need to be centralized as the processing is carried out on different nodes.
- **Low Bandwidth Communication**
  - The data should be transferred efficiently between sensors

Continued..

- **Large Scale Coordination**
  - The sensors need to coordinate with each other to produce required results.
- **Utilization of Sensors**
  - The sensors should be utilized in a ways that produce the maximum performance and use less energy.
- **Real Time Computation**
  - The computation should be done quickly as new data is always being generated.

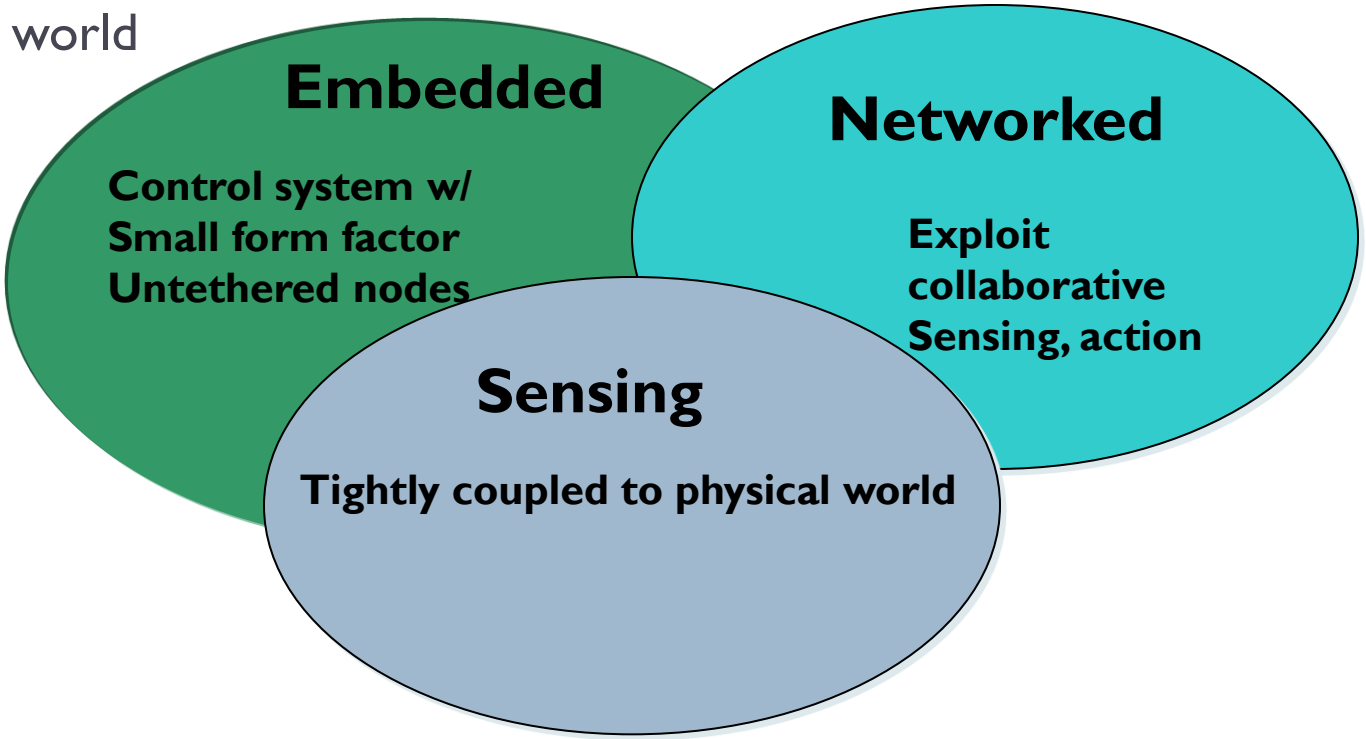
Operational Challenges of Wireless Sensor Networks

- Energy Efficiency
- Limited storage and computation
- Low bandwidth and high error rates
- Errors are common
  - Wireless communication
  - Noisy measurements
  - Node failure are expected
- Scalability to a large number of sensor nodes
- Survivability in harsh environments

Enabling Technologies

Embed numerous distributed devices to monitor and interact with physical world

Network devices to coordinate and perform higher-level tasks



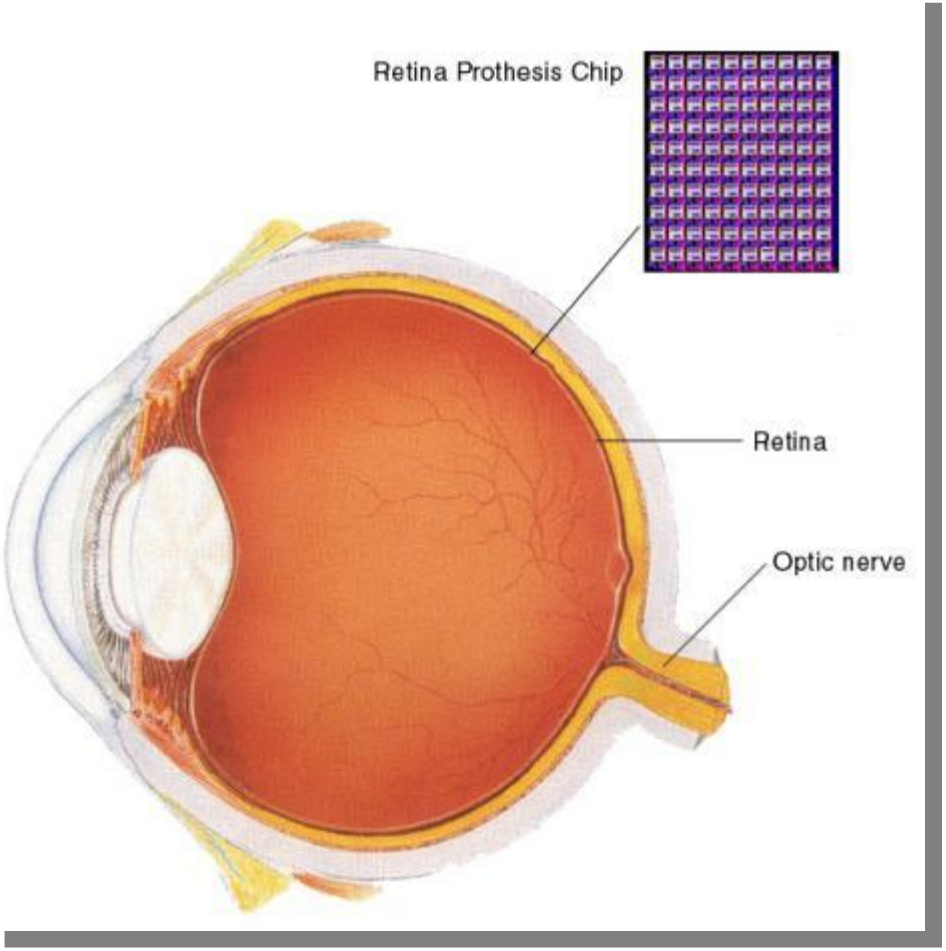
Exploit spatially and temporally dense, in situ, sensing and actuation

Future of WSN
Smart Home / Smart Office

- Sensors controlling electrical devices in the house.
- Better lighting and heating in office buildings.
- The Pentagon building has used sensors extensively.

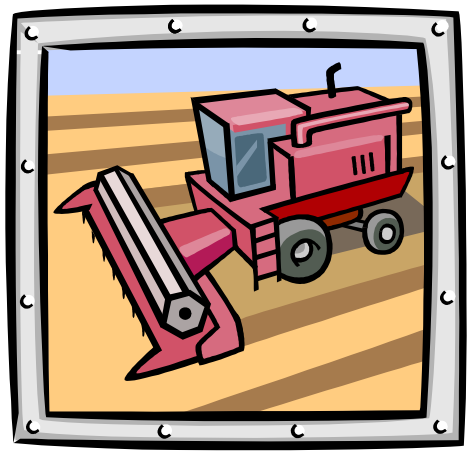
Biomedical / Medical

- Health Monitors
  - Glucose
  - Heart rate
  - Cancer detection
- Chronic Diseases
  - Artificial retina
  - Cochlear implants
- Hospital Sensors
  - Monitor vital signs
  - Record anomalies



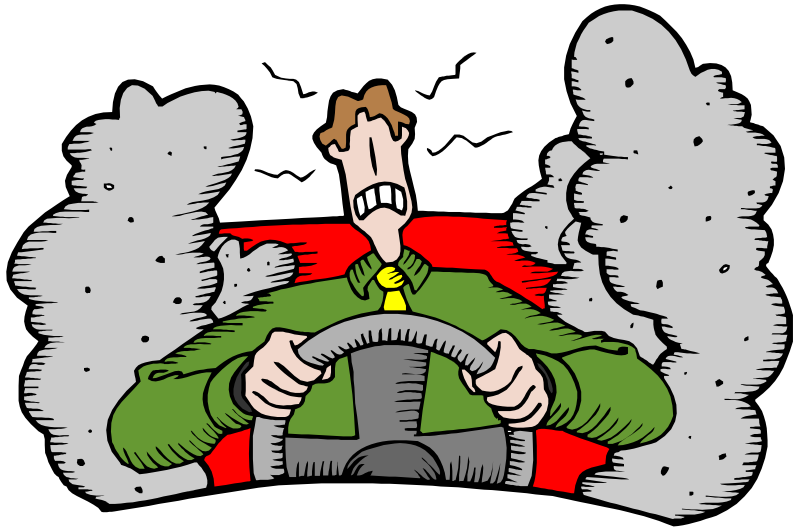
Industrial & Commercial

- Numerous industrial and commercial applications:
  - Agricultural Crop Conditions
  - Inventory Tracking
  - In-Process Parts Tracking
  - Automated Problem Reporting
  - Theft Deterrent and Customer Tracing
  - Plant Equipment Maintenance Monitoring



Traffic Management & Monitoring

- Future cars could use wireless sensors to:
  - Handle Accidents
  - Handle Thefts

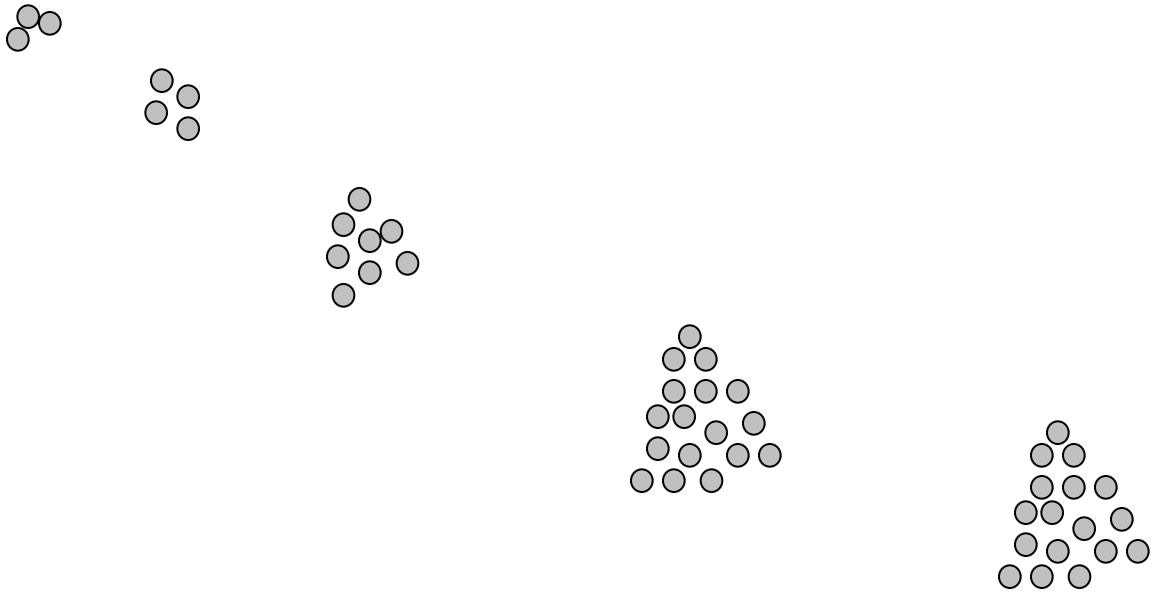


✓Sensors embedded in the roads to:

- –Monitor traffic flows
- –Provide real-time route updates

Military

Remote deployment of sensors for tactical monitoring of enemy troop movements.



Mobile Group Movement

- Future military: attacking by sensor nodes
- It needs coordination between nodes
- Combination between AI (artificial intelligence), sensor technology and wireless communications
- There is a goal for the nodes

What are motes?

Motes mainly consist of three parts:-

- Mote basically consists of a low cost and power computer.
- The computer monitors one or more sensors. Sensors may be for temperature, light, sound, position, acceleration, vibration, stress, weight, pressure, humidity, etc.
- The computer connects to the outside world with a radio link.

Mica 2 Motes

- These motes sold by Crossbow were originally developed at the University of California Berkeley.
- The MICA2 motes are based on the ATmega128L AVR microprocessor. The motes run using TinyOS as the operating system.
- Mica2 mote is one of the most popular and commercially available sensors which are marketed by CrossBow technologies.

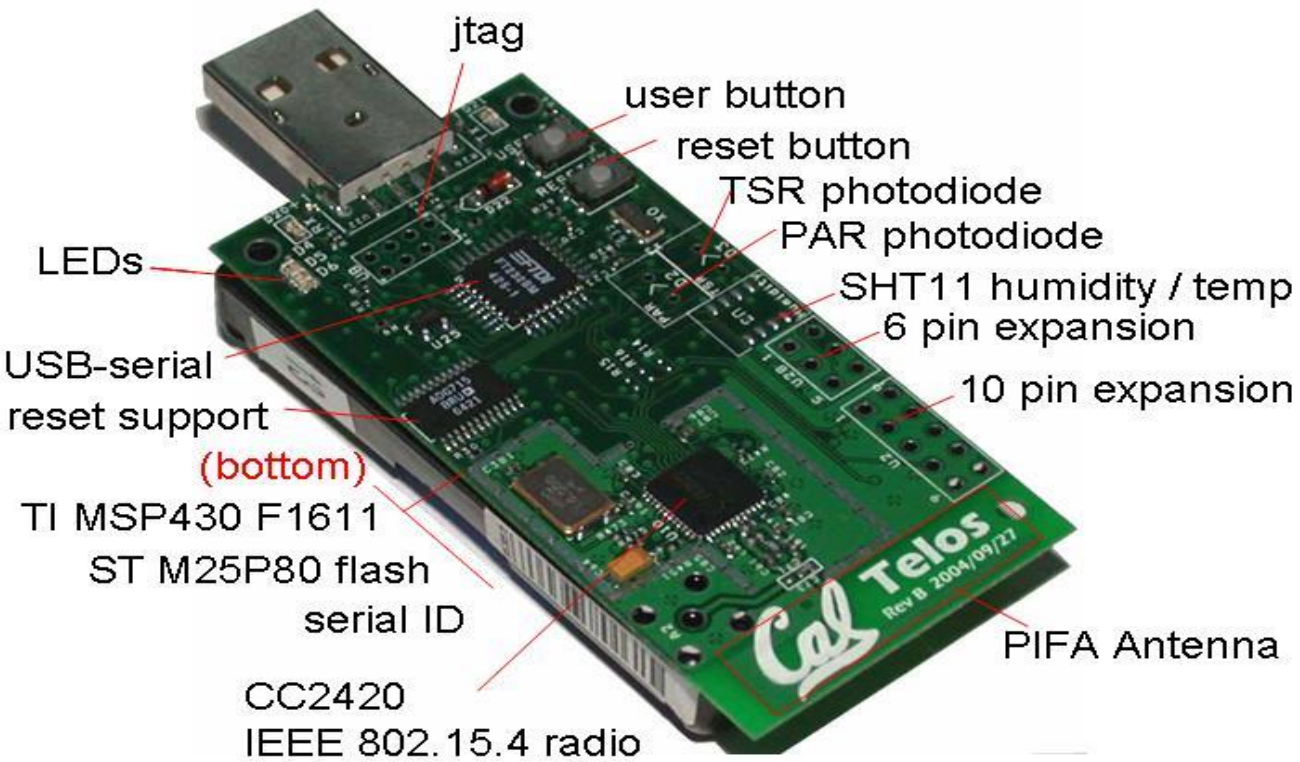
MICA 2 MOTE

Ref:http://www.xbow.com/Products/Product_pdf_files/Wireless_pdf/MICA2_Datasheet.pdf

Telosb Motes

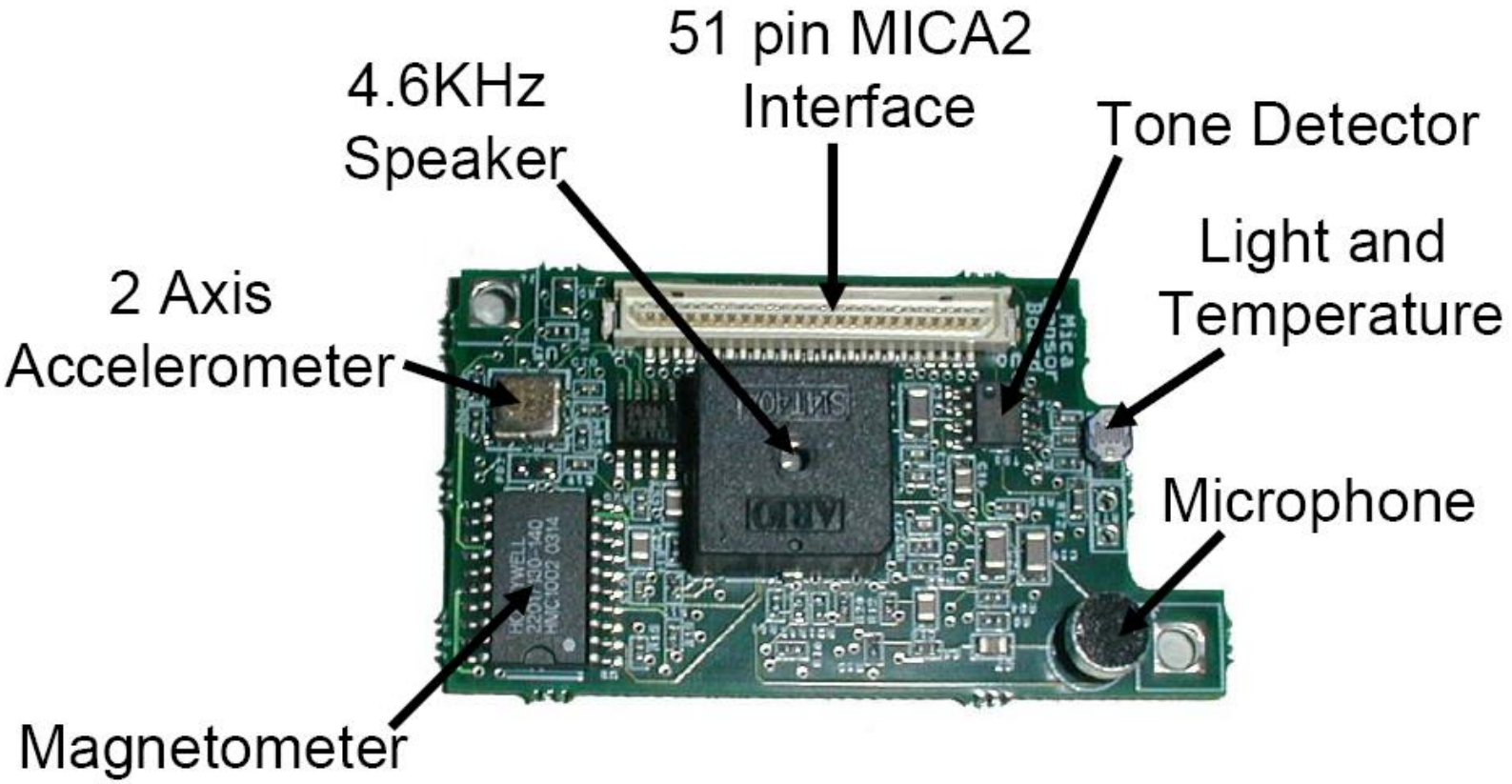
- Telosb motes have USB programming capability
- An IEEE 802.15.4 compliant, high data rate radio with integrated antenna, a low-power MCU
- There are also equipped with extended memory and an optional sensor suite

TELOSB MOTE



Ref:http://www.eecs.berkeley.edu/~culler/eecs194/labs/lab1/telosb.JPG

One Example Sensor Board - MTS310

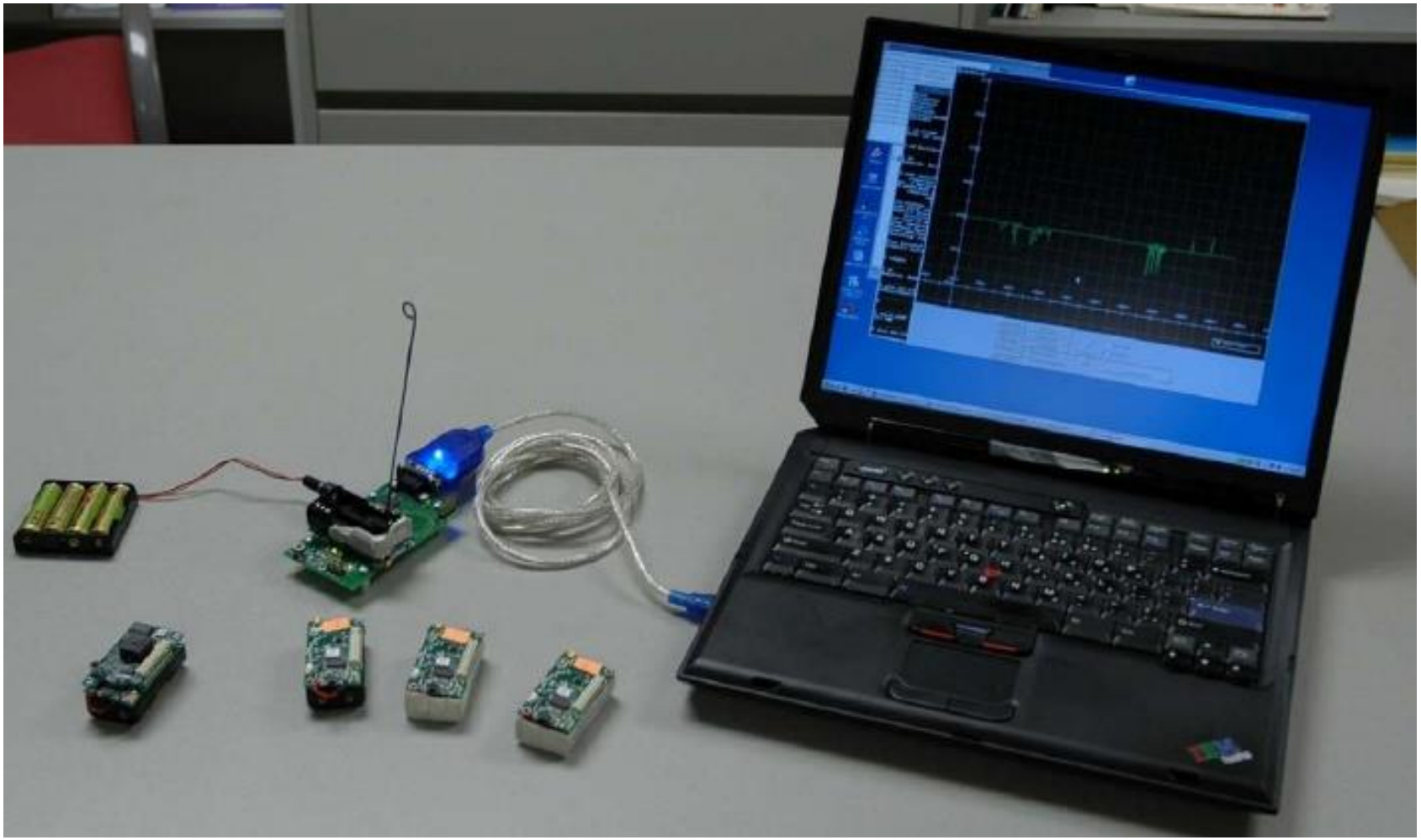


One More Example of Sensor Board - MTS400/420

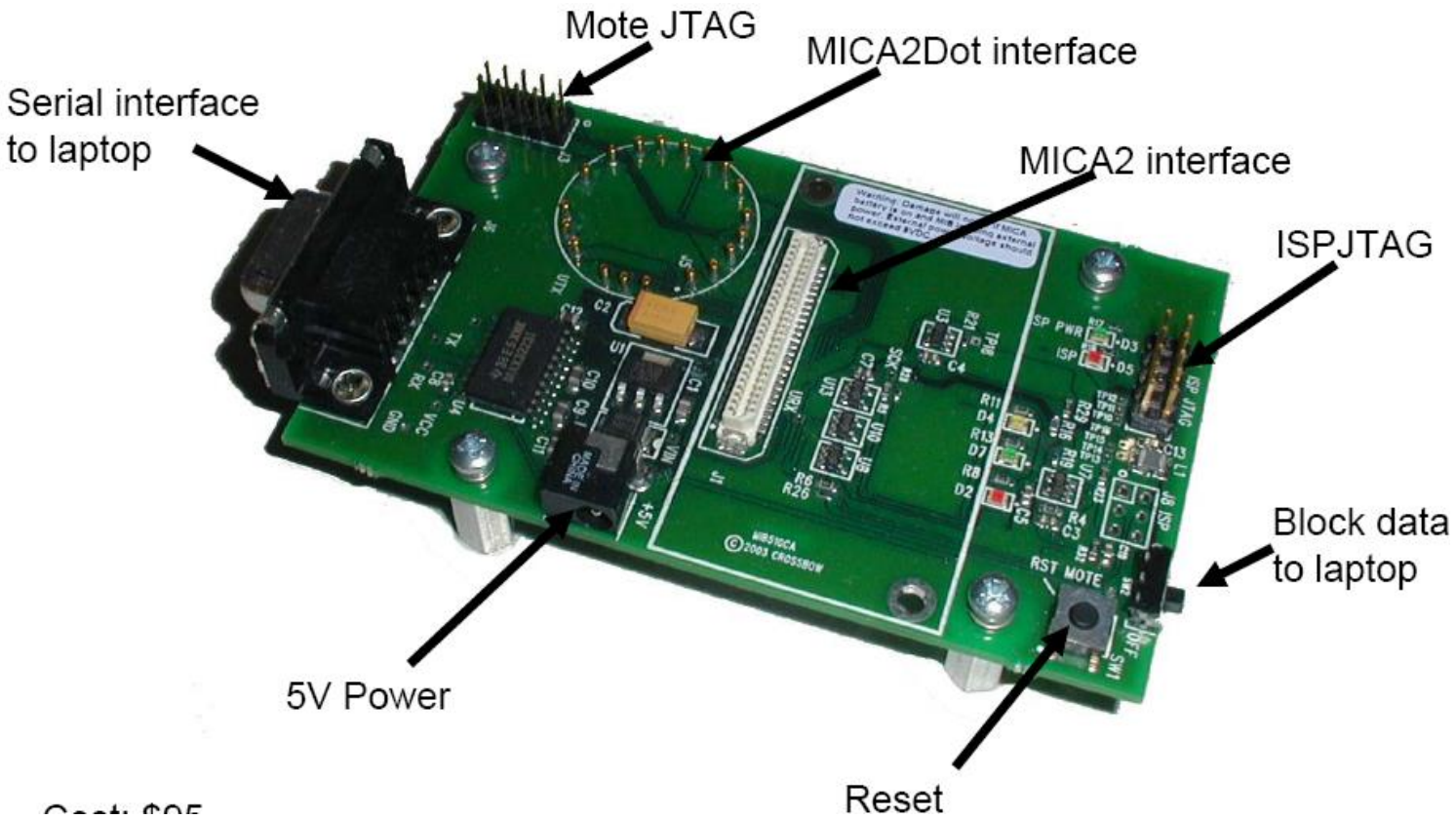
- Besides the functions of MTS 300, it mainly adds GPS functionality

- Further Reading
  - http://firebug.sourceforge.net/gps_tests.htm

Hardware Setup Overview



Programming Board (MIB520)



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