Wireless Sensor Networks

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Comp 150-CB, Summer 2007

Course: http://www.cs.tufts.edu/comp/150CB

ECS,Tufts University

Wireless Sensor Networks -- Welcome!!!

Everywhere!

- Deeply embedded, network enabled sensors (temperature, pressure, light, motion, vibration).
- The Economist article, May 2007

Diverse Applications!

– monitoring earthquake-prone regions, volcanoes, patient health, compost piles, vineyards, vehicle movement, traffic, pollution plumes, war zones ..

Applications: Vehicle Monitoring

- Sensors take magnetometer readings, localize object
- Communicate using geographic routing to base station
- Robust against node and radio link failure

Course Covers

- Wireless communication
- Focuses on Wireless Sensor Networks
  - Small, low power, wireless devices with sensors
  - Hands-on, develop a sensor net application
  - Research the state of the art

Course Outline – 3 parts

- Survey of Wireless Communication
  - radio communication, antennas, propagation
  - coding scheme, broadband, MAC
  - protocols: 802.11, Bluetooth, 802.15.4
- Research in Adhoc networks and TCP in mobile environments
- Wireless Sensor Networks
  - Applications
  - Support: operating system, security, power management, routing, localization, time synch

Class Goals

- Learn about wireless networks and sensor networks
- Read research papers
- Experiment with a real sensor network
- Do a project or write a paper (possibly survey) on an aspect of interest to you, perhaps publish.

Programming Project

- Goal learning the ropes of programming wireless sensor motes
  - Familiarize yourself with the mote kit
  - Learn to use the TinyOS operating system
  - Work in alone or in pairs
  - Code a simple multihop wireless protocol
  - Equipment from Prof. Hwa Chung, Tufts University.
  - Give yourself more ramp up time if you need to get comfortable with C programming.

Project Proposal

- Anything of interest to you related to the course
- Proposal 1-2 paragraphs due class-5 indicating what will be investigated and how to propose to go about it.
- Class 8 an update on project status
- Class 11 presentation, 20 mins + 5 mins for questions
- Paper summarizing your findings, 8-12 pages long.

Project Ideas

- Study Effects of packet loss on adhoc routing protocols
- Develop an improvement to an existing routing algorithm and test
- Develop a new energy management scheme for sensor networks
- Build a medical paging system
- Develop a security protocol for sharing information among “collaborating” nodes

Look – NO Wires!

- LAN telephone lines – expensive infrastruture, construction. Mobile telephones revolutionized telecommunications
- Cheap wireless sensing and computing devices are like Mobile phones to LAN lines! Revolutionizing sensing and reacting. Possible to scatter sensors in dangerous and/difficult to reach terrains.

Deeply embedded-networks – why is it exciting?

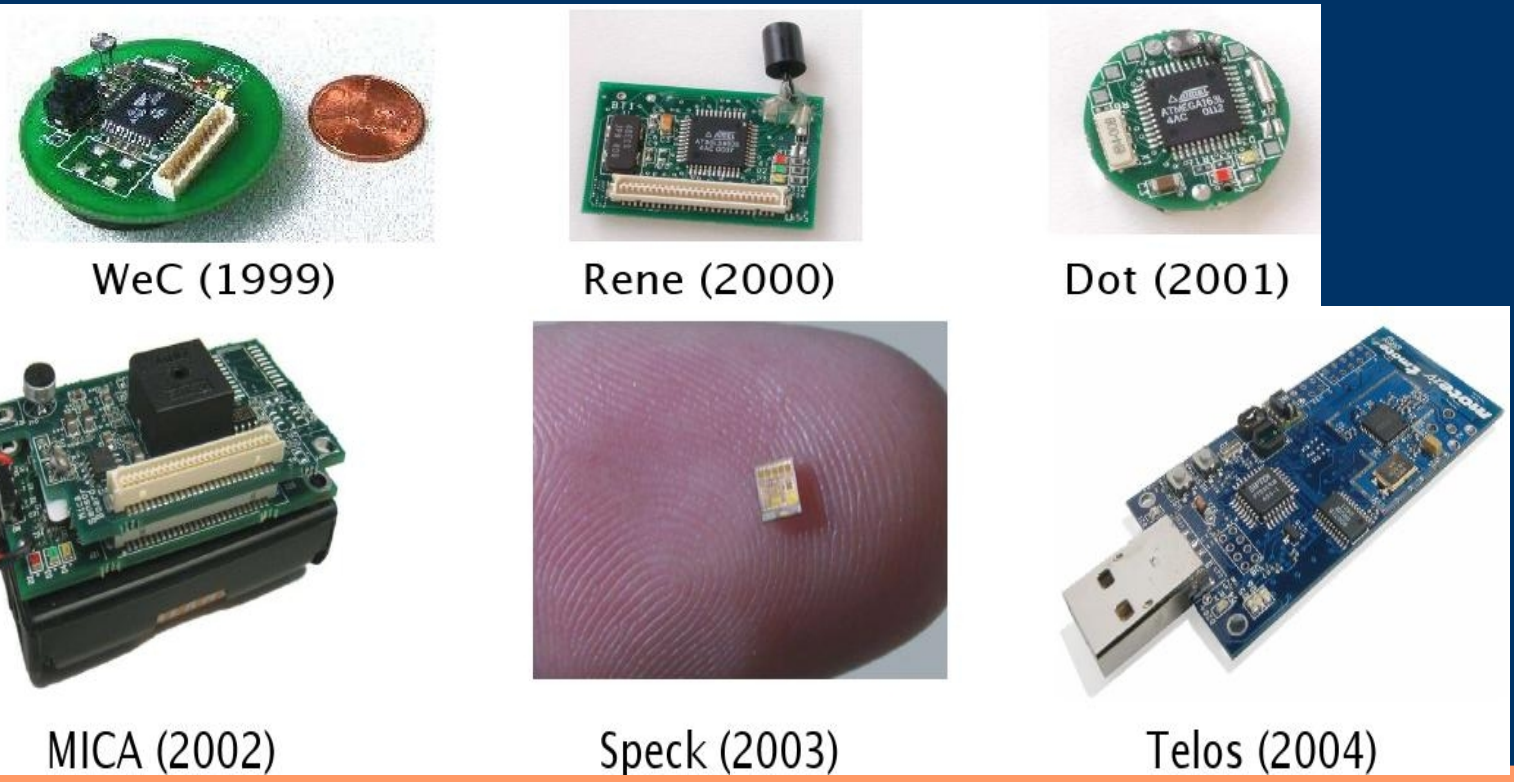
- The ability to sense the environment and communicate -- temperature, pressure, vibrations, acoustic, light, humidity.
- Takes computing out of the lab into the real world. Ability to respond and adapt in a timely manner by analysing the sensed information. Increase safety.

Challenges

- Battery life, solar?
- Communication bandwidth (radio transmission is energy expensive).
- On board storage capacity limited (but getting cheaper – current day flash cards pack it in)
- Commutation limitations
- Routing protocols (can't have large routing tables)
- Node failure, link failure (moving out of radio range or path loss)

Sensor Networks

- Integrates sensing, computing and communication
- Getting smaller, more capable and cheaper
  - goal smart dust, cheap enough to “scatter/coat”

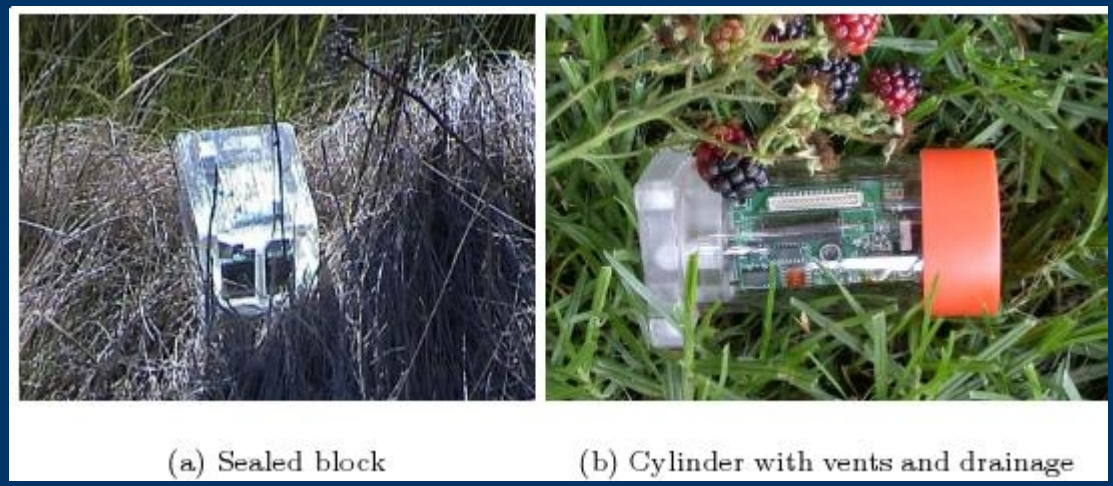


Applications: Vehicle Tracking

- Sensors take magnetometer readings, localize objects
- Communicate position to base station using geographic routing
- Robust against link and node failures (many sensors, all connected)

Applications: Habitat Monitoring

- Habitat sensing, Duck Island
  - without disturbing the birds detect their presence (temperature, infrared wavelength and humidity)
  - determine breeding and migration habits



(a) Sealed block (b) Cylinder with vents and drainage

Application: Habitat Monitoring

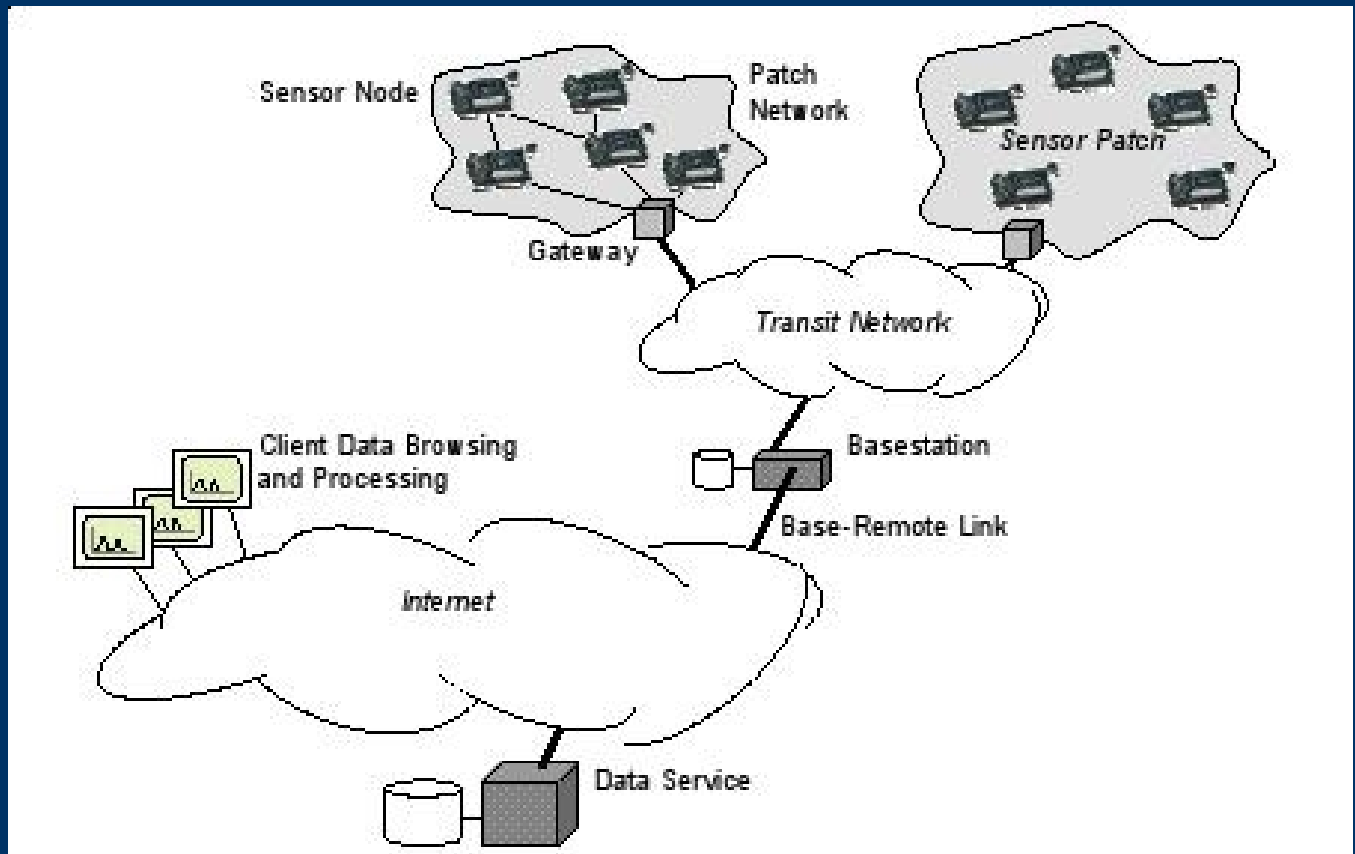


Fig. 2. System architecture for habitat monitoring

Application: Habitat Monitoring

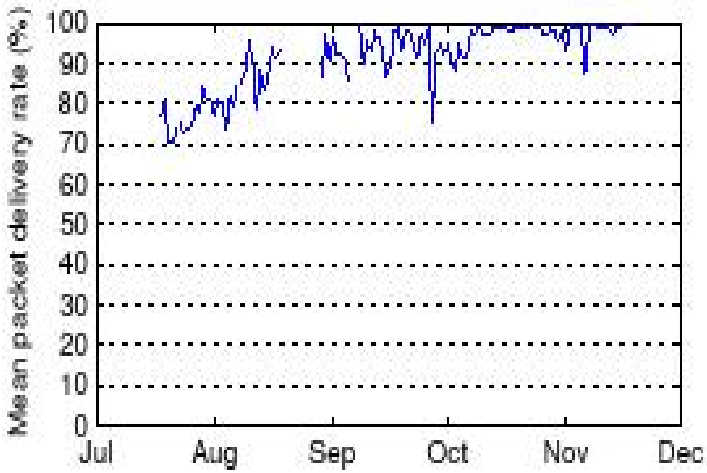


Fig. 3. Average daily losses in the network throughout the deployment. The gap in the second part of August corresponds to a database crash.

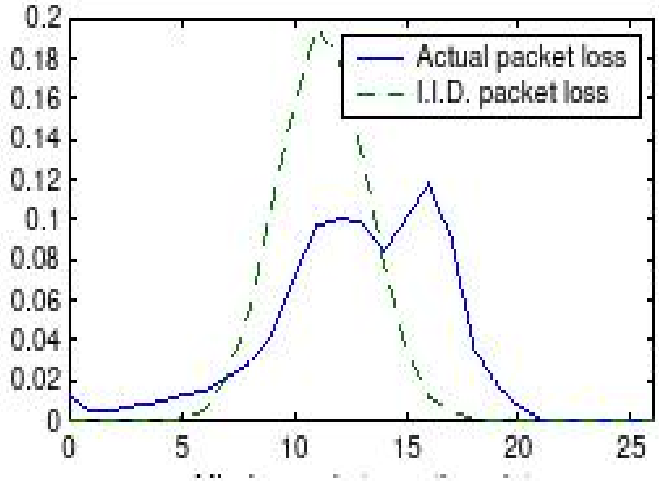
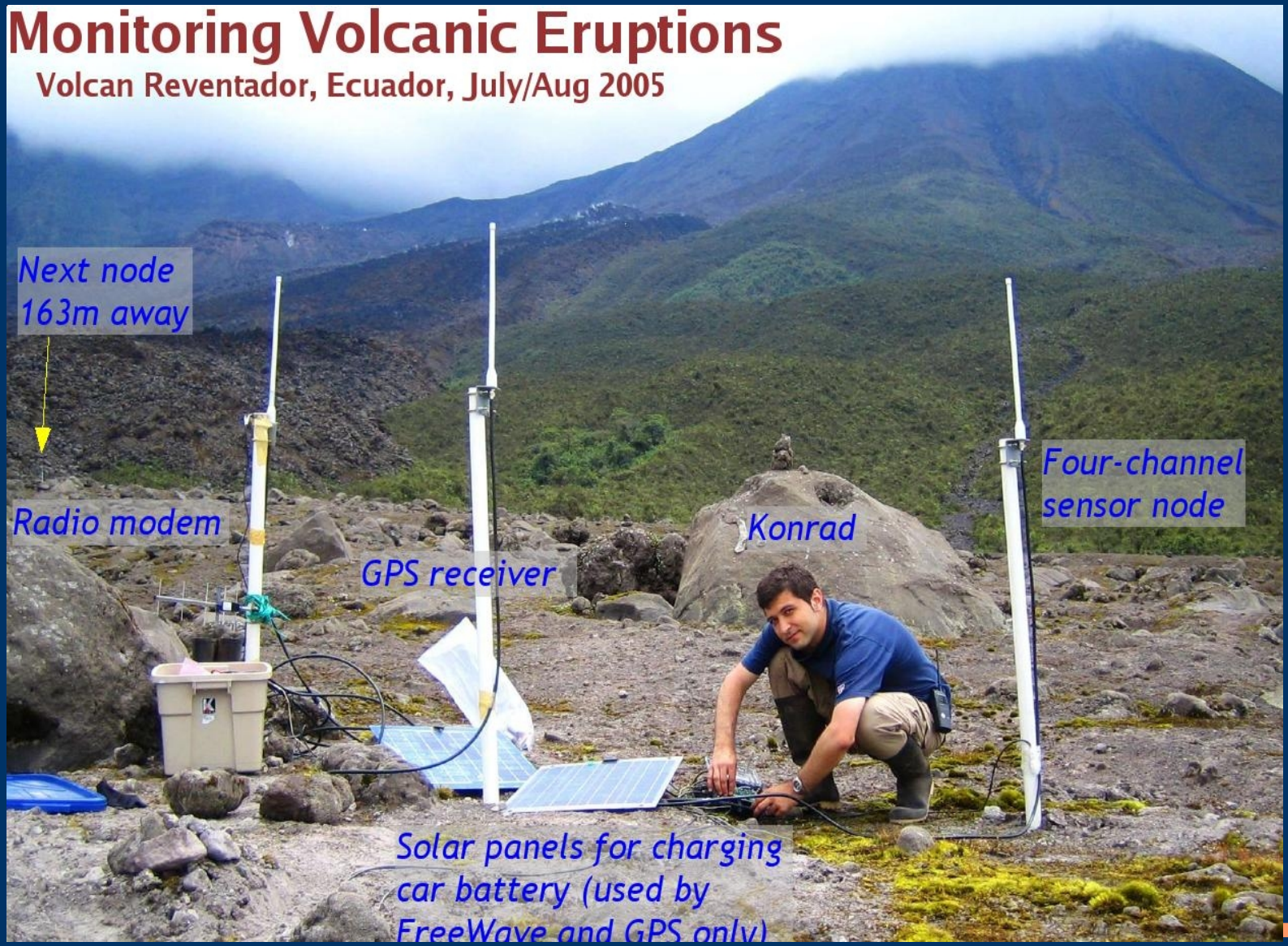
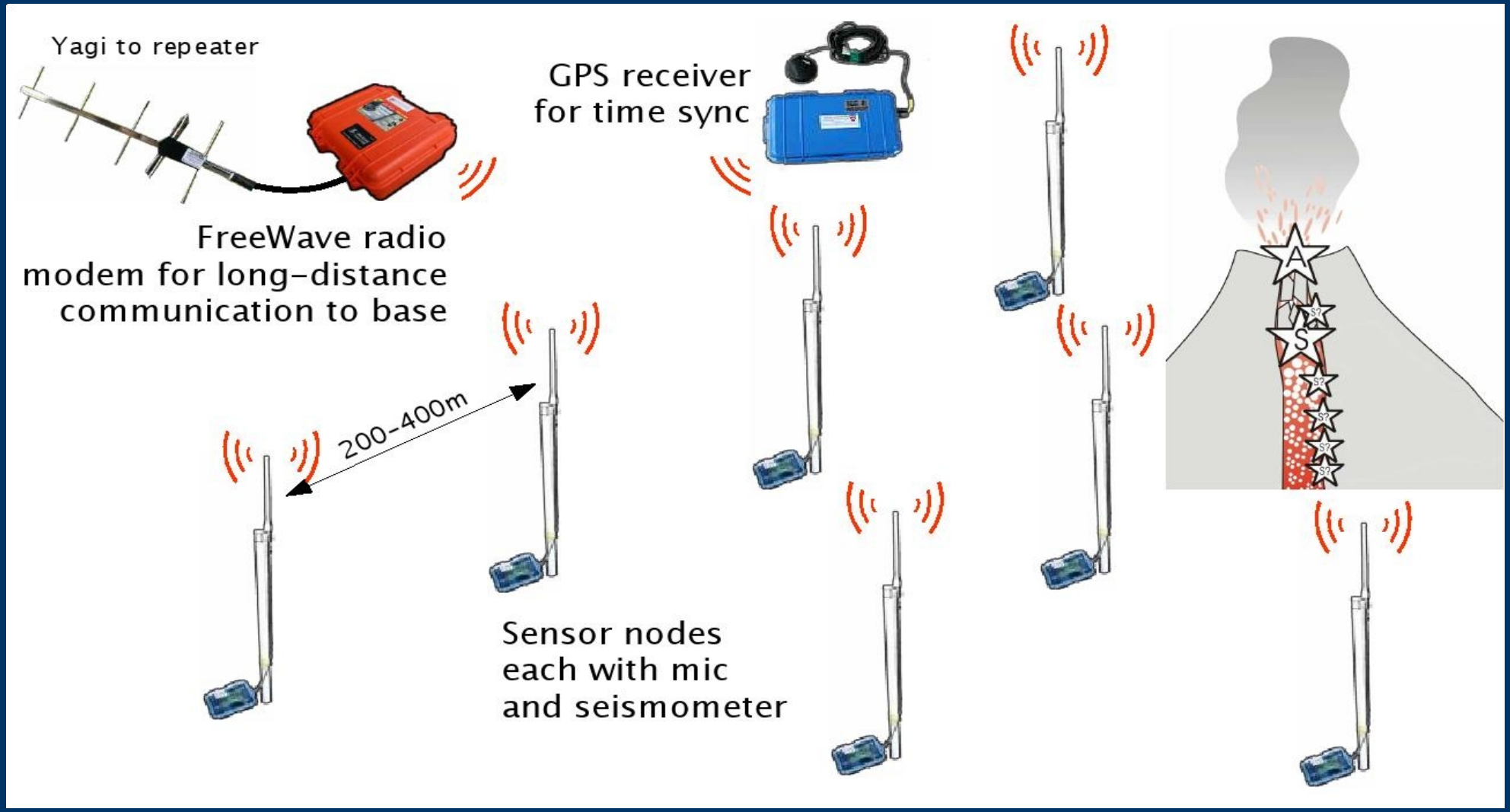


Fig. 4. Distribution of packet losses in a time slot. Statistically, the losses are not independently distributed.

Applications: Volcano Monitoring

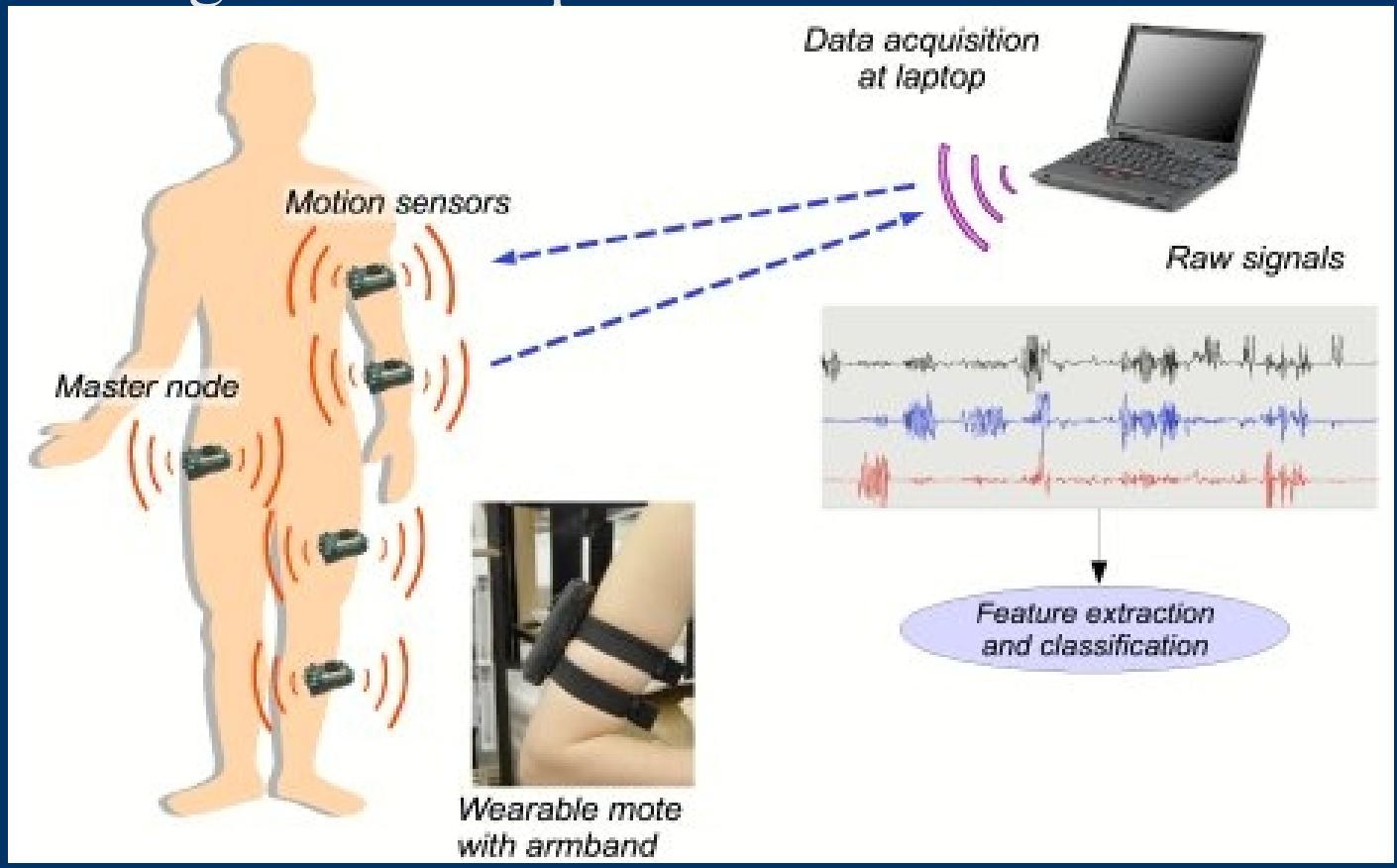


Application: Volcano Sensing Architecture



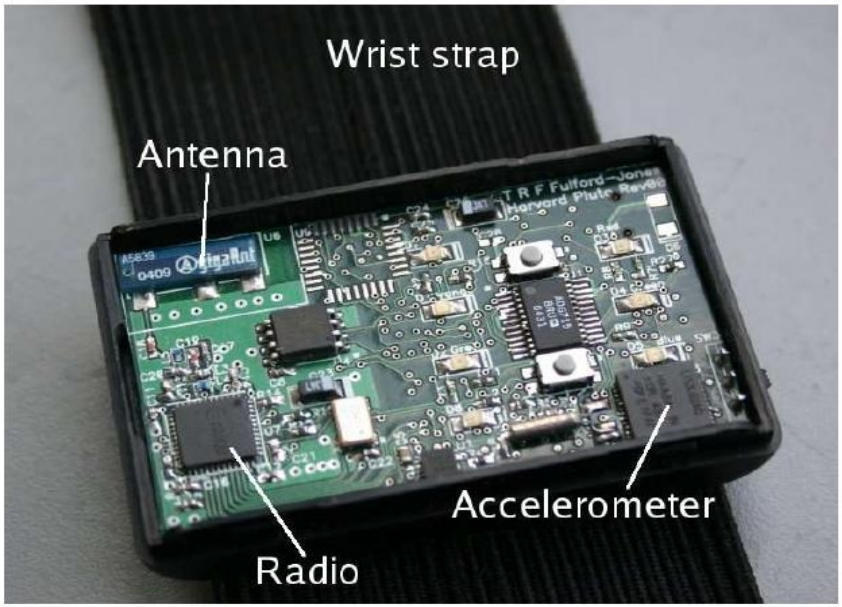
Applications: Medical -- CodeBlue

- pulse, EKG (heart monitoring),
- accelerometer, gyroscope and electromyogram sensing for stroke patients



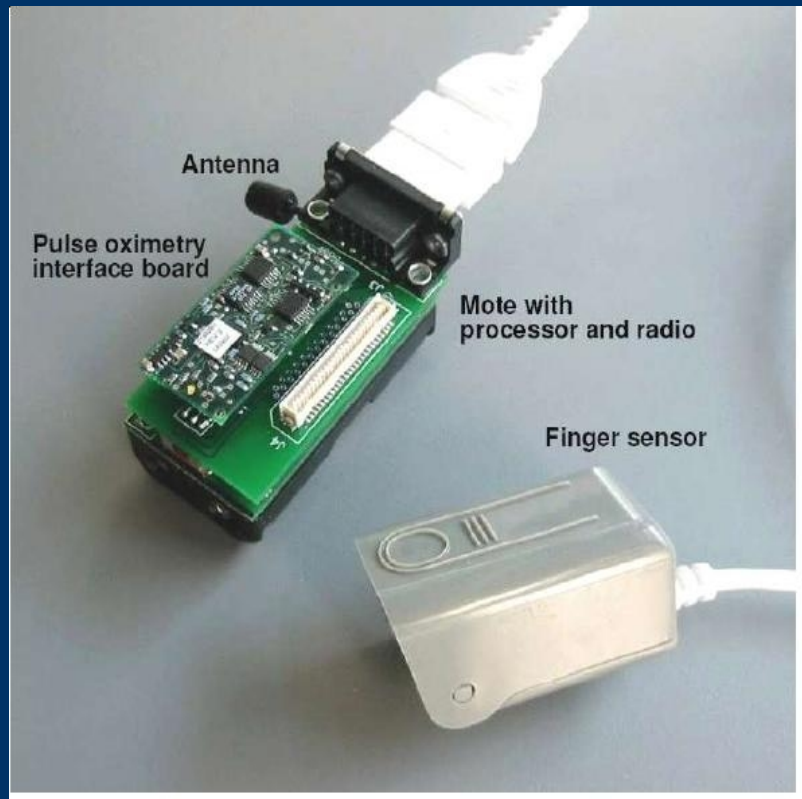
Applications: Medical

The Harvard Pluto Mote

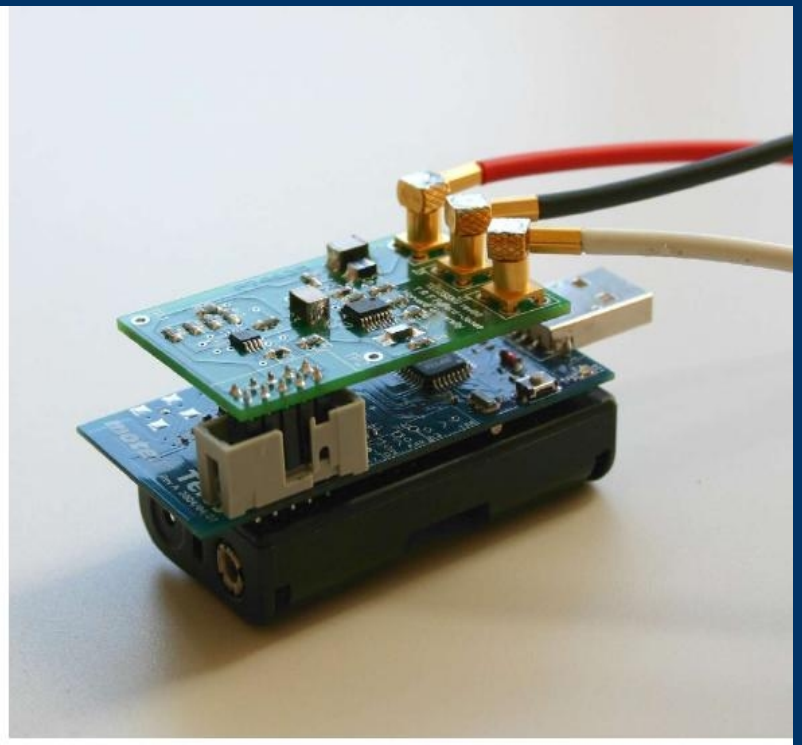


- Designed for wearable applications
  - 3-axis accelerometer
  - Tiny rechargeable battery

Applications: Medical



Pulse oximeter

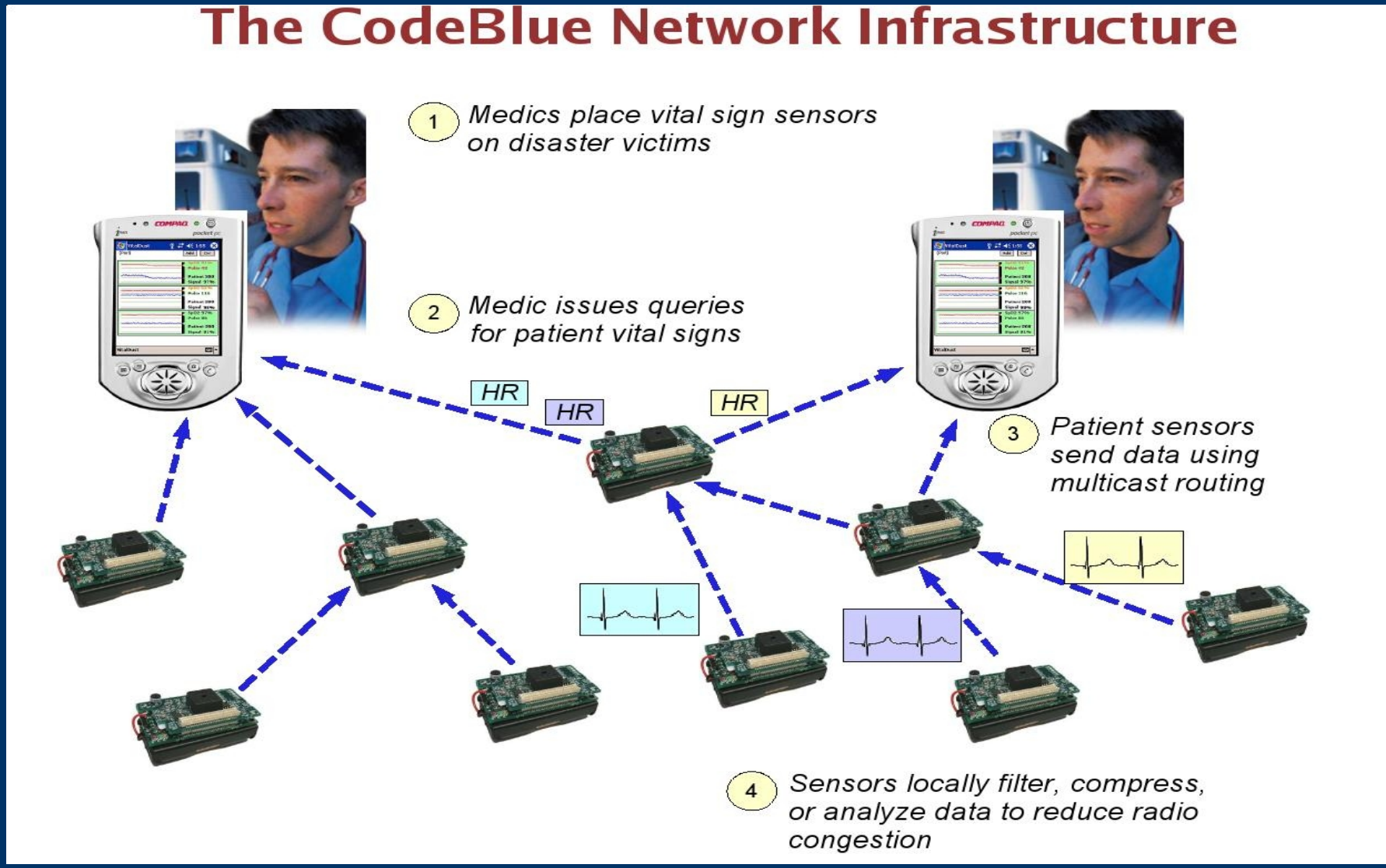


Two-lead EKG

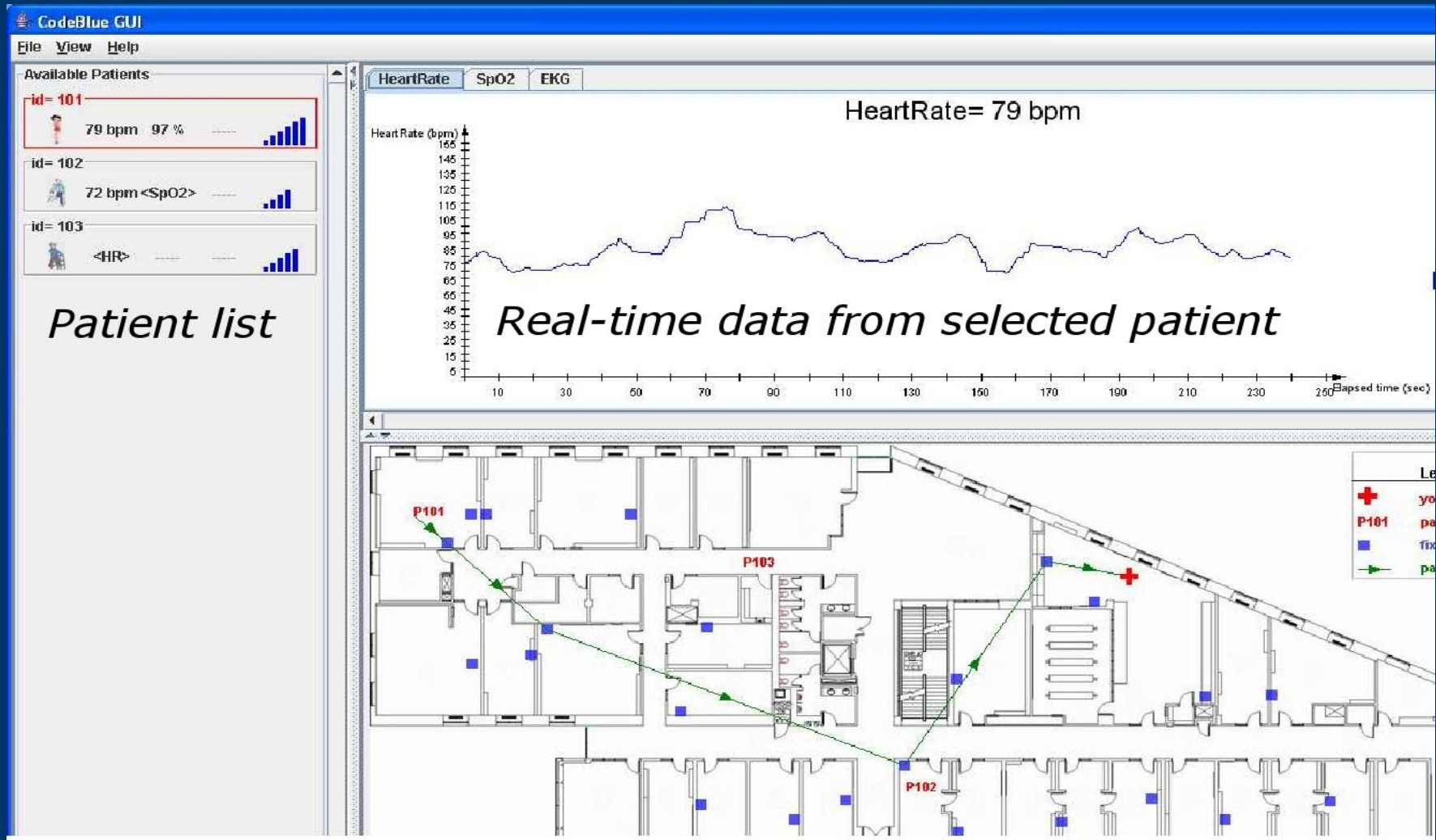
Harvard wireless vital sign sensors

- Vital sign data encrypted over radio
- About 30mA current consumption without duty cycling optimizations

Applications: Medical



Applications: Medical, Real-time patient Monitoring



Applications: Vineyard (1)

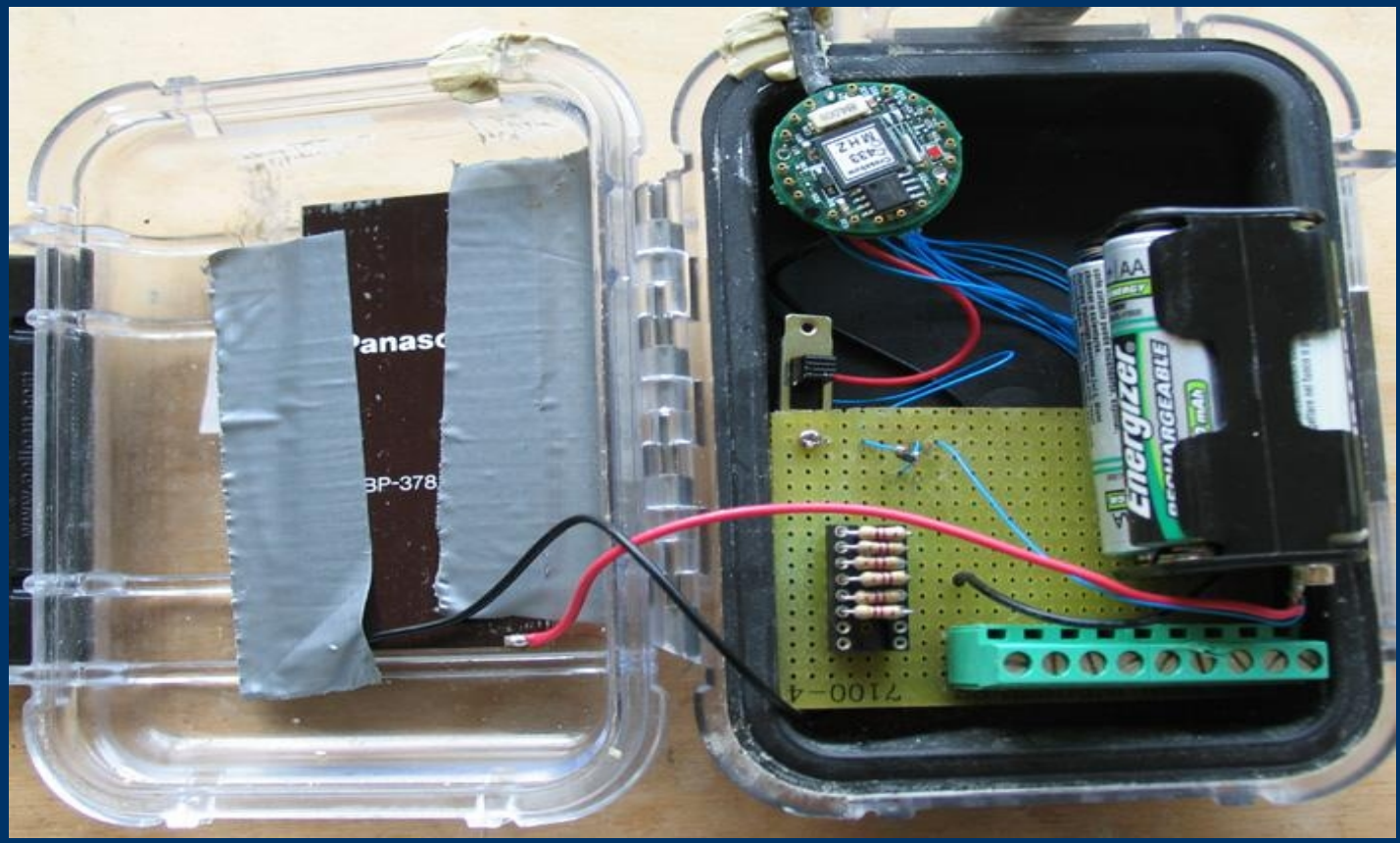
- Conserve water, improve quality of grape crop

Applications: Vineyard (2)

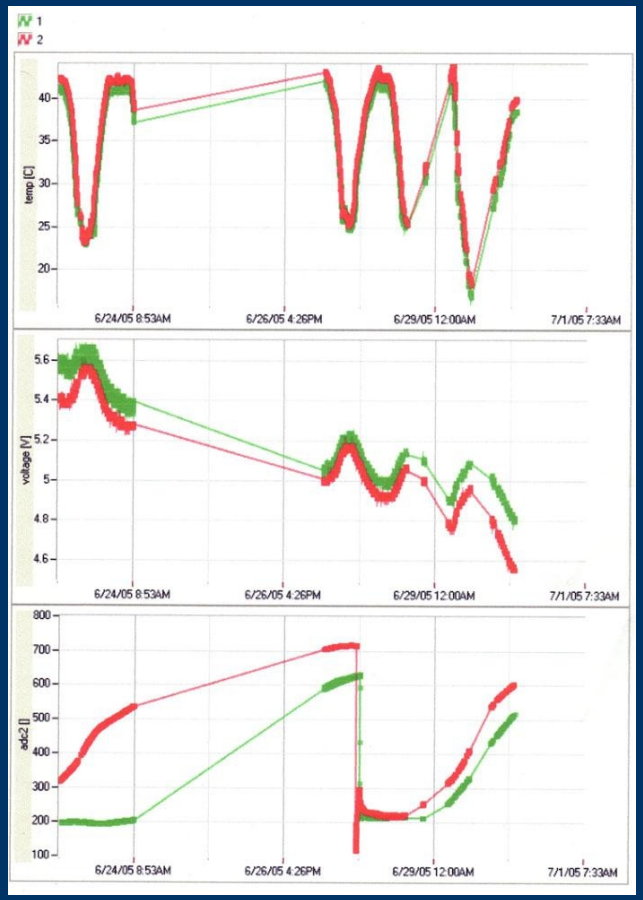
- At each Mote location:
  - 2 soil moisture sensors
  - 12” and 24” depth
  - 1 soil temp sensor to calibrate soil moisture sensors

Applications: Vineyard (3)

- Vineyard Mote prototype



Applications: Vineyard -- future

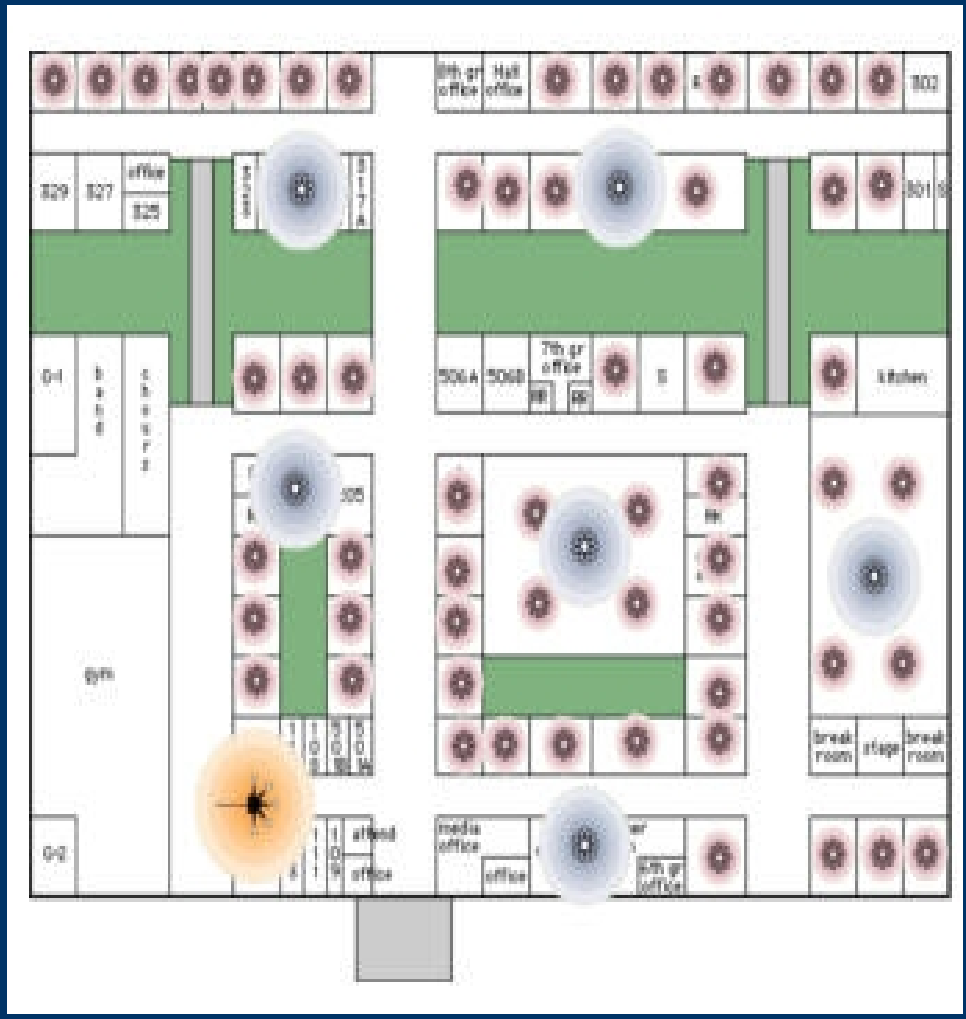


- Deer monitoring, Open Gates, Easement traffic.
- Wine storage temp
- Wine Making, Temps, CO2 level, flow
- Irrigation Control, remote valves.
- Green Home Monitoring; septic, heating
- Sensors embedded in the vines.
- Database costs, Web UI

Application: Compost Monitoring

- Removable wireless temperature and humidity sensing, easier on operators!
- Determine when to water, air (cool),

Application: Building Monitoring



- Air conditioning when school out of session
- Better thermostat control without expensive infrastructure

Application: Water Treatment

- Huge concrete tanks
- Lots of metal pipes
- Multiple floors
- Install tooks hours (instead of days)
- Repeaters easy to add.
- Mesh network