Wireless Sensor Networks

~ Introduction ~

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Credit: Some of the slides are based on those created by Prof. C.Lu at WUSTL

A vision of computing

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The PC world

Vision: Computers should ubiquitous; embedded in the physical world

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Miniature computers embedded in the **physical world**

Healthcare

Improve food

Environmental monitoring

Failure prevention

Save energy

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Is this vision feasible?

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log (people per computer)

Mainframe

Minicomputer

Workstation

PC

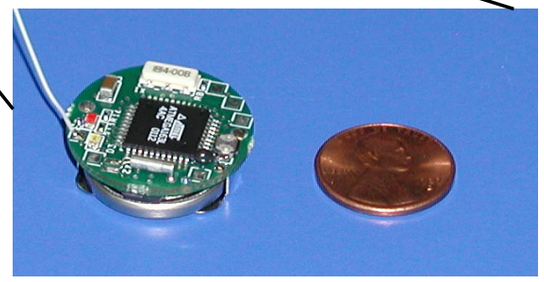
Laptop

PDA

Number Crunching
Data Storage

productivity
interactive

streaming
information
to/from physical
world



year

Credit: David Culler -- UC Berkeley

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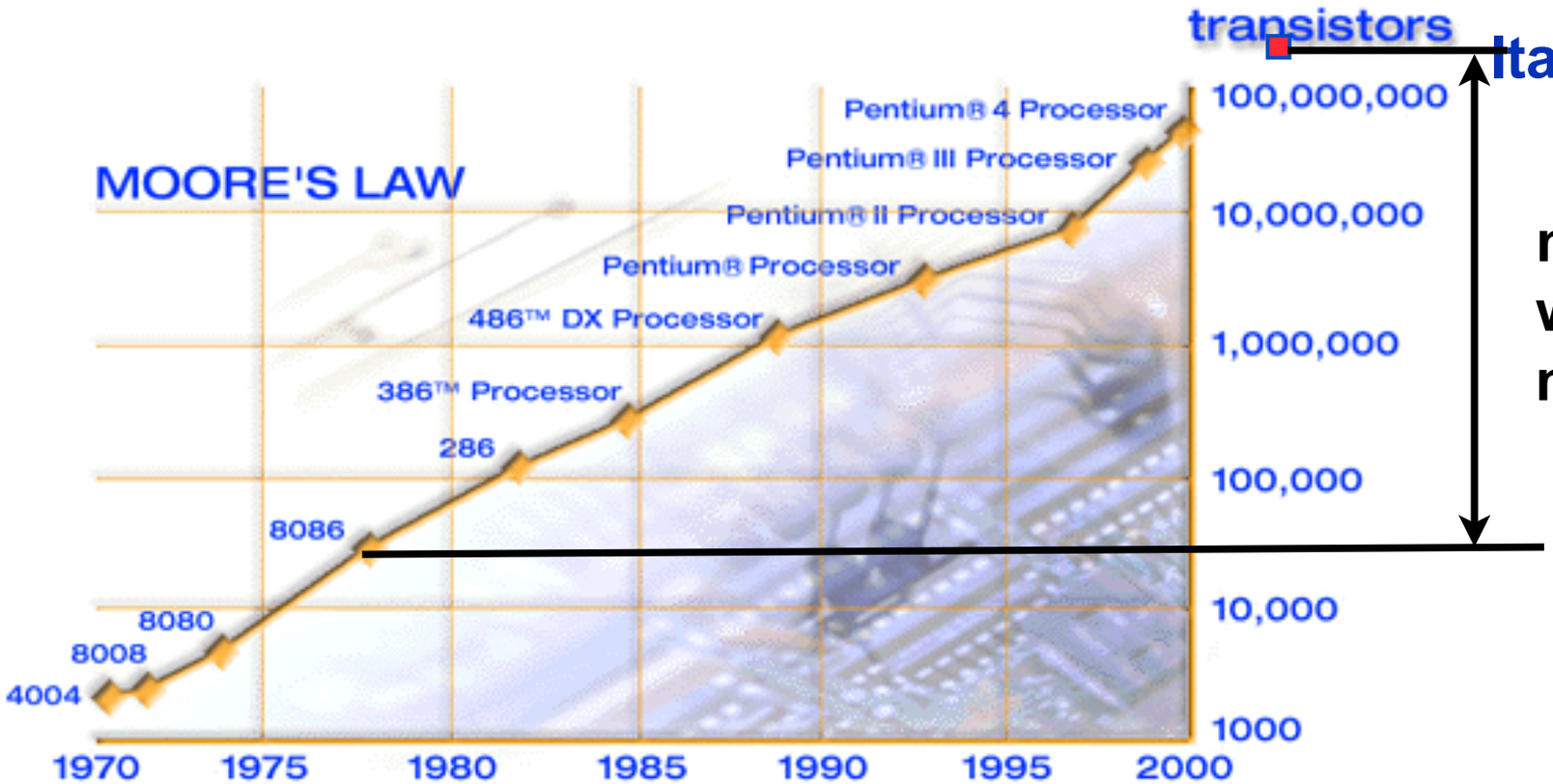
CMOS trends in miniaturization



Credit: David Culler -- UC Berkeley

WSN hardware

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WSN nodes

Mote Type	WeC	Renee	Mica	Mica2	Mica2Dot
					
Microcontroller					
Type	AT90LS8535	Atmega163	Atmega128	Atmega128	Atmega128
CPU Clock (Mhz)	4	4	4	7.3827	4
Program Memory (KB)	8	16	128	128	128
Ram (KB)	0.5	1	4	4	4
UARTs	1	1	2 (only 1 used)	2	2
SPI	1	1	1	1	1
I2C	Software	Software	Software	Hardware	Hardware
Nonvolatile storage					
Chip	24LC256		AT45DB041B		
Size (KB)	32		512		
Radio Communication					
Radio	RFM TR1000			Chipcon CC1000	
Frequency	916 (single freq)			916/433 (multiple channels)	
Radio speed (kbps)	OOK		ASK	FSK	
Transmit Power Control	Programmable resistor potentiometer			Programmable via CC1000 registers	
Encoding	SecDed (software)			Manchester (hardware)	

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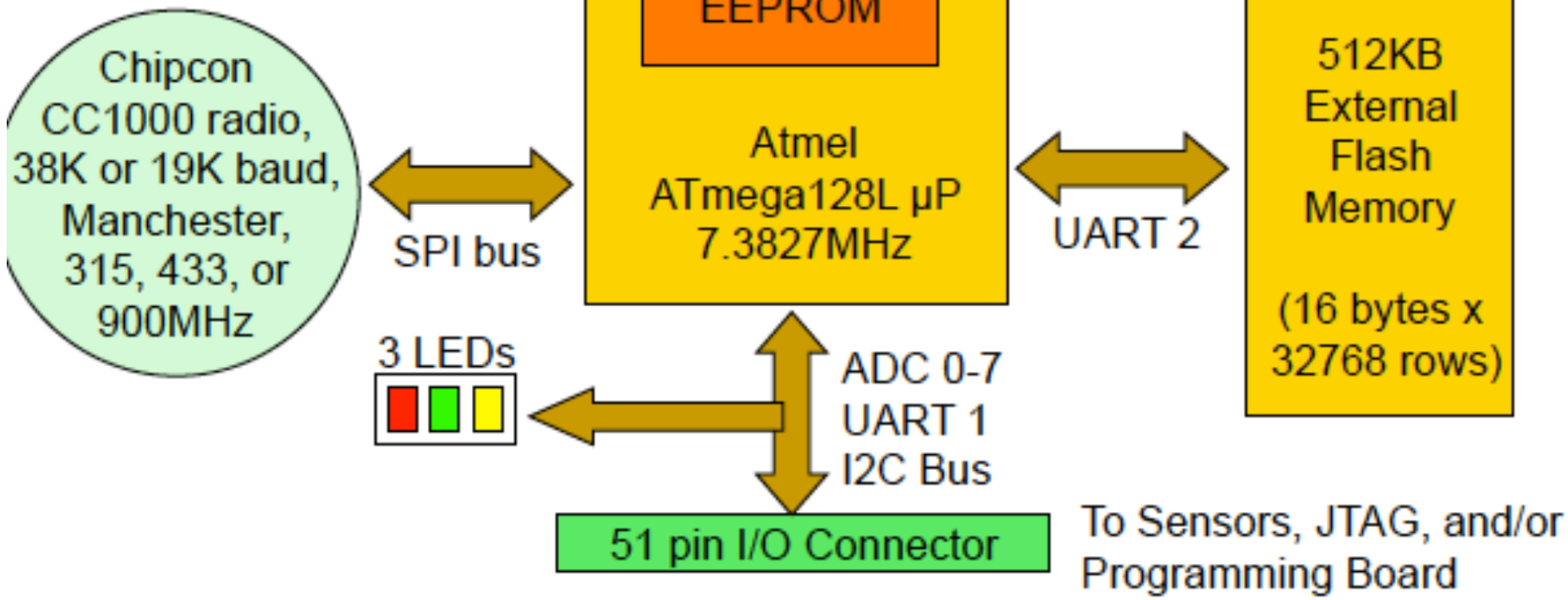
MICA2 mote



- Harvard architecture: separate instruction and data memory
- Limited computational power => power efficient CPU
- Low data rate radio
- Device powered by 2 AA batteries

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Energy consumption

SYSTEM SPECIFICATIONS		
Currents		
	value	units
Micro Processor (Atmega128L)		
current (full operation)	6	ma
current sleep	8	ua
Radio (Chipconn 1000)		
current in receive	8	ma
current xmit	12	ma
current sleep	2	ua
Flash Serial Memory (AT45DB041)		
write	15	ma
read	4	ma
sleep	2	ua
Sensor Board		
current (full operation)	5	ma

- Average full operation ~ 15 ma
  - AA batteries provide 1800ma => 5 days of continuous operation
- Significant energy consumed for:
  - radio
  - flash

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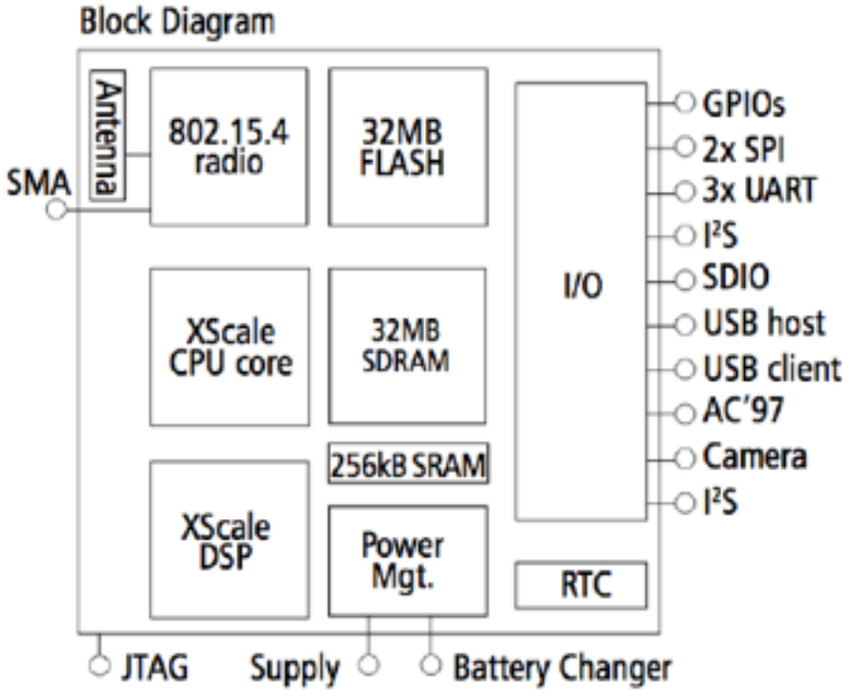
iMote2 by Intel



- Intel PXA271 Xscale processor
  - 13 - 416 Mhz
  - 32MB flash / 32MD sdram
- 802.15.4 radio @ 2.4 Gz
- impressive IO capabilities

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Take-home message ...

- Computational power is reduce in favor of
  - reduced energy consumption => operate without changing batteries for long periods of time
  - reduced form factor => easy to wear or deploy
  - low cost => possible to deploy in large numbers

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Applications

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Archetypical sensor network systems

- Great Duck Island Expedition
- A Macroscope in the Redwoods
- Volcano monitoring
- Clinical monitoring

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Great Duck Island Petrel monitoring

- **Goal: understand the breeding preferences of Leach's Storm Petrel**
  - nest occupancy
  - difference in micro-climate between active and inactive nests
  - monitor environmental conditions during breeding seasons (7 months)

- **Requirements:**
  - reduce the "observer effect" => no interventions
  - prolonged lifetime
  - hazards due to environmental conditions
  - collect as must data as allowed by energy constraints

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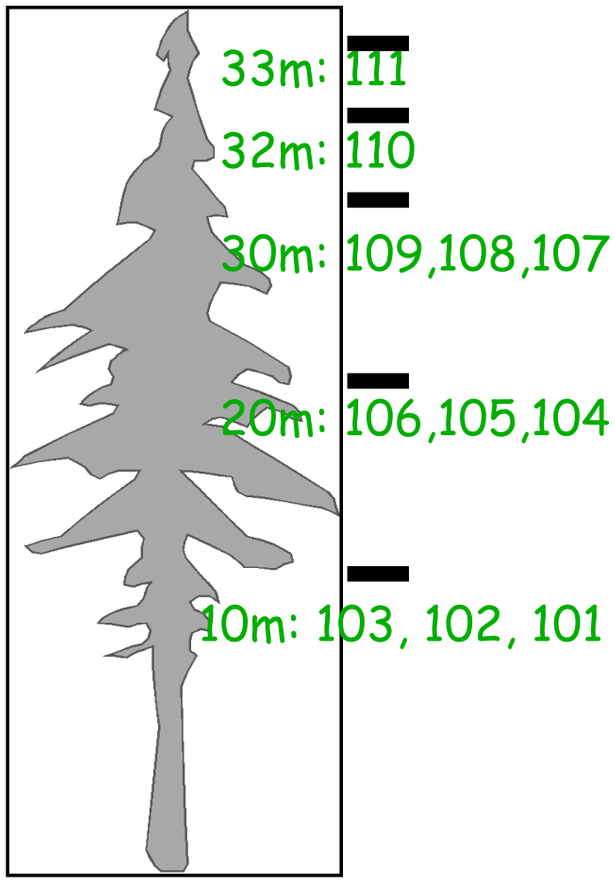
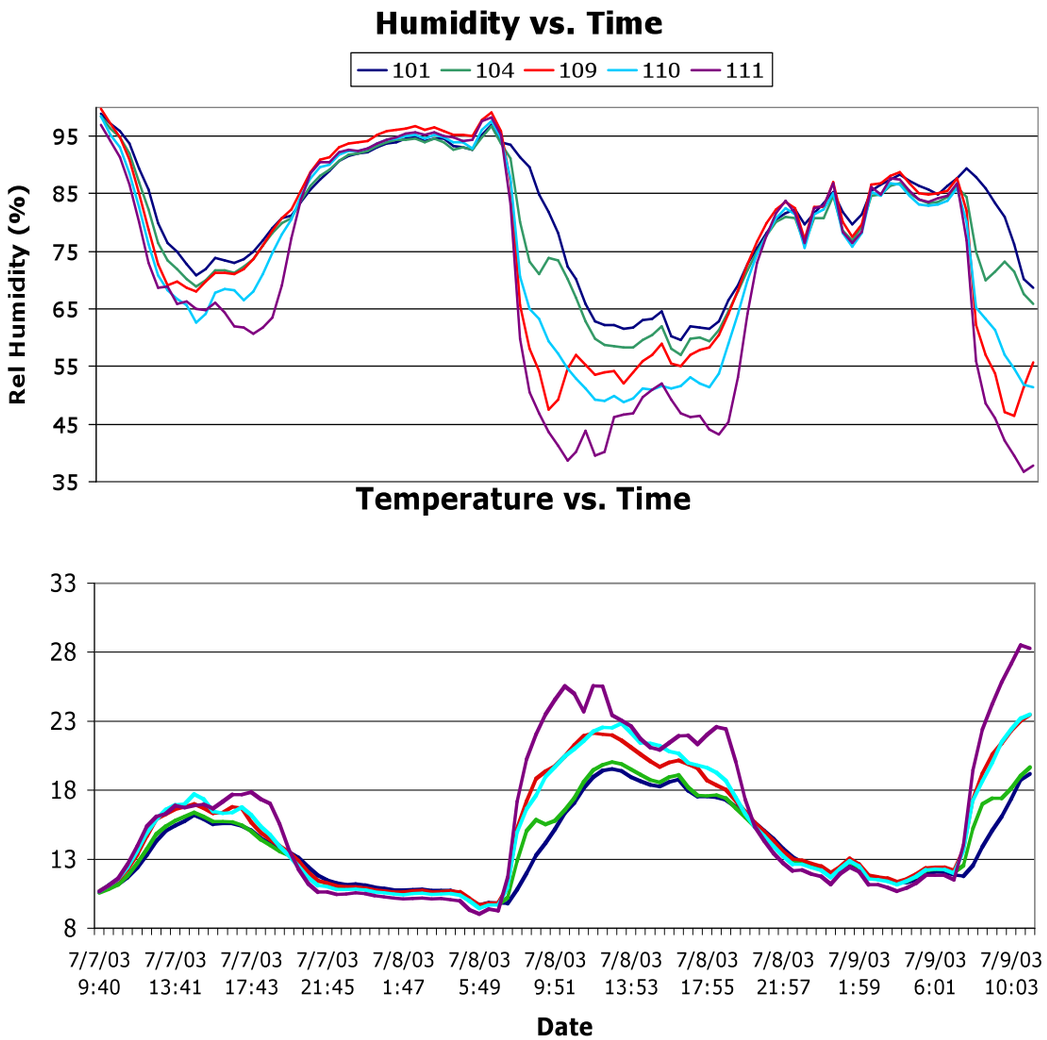
Redwood tree monitoring

- **Goal: monitor the micro-climate of a redwood tree**





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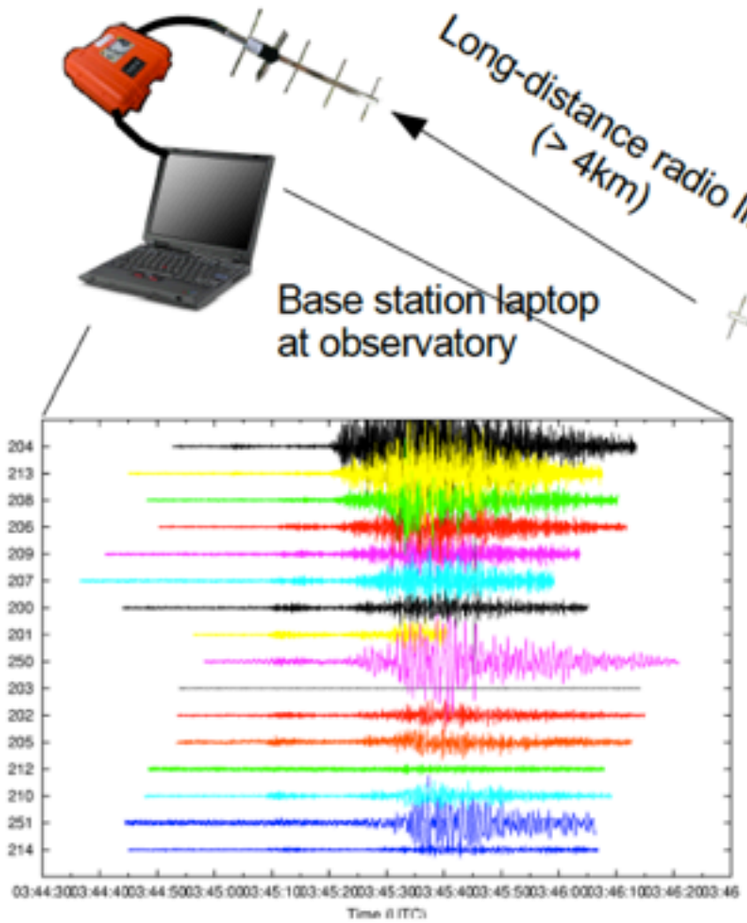
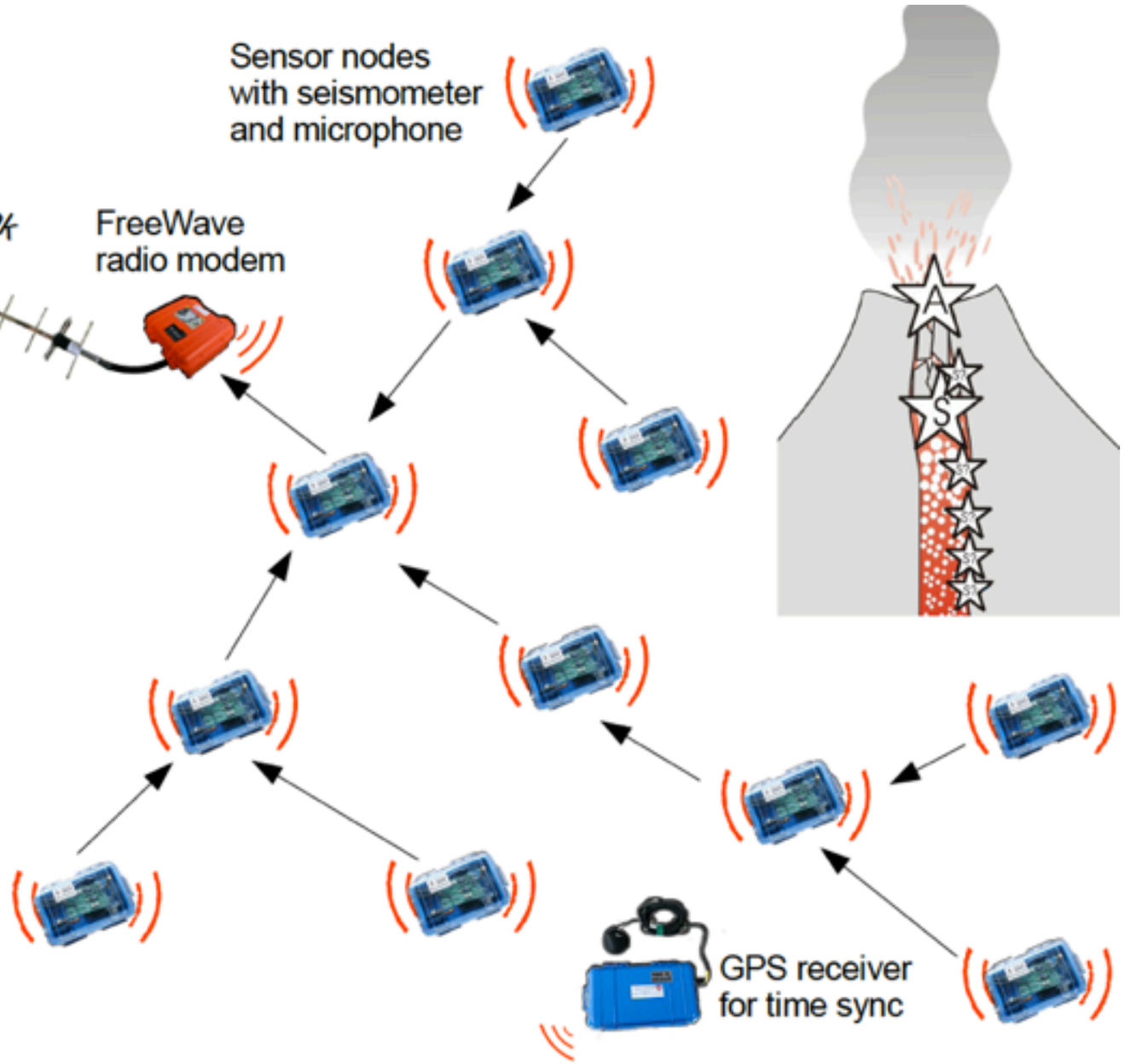
Volcano monitoring

- **Goal: High-density monitoring of volcanic activity**



Download 60 sec. of data
following an "interesting" seismic event



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Volcano monitoring

- **Motes sample data continuously and store it in flash**
  - 100Hz sampling rate @ 24 bits per sample
  - flash can store 20 mins => need to download the data

- **Time synchronization is necessary to align sensor readings**

- **Each mote detects “interesting seismic activity”**
  - sends a report over multiple hops to the base station
  - download initiated when multiple motes detect interesting activity

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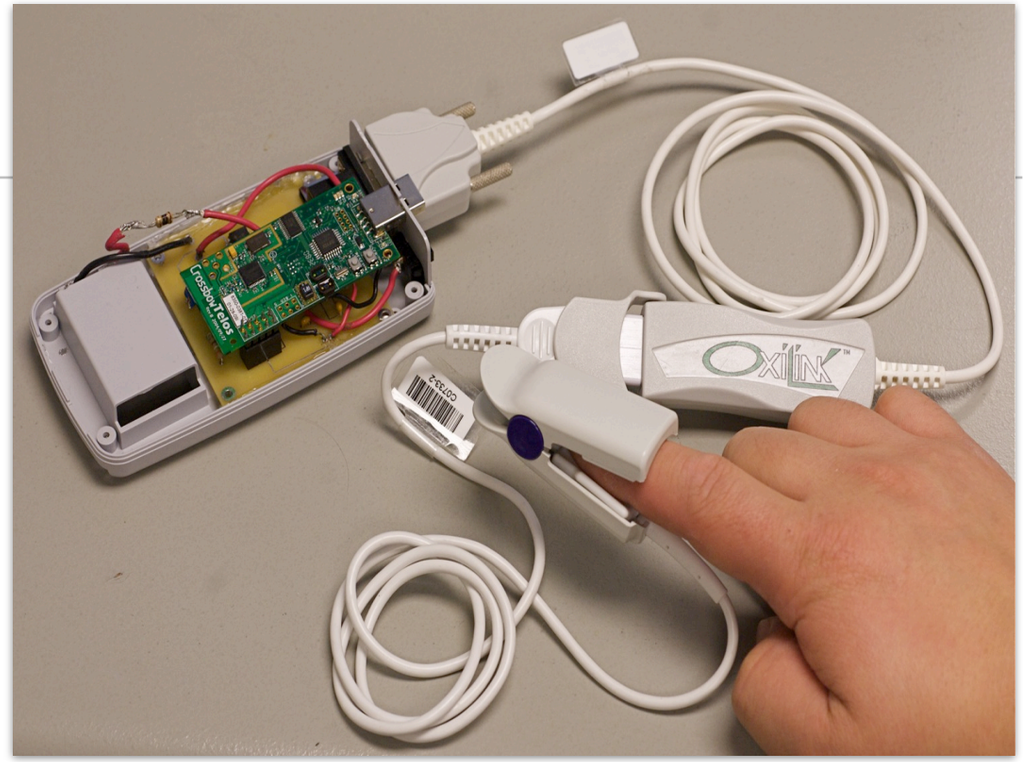
Clinical monitoring



- **Goal: low-cost pulse oximetry**
- **Requirements:**
  - high reliability
  - support for mobile users
  - low-power operation
- **BJC deployment:**
  - orders of magnitude more data than possible through manual collection
  - highly reliable networking
  - early detection of clinical deterioration is possible

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Motion analysis

- Applications:
  - fall detection
  - activity analysis
  - game control

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Grading policies

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Grading policies

- Project (60%)
  - proposal and presentation (10%)
  - demo 1 (5%)
  - demo 2 (5%)
  - final report and demo (40%)
- Critiques (30%)
- Participation (10%)

- **ALL EMAIL MUST HAVE IN THE TITLE:**
  - **[wsn-class]** ....
  - reply within 24 hours

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Critique

- **Critique of research papers**
  - 1/2 a page; no essay form necessary; bullets are fine
  - due at 11:59am on the class day
  - email the critique in plan text to me
- **Evaluation**
  - do ***NOT*** summarize the content of the paper
  - interested in your insights about the papers
    - are the assumptions of the paper reasonable?
    - is the solution practical? do you think it will work?
    - any technical errors that you found? limitations?
    - do the results support the claims?
    - how can you improve the paper?

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Project topics

- **Applications**
  - develop an interesting application
- **Experimentation**
  - evaluate and compare existing approaches
- **To something new!**

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Project

- Identify your favorite topic
- Form a team => 3 students per team
- Propose a solution
- Analyze and implement your solution
- Evaluate your solution
- Two progress demos
- Write a technical report
- Demo your results in class

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Get started early!

- Think about ideas
- Let me know what hardware you will need
- Come to the office hours to discuss your ideas
- Put together a team

- The project will be a **lot** of work and a lot of fun!

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Final report

- Due: last day of finals week; 11:59 pm
  - email me the report
  - drop a DVD containing all other course materials
- Report:
  - organization => typical conference paper
  - 6 pages; 2 columns; 10 pts
  - writing a good report takes time!
- To turn in:
  - slides from all your presentations
  - source code
  - documentation on how to run and install source code
  - videos (if required)
  - final report

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A+ grades -- publication worthy report

Class projects can turn into publications!

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Project Ideas

- Application
  - fall detection, park-spot finder, games, augmented reality

- Network protocols
  - new protocols or comparison of existing protocols
  - develop a simulation environment

- OS projects
  - implement virtual memory in T2, develop a virtual machine, develop a lightweight database

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