Lecture slides from Ohio State (Prof. Anish Arora)

Wireless Sensor Networks for Habitat Monitoring

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Motivation

Questions

- **What environmental factors make for a good nest?**
- **How much can they vary?**
- **What are the occupancy patterns during incubation?**
- **What environmental changes occurs in the burrows and their surroundings during the breeding season?**

Motivation

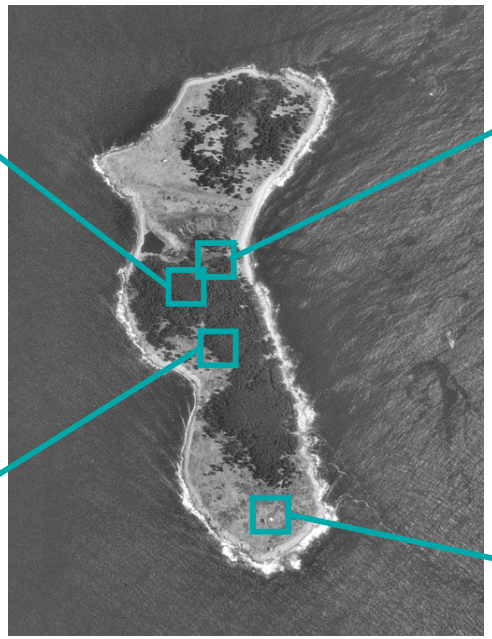
Problems

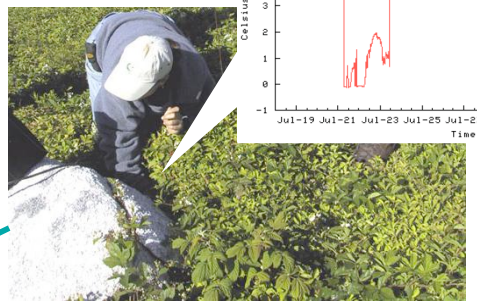
- **Seabird colonies are very sensitive to disturbances**
- **The impact of human presence can distort results by changing behavioral patterns and destroy sensitive populations**
- **Repeated disturbance will lead to abandonment of the colony**

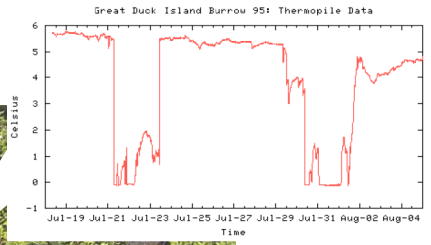
Solution

- **Deployment of a sensor network**

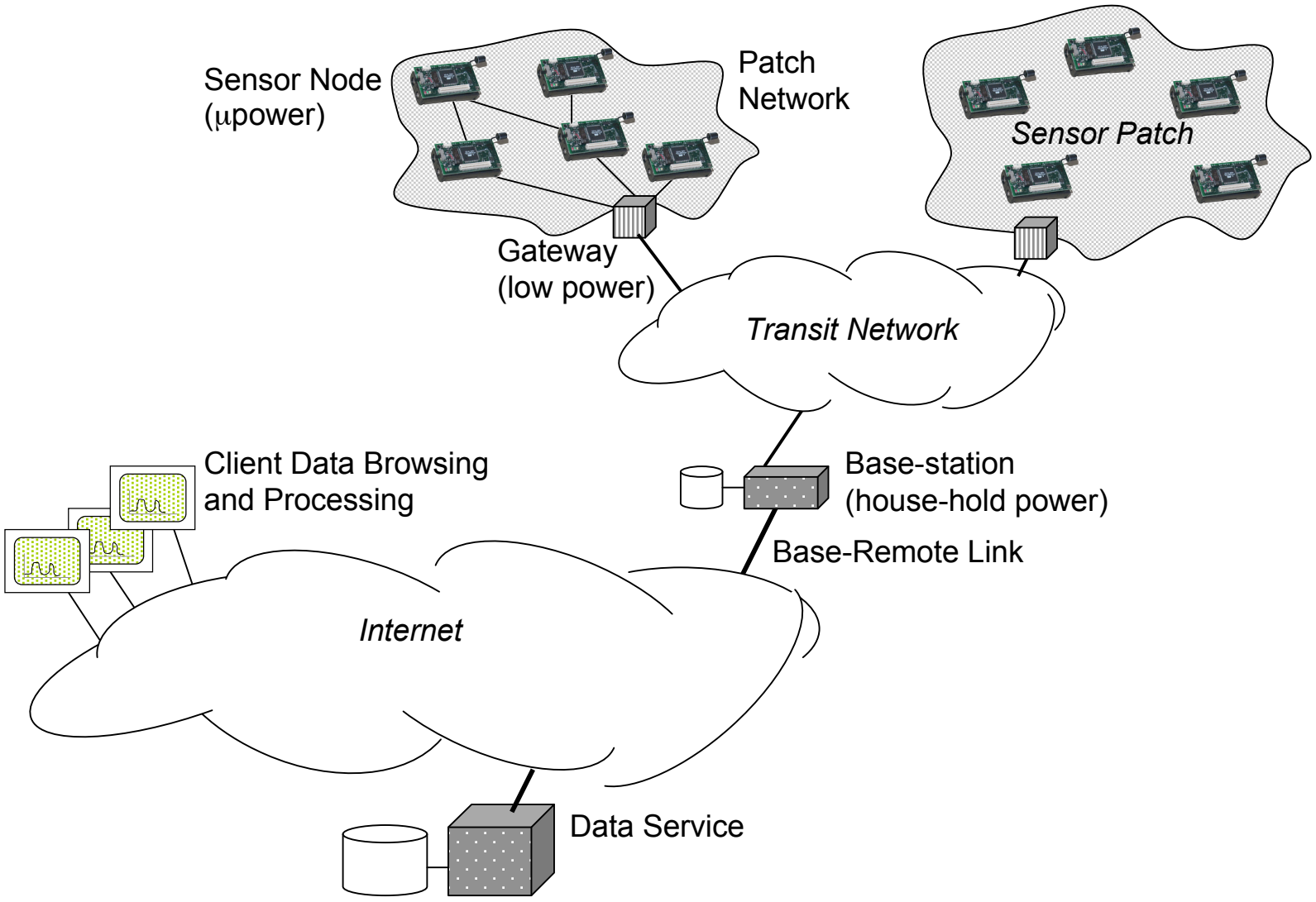
Great Duck Island Project



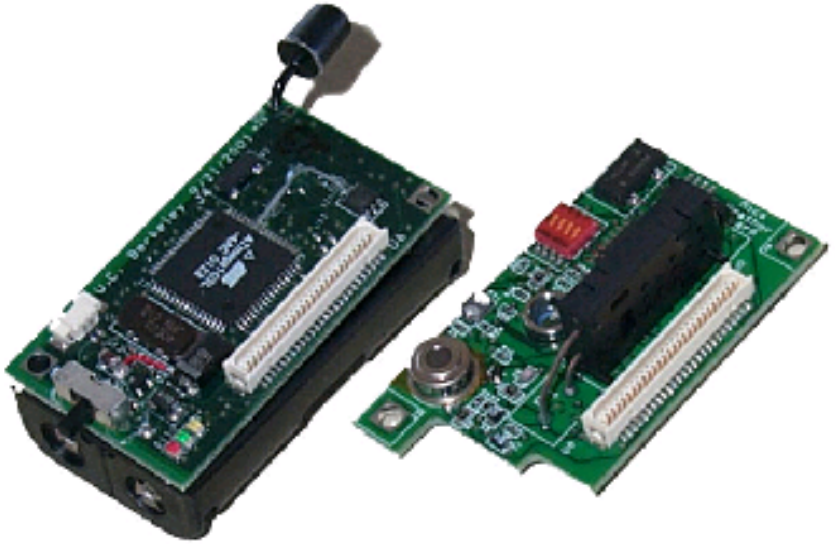




GDI Sensor Network



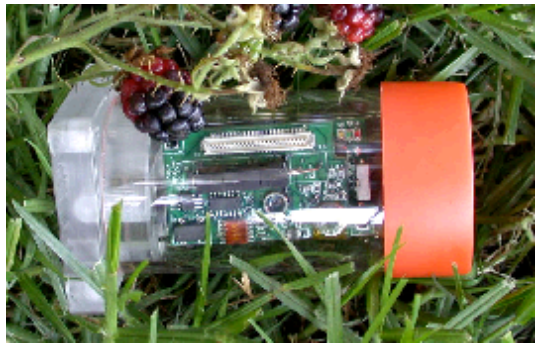
Mica Sensor Node



Left: Mica II sensor node
2.0x1.5x0.5 cu. In.

Right: weather board with temperature, thermopile (passive IR), humidity, light, acclerometer sensors, connected to Mica II node

- Single channel, 916 Mhz radio for bi-directional radio @40kps
- 4MHz micro-controller
- 512KB flash RAM
- 2 AA batteries (~2.5Ah), DC boost converter (maintain voltage)
- Sensors are pre-calibrated (±1-3%) and interchangeable



Power Management

Sensor Node Power

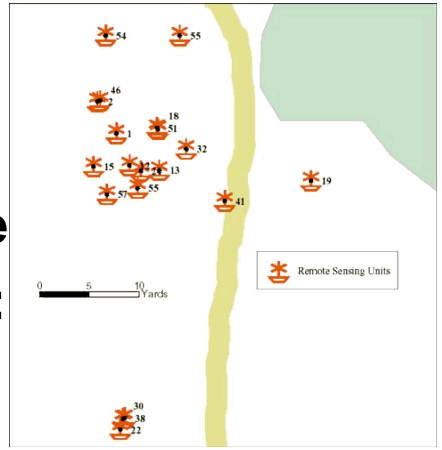
- **Limited Resource (2 AA batteries)**
- **Estimated supply of 2200 mAh at 3 volts**
- **Each node has 8.128 mAh per day (9 months)**
- **Sleep current 30 to 50 uA (results in 6.9 mAh/day for tasks)**
- **Processor draws apx 5 mA => can run at most 1.4 hours/day**
- **Nodes near the gateway will do more forwarding**

Operation	nAh
Transmitting a packet	20.000
Receiving a packet	8.000
Operating sensor for 1 sample (analog)	1.080
Operating sensor for 1 sample (digital)	0.347
Reading a sample from the ADC	0.011
EEPROM Read Data	1.111
EEPROM Program/Erase Data	83.333

Operation	Operating Time/Day	Duty-Cycle	Sample Rate
Always Sleep	24 hours	0%	0 samples/day
+ μCPU on	75 minutes	3.61%	0 samples/day
+ Radio On (Listen)	28 minutes	1.94%	0 samples/day
+ Sample All Sensors	21 minutes	1.45%	630 samples/day
+ Transmit Samples	20 minutes	1.38%	600 samples/day

Communication

Routing



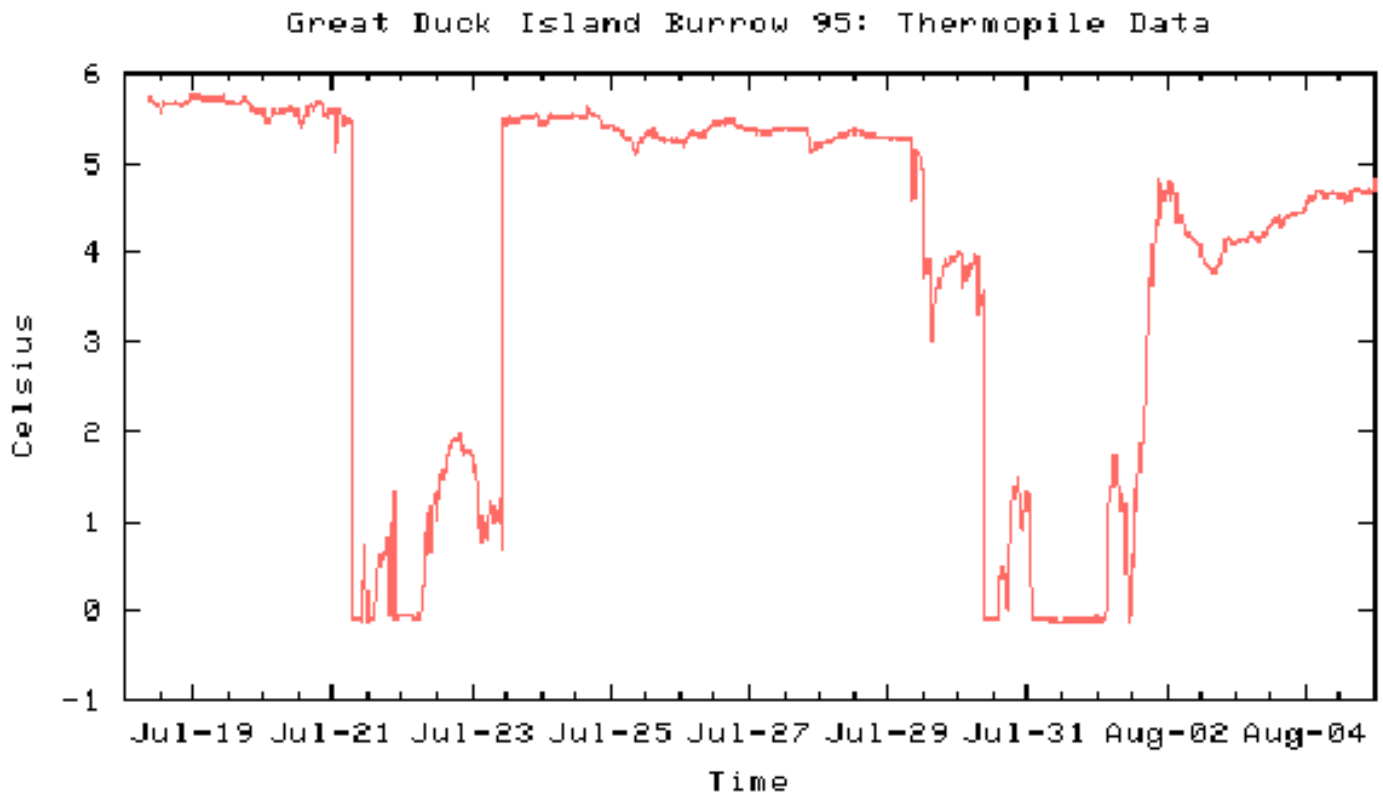
- **Routing directly from node to gateway not possible**
- **Approach proposed for scheduled communication:**
  - **Determine routing tree**
  - **Each gate is assigned a level based on the tree**
  - **Each level transmits to the next and returns to sleep**
  - **Process continues until all level have completed transmission**
  - **The entire network returns to sleep mode**
  - **The process repeats itself at a specified point in the future**

Network Re-tasking

Initially collect absolute temperature readings

- **After initial interpretation, could be realized that information of interest is contained in significant temperature changes**
- **Full reprogramming process is costly:**
  - **Transmission of 10 kbit of data**
  - **Reprogramming application: 2 minutes @ 10 mA**
  - **Equals one complete days energy**
- **Virtual Machine based retasking:**
  - **Only small parts of the code needs to be changed**

Sensed Data



Raw thermopile data from GDI during 19-day period from 7/18-8/5/2002. Show difference between ambient temperature and the object in the thermopile's field of view. It indicates that the petrel left on 7/21, return on 7/23, and between 7/30 and 8/1

Health and Status Monitoring

- Monitor the mote's health and the health of neighboring motes
- Duty cycle can be dynamically adjusted to alter lifetime
- Periodically include battery voltage level with sensor readings (0~3.3volts)
- Can be used to infer the validity of the mote's sensor readings

Conclusion

Paper conclusion

- **Applied wireless sensor networks to real-world habitat monitoring**
- **Two small scale sensor networks deployed at Great Duck Island and James Reserve (one patch each)**
- **Results not evaluated**

Future

- **Develop a habitat monitoring kit**