Life Under Your Feet: A Status Update

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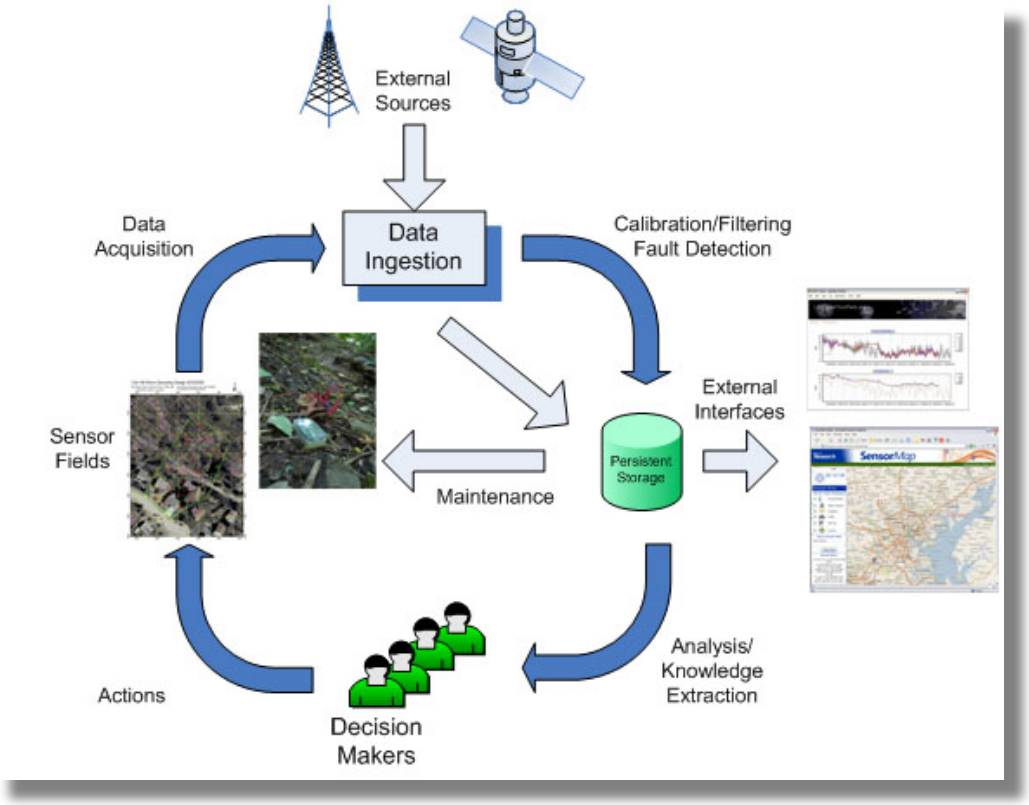
All Hands Meeting

Outline

- Turtle nest monitoring using sensor networks
- *Koala:* An ultra-low power data gathering system
- Fault detection in the real world

Why Wireless Sensor Networks?

- WSNs: Sensors, computation, and communication feasible at small packages and large numbers
  - Ability to monitor phenomena at fine spatial and temporal granularities
- Vision: **Embedded Networked Sensing will reveal previously unobservable phenomena**
- A new type of scientific instrument: *macroscope*

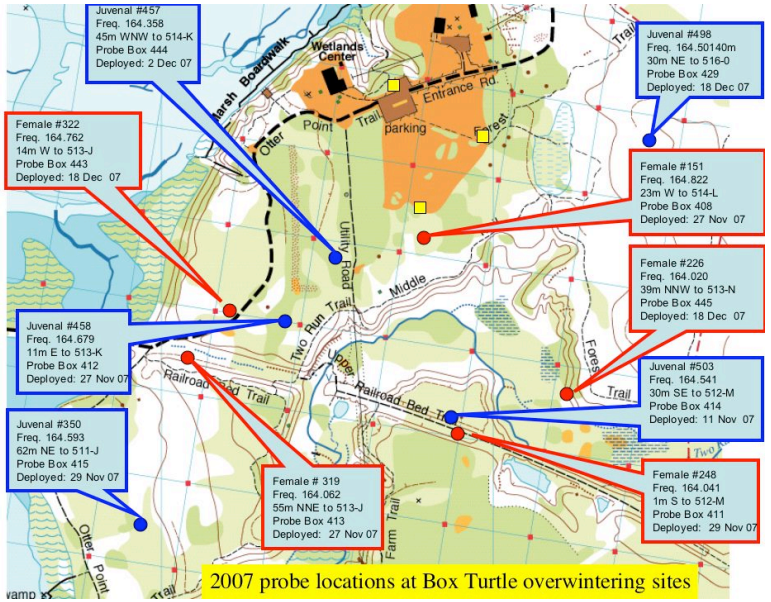


Box Turtles lay eggs in the soil where solar radiation provides the heat for incubation

Gender is determined by the temperature at which the embryos develop

Male box turtles hatchlings develop when incubation temperatures are 27-28 °C, whereas females develop at 29-30 °C

Global warming has the potential of raising the summer soil temperatures where turtles nest, and it potentially leads to a bias in hatchling sex



2007 probe locations at Box Turtle overwintering sites

Preliminary Data

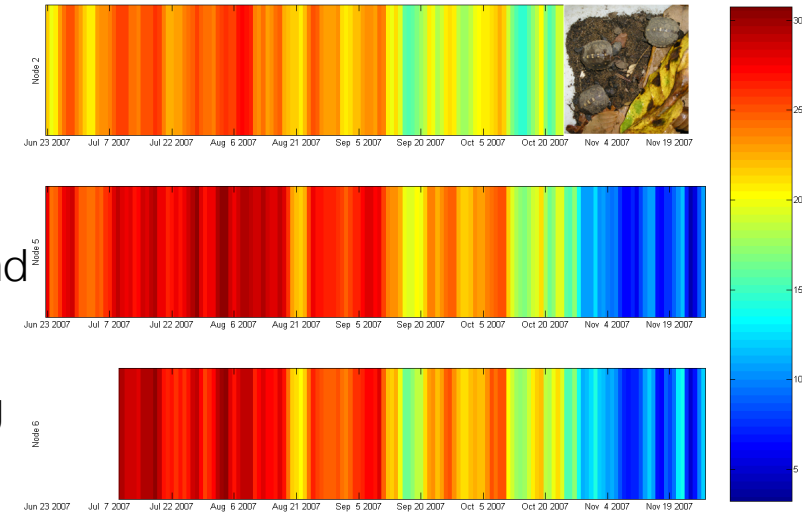
Soil Temperature (C)

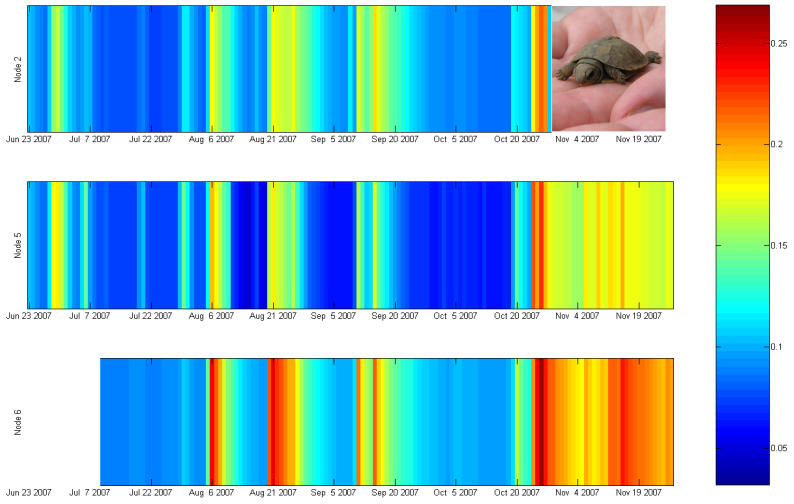
Soil Moisture (GWC)

Forest Edge

Open Grassland

Parking Lot

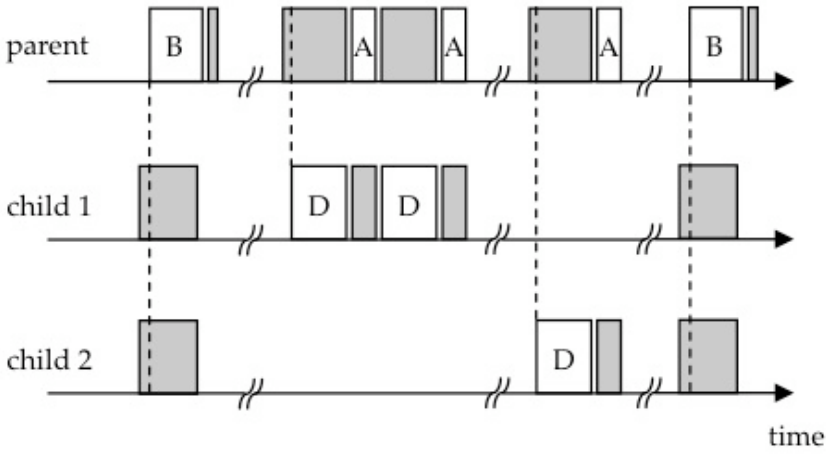




This is the first study to demonstrate Box Turtle nesting conditions in situ. Sensors showed considerable differences in the soil abiotic conditions among the three nests. We expect that the remaining two nests will hatch in spring 2008

Data Gathering Applications

- Require reliable extraction of collected measurements
- Long deployments necessary to capture yearly cycles
- Sparse topologies
- Need for low duty cycles (< 0.1 %)
- Current Solution: Multi-hop routing tree with duty cycling [Dozer]



Key Insights

- Many applications do not require real-time access to collected measurements
- Motes expend considerable energy to maintain *persistent routing state*
- Duty-cycled routing protocols increase the size and complexity of mote code

A different approach

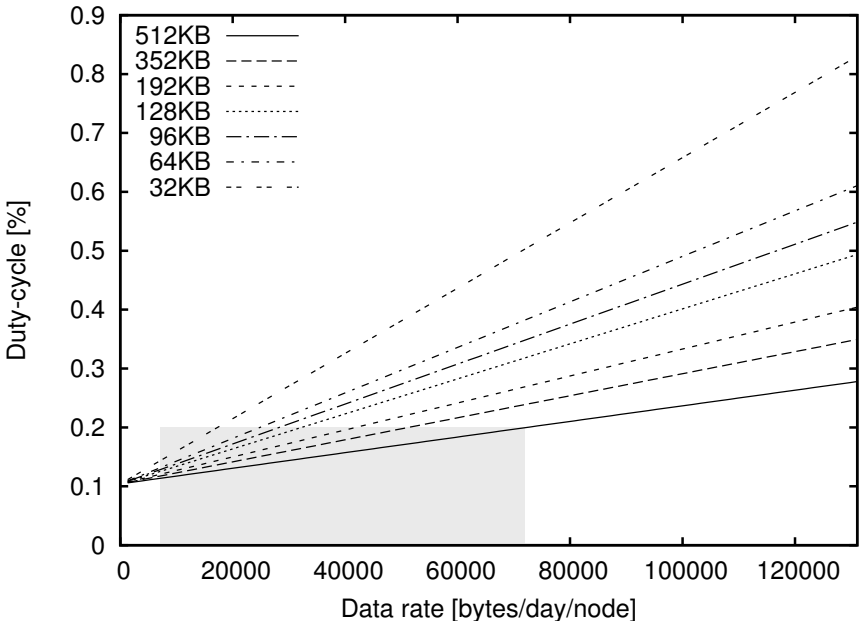
- Separate routing **control plane** and **data plane**
  - Motes are mostly asleep and do not know how to forward data
  - Implement **network-wide** routing control plane
    - Calculates end-to-end paths
    - Installs forwarding state to the network's motes
- Benefits
  - Reduced mote code complexity and energy consumption
  - Potential for network-wide route optimization

Koala

- System for reliably extracting bulk data from duty-cycled nodes
- Combines
  - Network-wide wake up mechanism
  - Network path establishment
  - Data extraction

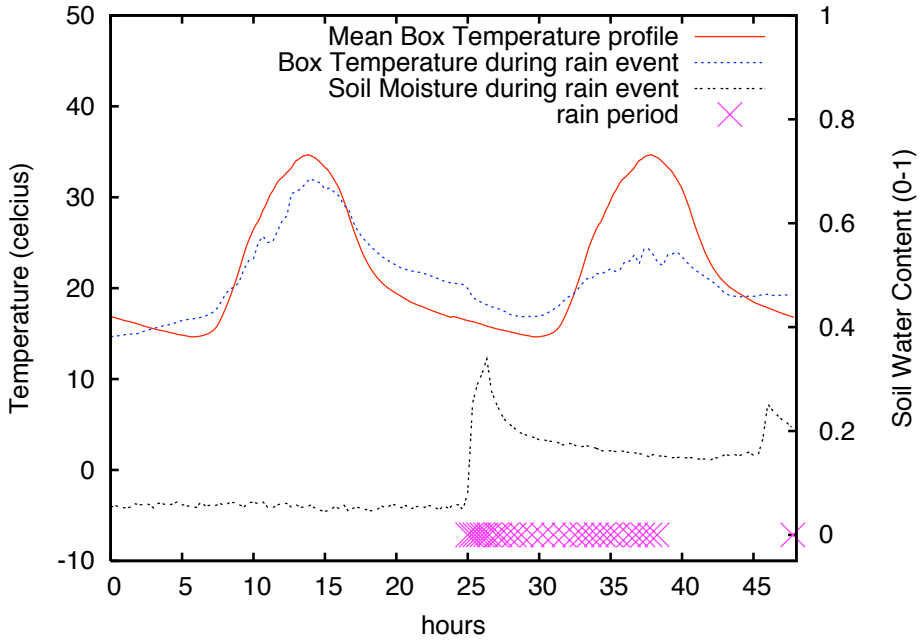
Results

- Koala provides ability to adjust download quanta
- Larger downloads are more efficient but increase latency
- Koala outperform most energy-efficient protocol to this day [Dozer]
- Significant room for further improvements



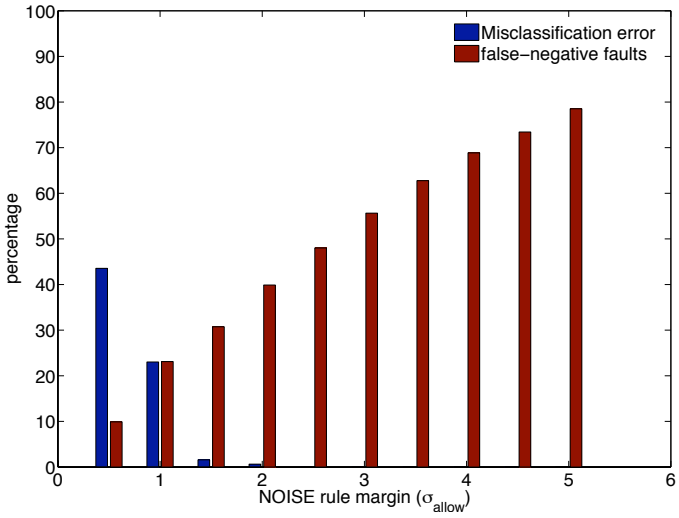
Fault Detection in Sensor Networks

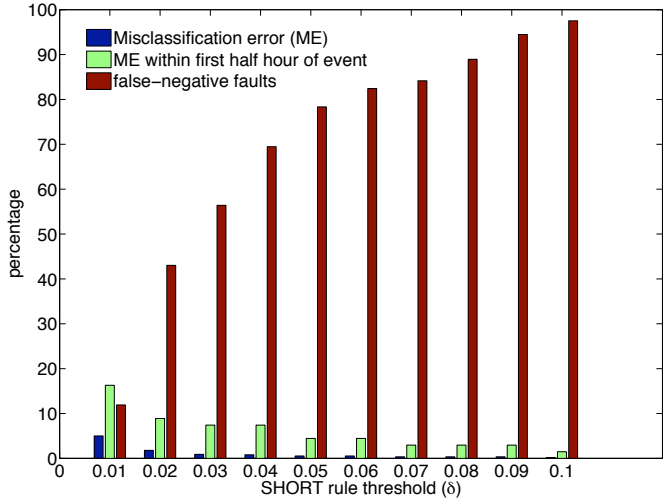
- Data gathered by sensor networks contain occasional faults
- Delivering faults consumes valuable resources and pollutes experiment
- Fault detection techniques attempt to detect faults as *deviations* from “normal” data
- **Caveat:** Some “abnormal” data are important *events* of scientific interest



Fault detection in the presence of events

- **Bad News:** Data gathered during events are classified as faults
- **Worse News:** Minimizing misclassifications leads to large numbers of false negatives
- **Solutions**
  - Nodes should *buffer* "suspicious" measurements until it is possible to compare them with *event signatures* and neighbor's data
  - Statistical techniques (*e.g.* PCA) can be used to extract event signatures



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