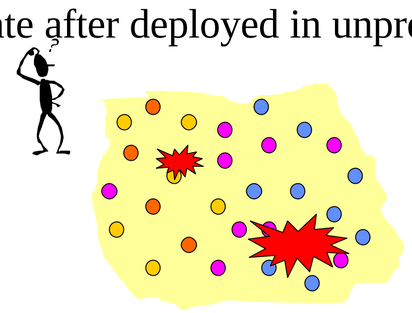
UNIVERSITY OF SOUTHERN CALIFORNIA *INFORMATION SCIENCES INSTITUTE*

Sensor Network Tomography: Monitoring Wireless Sensor Networks

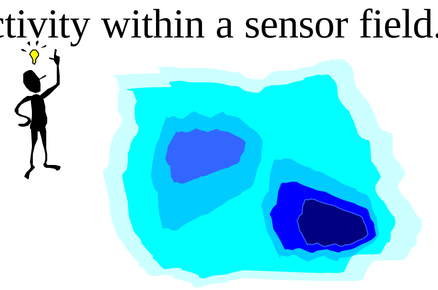
Yonggang "Jerry" Zhao (USC/ISI), Ramesh Govindan (USC/ISI)
And Deborah Estrin (UCLA)

Goal

SNT scans provide continuous updates of overall sensor network state after deployed in unpredictable environment for …



Analogous to weather maps or radar images, a scan depicts resource availability or sensing activity within a sensor field.



Early Warning of System Failure

Discover those regions that may fail because of resource depletion.

Incremental Deployment

Provide guidance to selectively place additional sensors to "weakest regions" or "hot spots" to improve performance.

Functionality Validation

Evaluate overall response of the sensors to known stimulus or fine-tune detection algorithms.

Challenges

Compared to instrumentation of other distributed systems such as the Internet, continuously monitoring a wireless sensor network poses different challenges …

Low User-to-Device Ratio

The sheer number of sensors makes it infeasible to centrally collect detailed state from individual sensor nodes.

Highly Distributed Data Processing

Knowledge of overall state over a region is more useful than of the individual node states.

Limited Energy Resource

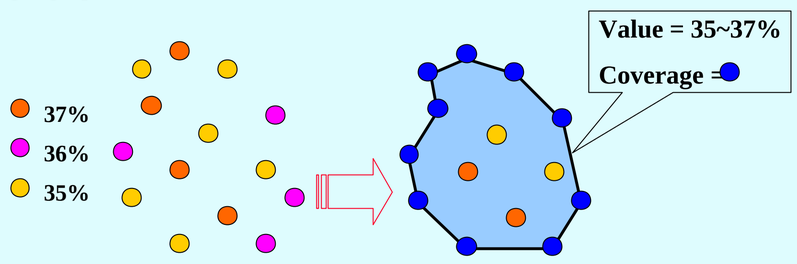
High cost of communication requires carefully design to collect monitoring data.

Our Approach

Abstracted Representation

Instead of extracting individual node state, SNT scans represent abstracted view of particular network characteristics.

Example: A Residual Energy Scan consists of value range and a polygon with geographic locations of outline nodes.



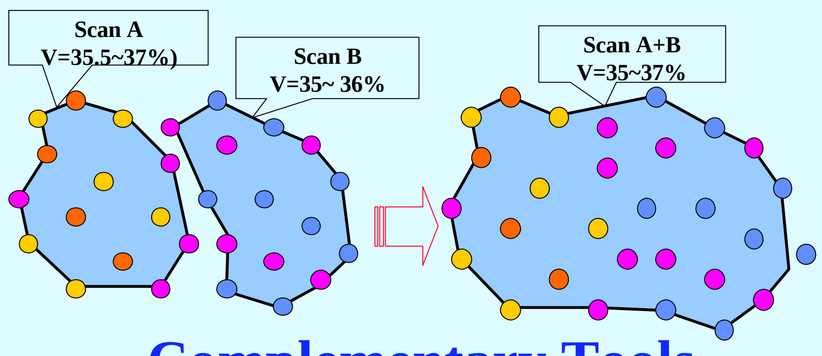
Incremental Update

When scan changes, only the changed part need to be reported as an update, and it may be dropped if the change is within the error introduced by aggregation.

In-network Aggregation

Scans are constructed by aggregating small ones when being delivered within the network. Details are discarded to compensate local processing cost by saving communication cost.

Example: Conditions for aggregating two residual energy scans: *Values are similar* and *Coverages are adjacent*. Errors are introduced by aggregation.



Complementary Tools

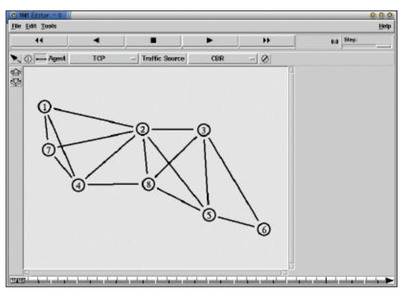
Detailed network states of a particular region can also be extracted once the user identify suspicious problems.

Preliminary Results and Future Work

Link Scan

Display connectivity between sensor network testbed nodes

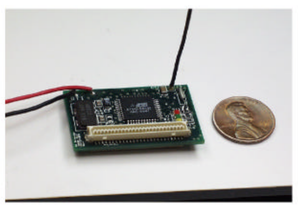
✍ Very helpful to set up preferred network topology to debug/demonstrate different wireless routing protocols.



Implementation on Testbed

PC/104 based wireless nodes with Radiometrix transceiver (On-going)
Linux 2.2 + DirectedDiffusion-3

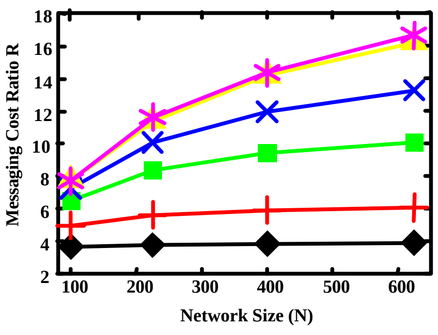
UCB mote hardware with RFM radio transceiver (Future)
Tiny-OS + Tiny-diffusion



Residual Energy Scan

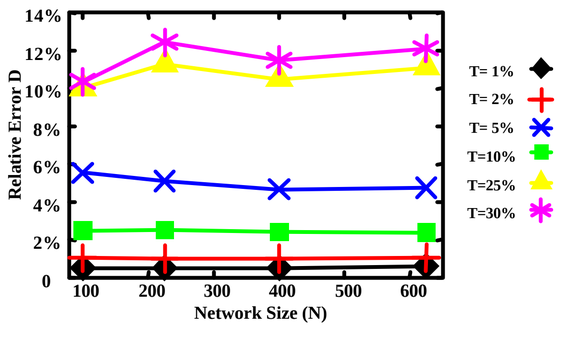
Depict overall distribution of the remaining energy levels of sensor nodes.

✍ Compared to extracting energy levels from individual nodes,



Constructing residual energy scans by aggregation and incremental update shows better scalability and energy-efficiency characteristics.

The error introduced by aggregation is acceptable.



Future Work

✍ Continue to explore design space
- ✍ Alternative Representation and Aggregation Schemes
- ✍ Study the robustness of our design to network dynamics

✍ Another type of scan: Outlier Scans
- ✍ To Depict Abnormal Behaviors within the Network
- ✍ Challenge: Compute the cut-off values to identify outliers

✍ Implementation
- ✍ Provide tools for other researchers