An Energy-Efficient Fault-Tolerant Monitoring System for Wireless Sensor Networks

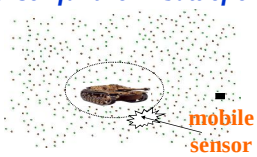
Changlei Liu, Guohong Cao

PENNSTATE 1855

Because sensors are often deployed in *harsh* or *adversarial* environments, the sensors or the communication links may fail and hence endanger the mission of the sensor network.

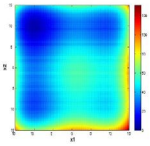
Sensor status (such as *liveness, density estimation, residue energy*, etc.) has to be closely monitored and made known to the sink, which can take prompt reactions

Sensor failure in battlefield



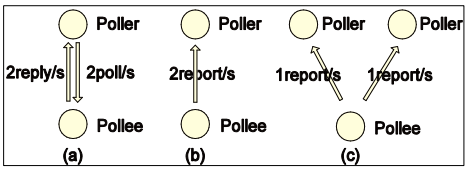
Fire disaster

Energy contour map



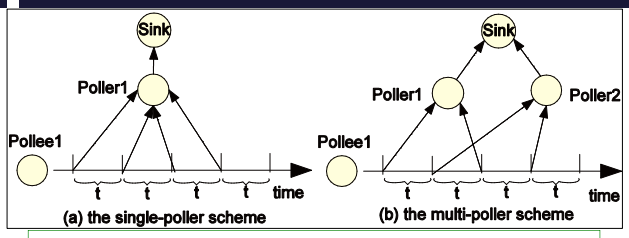
Redeploy sensors

Revisit Poller-Pollee Structure



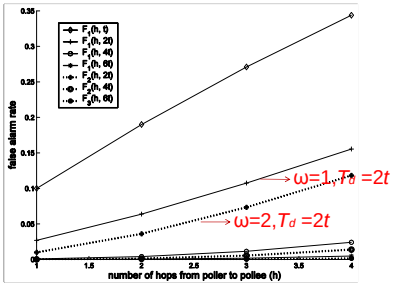
- *Basic structure*: single poller, widely used in IP networks
- *Extended structure*: multi-poller, proposed for error prone wireless links
- *Two-tiered architecture*: pollees at the lower tier periodically send status reports to the pollers at the higher tier, which aggregate and forward the collected status reports to the sink

Round Robin Multi-Poller Scheme



- *Single poller scheme*: each pollee sends a status report to the same poller every t
- *Multi-poller scheme*: each pollee sends a status report to each of its ω pollers every ωt
- *In both schemes*, the sink evaluates the failure condition every T_d, where $\omega t \le T_d$, and hence has the same bandwidth requirement

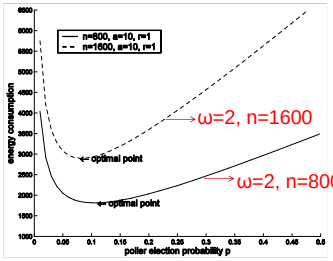
Analysis of False Alarm Rate



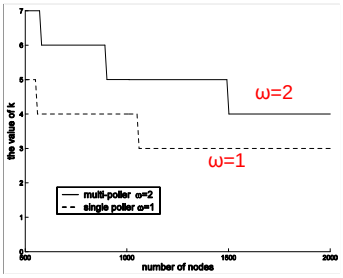
Comparison of single poller and multi-poller scheme

- The link failure is transient, modeled as a continuous-time markov chain
- The left figure shows the multi-poller scheme can reduce false alarm rate by 30%~70%

A Randomized Algorithm



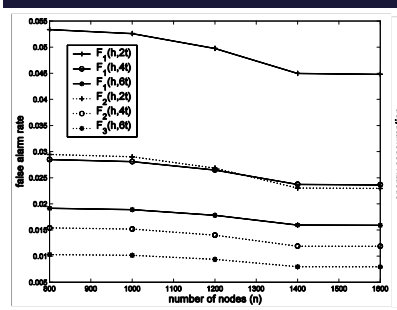
Energy Vs. poller election probability p



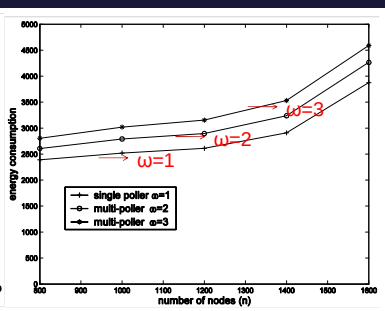
The value of k-hop for obtaining ω pollers

- Each node elects itself with a probability p, and broadcasts k-hop wide
- Each pollee selects ω pollers within k-hop
- We assume n sensors are uniformly distributed and derive the optimal p value based on existing geometrical result

Simulations



Comparison of false alarm rate



Comparison of energy consumption

- The left figures shows the multi-poller scheme reduces false alarm rate by about 50%, compared with the single poller scheme
- The right figures shows the improvement of false alarms in multi-poller scheme is at the cost of around 7% increase in energy

This work was supported in part by National Science Foundation (CNS-0519460)