Node Mobility for Mission-oriented Sensor Networks

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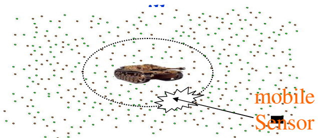
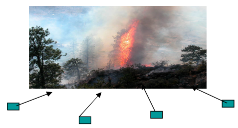
Background & Motivations

Mobility can significantly increase the capability of the sensor network by making it ***resilient to failures***, ***reactive to events***, and able to ***support disparate missions*** with a common set of sensors.

Sensor failure in target



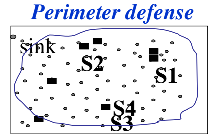
Fire detection



Sensors move to aggregate

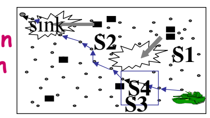
Multiple missions, each with different requirements, may share common sensors to achieve their goals.

Perimeter defense



Mission switch

Target tracking



To have adequate sensors along the perimeter

To have enough sensors along the track of the target

Framework

A *mobility assisted* Framework

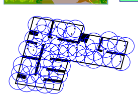
Integrated mobility for sensing& routing	
Mobility assisted sensing	**Mobility assisted routing**
Sensor network monitoring	

Mobility in sensor network is *controllable*, different from ad hoc networks

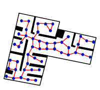
Mobility assisted sensing

Motivations for sensor relocation

- React to sensor failure
- React to events (e.g., fire, chemical spill, incoming target): more sensors move to achieve a better coverage



Coverage



Connectivity

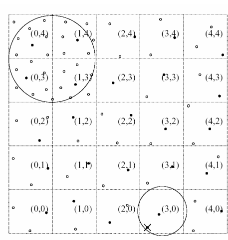
After initial random sensor deployment, mobile sensors may relocate to satisfy both coverage and connectivity requirements

Challenges of sensor relocation:

- It has strict time, power constraint
- Relocation should not affect other missions

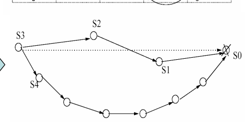
Part I: finding the redundant sensors:

- Similar to the publisher/subscriber problem
- Flooding has too much overhead
- Using a grid concept combined wit quorums to reduce the search overhead



Part II: relocating redundant sensors:

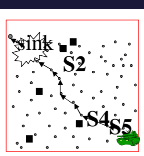
- Directly moving the sensor to the destination suffers from long delay and unbalance power consumption
- use cascaded movement

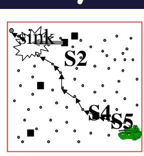


S3->S2, S2->S1, S1->S0. All movements occur at almost the same time

Mobility assisted routing

Motivations





Move to heal the broken path
Move to increase the capacity
Move to save the power

Objective

Work in progress

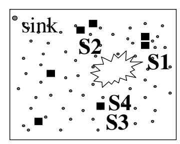
- propose a distributed motion decision framework for the relay nodes based on simulated annealing
- find the node positions to minimize the total required transmission power for all the active flows in the network

Sensor network monitoring

Purpose: continuously monitor sensors' status (i.e., aliveness, battery state, etc.) and quickly detect coverage hole

Coverage hole detection:

- Use theoretical geographical techniques, e.g., Voronoi diagram, K-coverage
- Require information about both sensor status and mission requirement

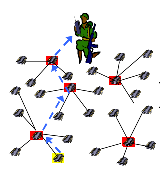


Mission oriented: satisfy the coverage requirement of perimeter defense, but present a coverage hole for target tracking

Previous work on sensor status monitoring

- **Centralized approach:** sensor status is aggregated and sent to a base station
- **Distributed method:** each node is monitored by its one-hop neighbors. It only detects the isolated failure pattern
- **Based on network topology continuously learned:** large overhead for sensor networks

Our solutions: a distributed poller-pollee structure



- The sensors are organized into *clusters*, with cluster head to be the *poller* and cluster members to be the *pollees*
- Our objective is to minimize the number of pollers subject to the constraint of bandwidth allocated to the monitoring purpose

Co-Design of monitoring and coverage hole detection

- **Coverage hole estimation** is executed by the sink whenever the mission requirement is changed
- **The sensor monitoring** is executed continuously, but should dynamically adapt to the mission within the area of interest

Prototyping

UC Berkeley: COTS Dust
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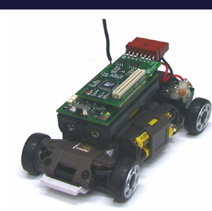
UC Berkeley: Smart Dust
UCLA: WINS
Rockwell: WINS
JPL: Sensor Webs



- Currently evaluate with *ns*.
- Considering prototype with commercial off-the-shelf component. Each -- robot is small (5" x 2.5" x 3") and costs under $200 each
- Mobility, built from remote-controlled toy cars.
- Runs TinyOS, based on Berkeley Mica Motes, has processor and wireless communication.

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