Communication Support for NASA Enterprises: Sensor Management and Routing for Sensor Networks

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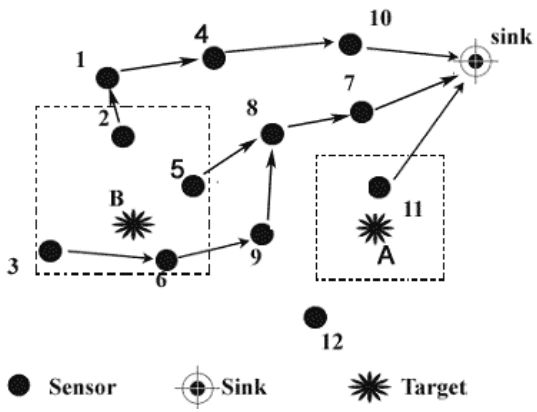


A Sample Target-tracking Wireless sensor Network (WSN)

Motivation

- Wireless sensor networks often feature high node density and redundancy.
- High redundancy can lead to excessive flow of redundant data in network resulting in waste of precious bandwidth and energy.
- Redundancy can be exploited to prolong network longevity.
- All are particularly important in challenging environments such as planetary exploration.

Achievements

- Developed two decentralized lightweight senor activation protocols (SAPs) which activate sensors based on local network redundancy information while trying to meet the application's quality of service requirements.
- Proposed a new set of link metrics which can directly incorporate network redundancy information into route selection.

Probability-based SAP

- Sensors activate themselves with certain probability such that expected value of number of active sensors equals to the number required by the application.
- **Pros**: simple implementation, fully decentralized; no communication overhead.
- **Cons**: no guarantee that enough number of sensors will be active, measured by **probability of undercoverage** (P^{uc}) which is defined as the probability that number of active sensors are fewer than required.

Declaration-based SAP

- Nodes activates itself by broadcasting an Activation Control Message (ACM) after a random delay.
- Only the first S nodes which successfully transmitted their ACMs will be activated.
- **Pros**: low P^{uc} with proper parameter values.
- **Cons**: Introduce communication overhead

Redundancy-Aware Routing

Link metric:

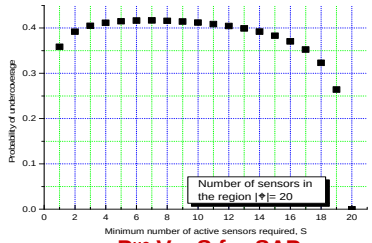
$$C_{ij}(t) = [1 + SI_i(t)]^a \left[\frac{E_i(0)}{E_i(t)}\right]^b [e_{rx} + e_{tx}(i,j)]^g$$

Notations:

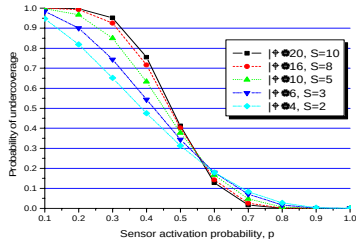
S: Number of active nodes required by the application

N: Number of nodes available in the region

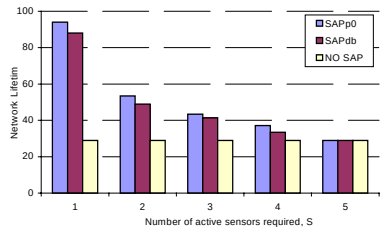
Degree of Redundancy: DoR=N/S; Strategic-Importance: SI=1/DoR



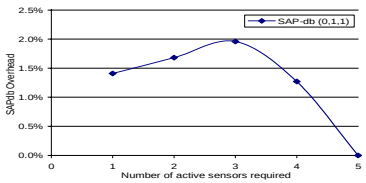
P^{uc} Vs. S for SAP-p



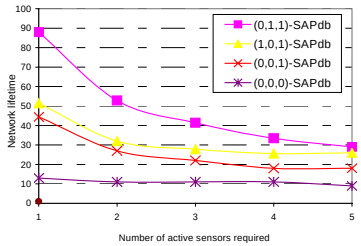
P^{uc} Vs. activation probability for SAP-p



Network lifetime using different SAPs



Control overhead for SAP-db



Network lifetime using different link metric