Predictive Scheduling for Spatial-dependent Tasks in Wireless Sensor Networks

Hua Huang, Shan Lin, Anwar Mamat and Jie Wu
Department of Computer and Information Sciences, Temple University

Introduction

Sensor networks are deployed for various military surveillance, scientific exploration , and first responder applications .

To sustain long-term system operations, a **mobile charger (MC)** will travel to recharge the sensor network.

Problem: How to schedule the MC to achieve high **coverage ratio**?

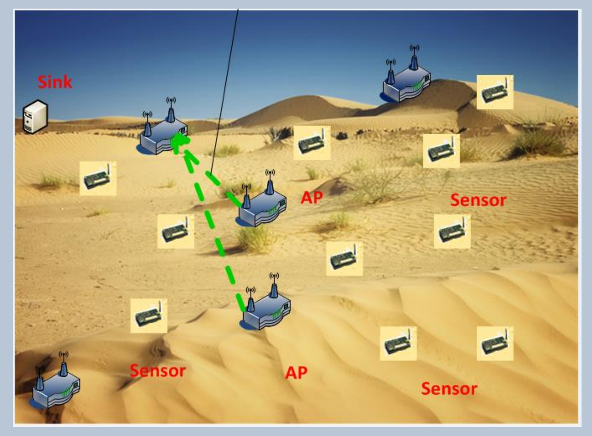


Fig 1 Scientific Exploration

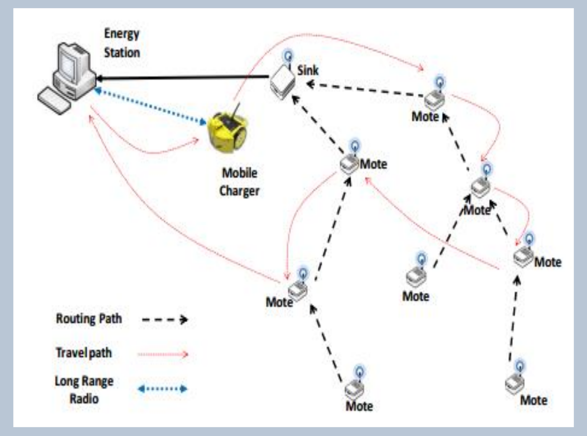


Fig 2 Mobile Charger

Shortest Path Scheduler

Use the solution to Traveling Salesman Problem (TSP).

Generate a route that traverses the whole network with minimum travelling distance.

Works well when the energy consumption rates are **evenly distributed**.

In fig. 3(a), TSP achieves only 82.15%. Because it spends too much time on nodes with low energy consumption.

100% of coverage in fig. 3(b).

Maximum Response Ratio Scheduler

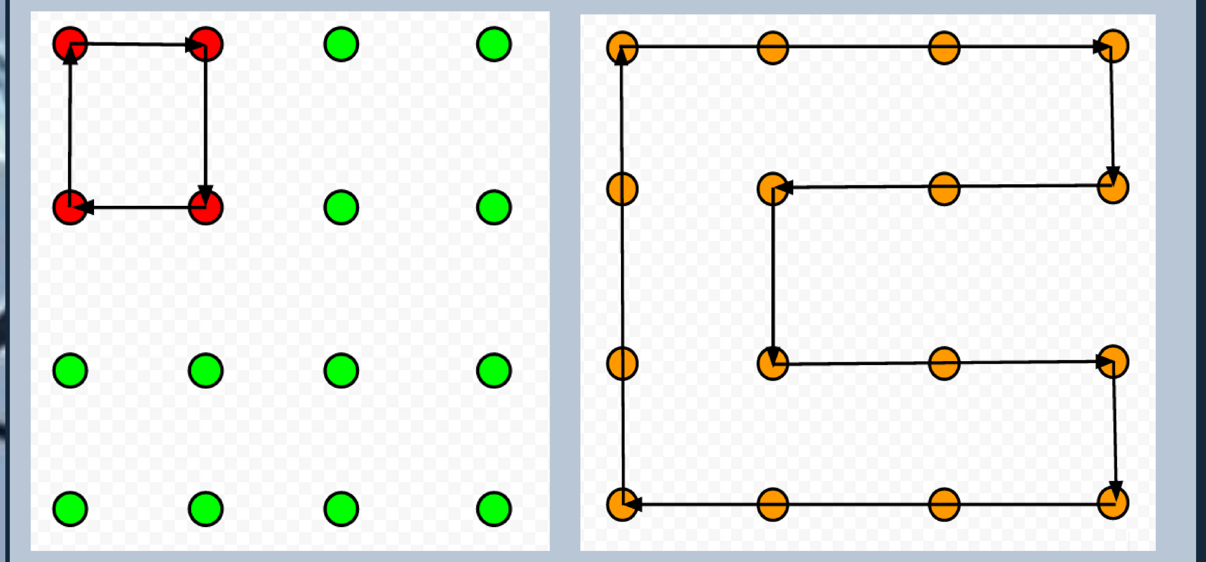
Use Maximum Response Ratio (MRF) First scheduling algorithm to eliminate long starvation of nodes.

Defined a node's priority as follows,

$$Priority = \frac{t_i \times r_i}{p_i} \quad (1)$$

where t_i is waiting time of node i, r_i represents energy consumption rate, and p_i denotes the traveling time.

Works well when all energy consuming nodes are **clustered**.



(a) (b)

Fig 3 two scenarios that can be solved

In fig. 3(b), MRF achieves only 80% of coverage. Because its travelling route is not efficient.

100% of coverage in fig. 3(b).

But sometimes both TSP and MRF will fail.

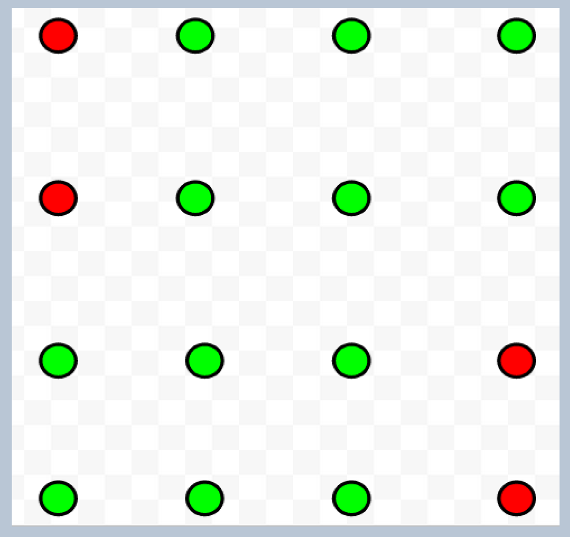


Fig 4 a challenging scenario

Insights

MRF works well when high energy consuming nodes are clustered.

TSP works well when high energy consuming nodes distribute evenly.

This can be measured by the spatial energy consumption rate density.

Predictive Model

Nodes have **spatial dependencies**.

- *Nodes near MC's path*: More beneficial to recharge node C, D before B.

Spatial Laxity Filling (SLF): Recharge nodes near path if the laxity of target node is large enough.

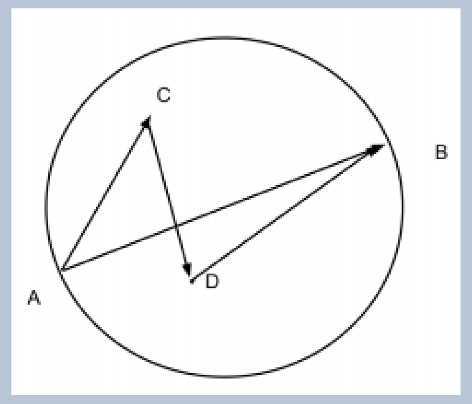


Fig 5 nodes near path

- *Node clusters:* More beneficial to recharge the node cluster on the right first, even if node B has close due time.

Spatial Laxity Clustering (SLC): Divide the network into 9 clusters. Select clusters based on their average response ratio.

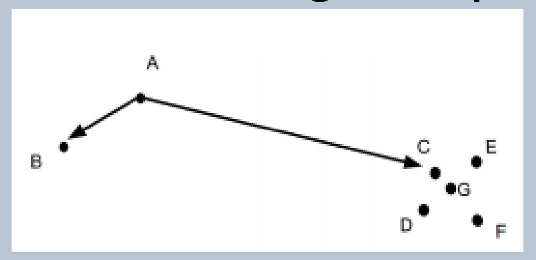


Fig 6 node cluster

Evaluation

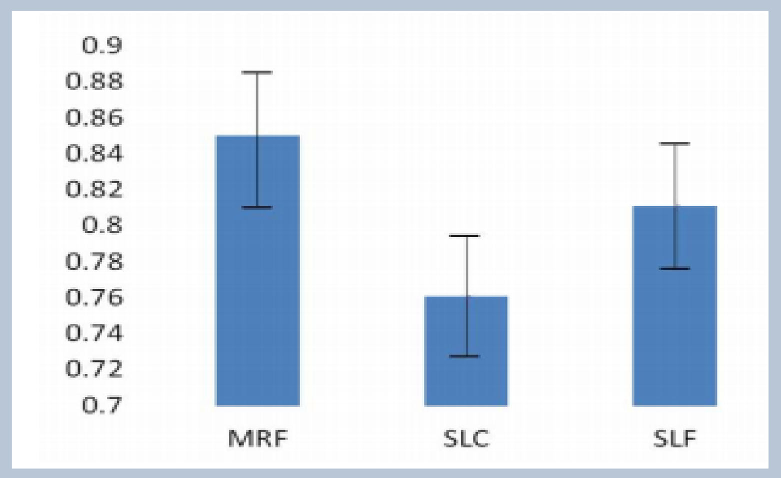


Fig 7 Coverage Ratio

MRF: 85% of coverage ratio.

Have good trade-off between travelling time and node due time.

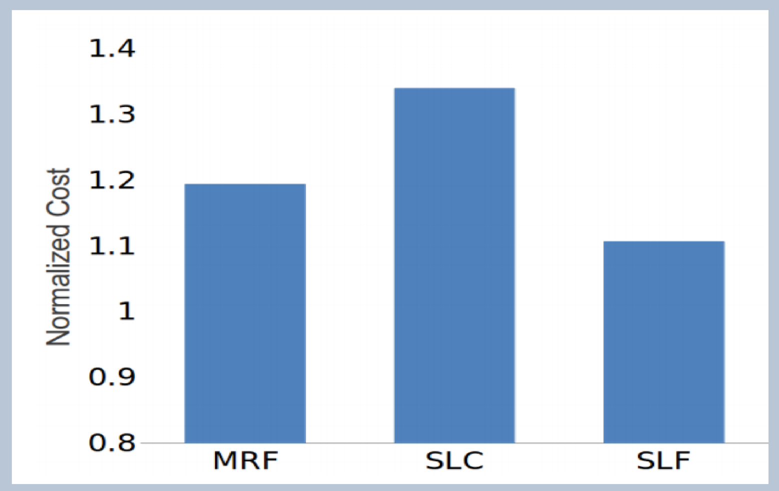


Fig 8 Normalized Travelling Cost

SLF: travelling cost 10% smaller than MRF.

Reduce travelling cost by recharging nodes near path.

Reference

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