

# Distributed Path Planning for Robots in Dynamic Environments Using a Pervasive Embedded Network

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## Introduction

We investigate the application of a low-cost, pervasively distributed network to plan paths for mobile robots in environments with dynamic obstacles. We consider a heterogeneous system composed of small, embedded, immobile, possibly sensor-less, communication nodes and larger mobile robots equipped with sensors and manipulators.

The embedded network serves as a pervasive communication and computation fabric, while the mobile robots provide sensing and actuation. The network is responsible for planning paths for the mobile robots even though paths are being created and destroyed dynamically. The embedded network provides nearly optimal path planning without the network nodes or the robots having global knowledge or localization capabilities.

## Approach

### Assumptions for Embedded Nodes

- Embedded nodes have limited computation and memory
- Short range communication
- Communication paths are similar to navigation paths

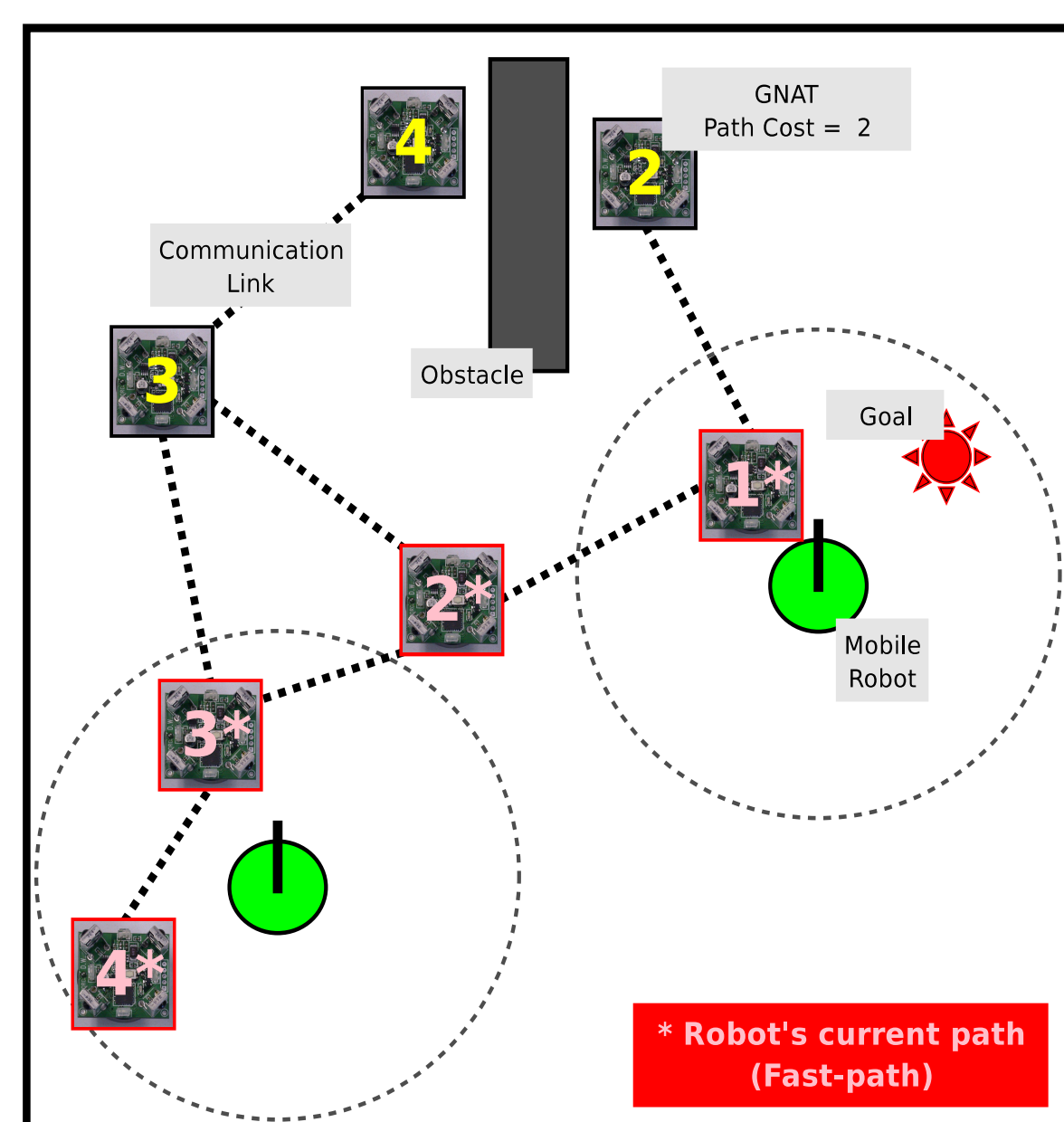
### Assumptions for Mobile Robots

- Robots can communicate with embedded nodes
- Relative bearing estimation to nearby embedded nodes
- Local obstacle and attractor sensing

### Distributed Path Planning

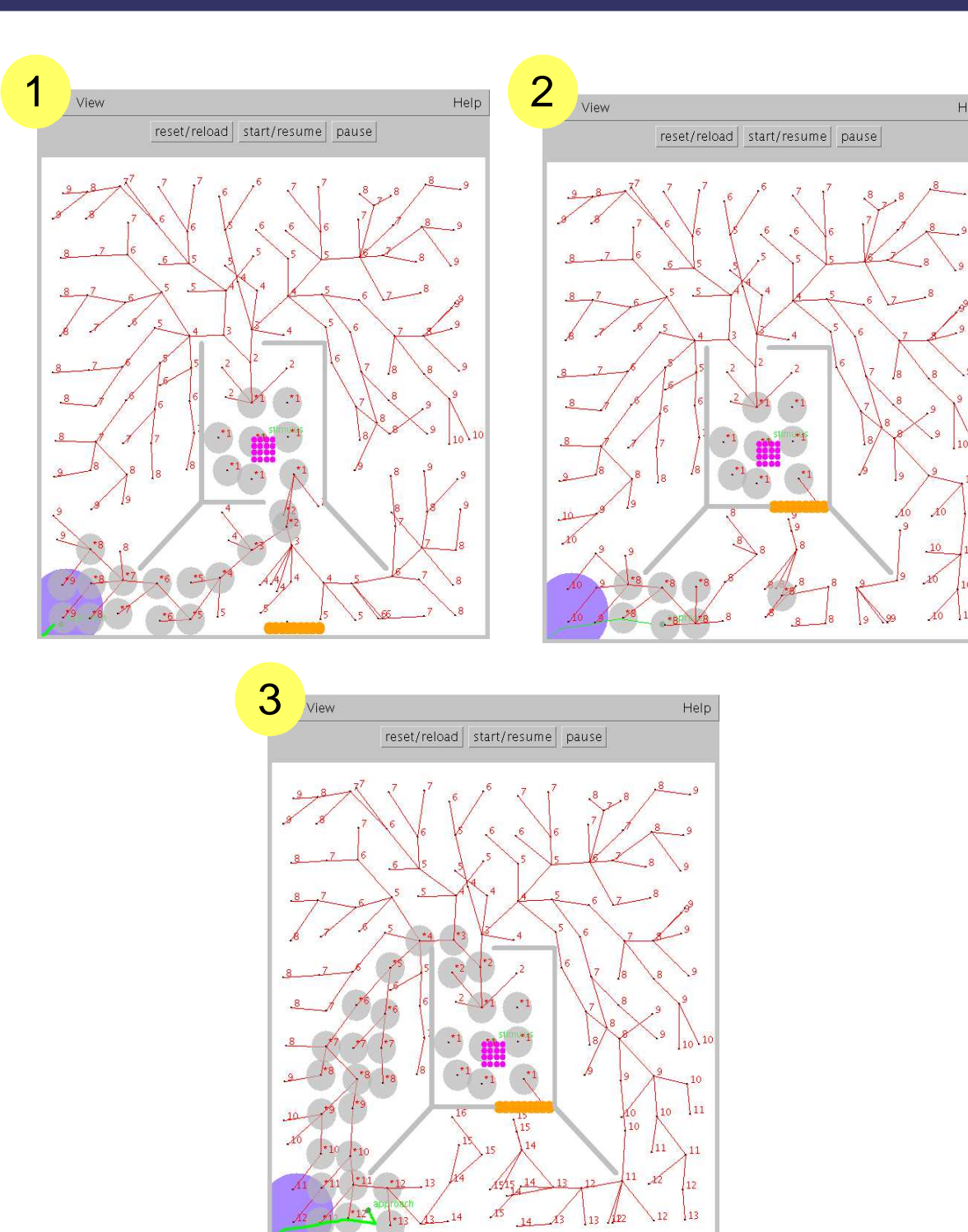
- Distributed Bellman-Ford Algorithm
- Embedded nodes share path-costs
- Embedded nodes monitor neighbors
- The robots' current path(s) are monitored more often to detect changes in environment

## A Navigation Network

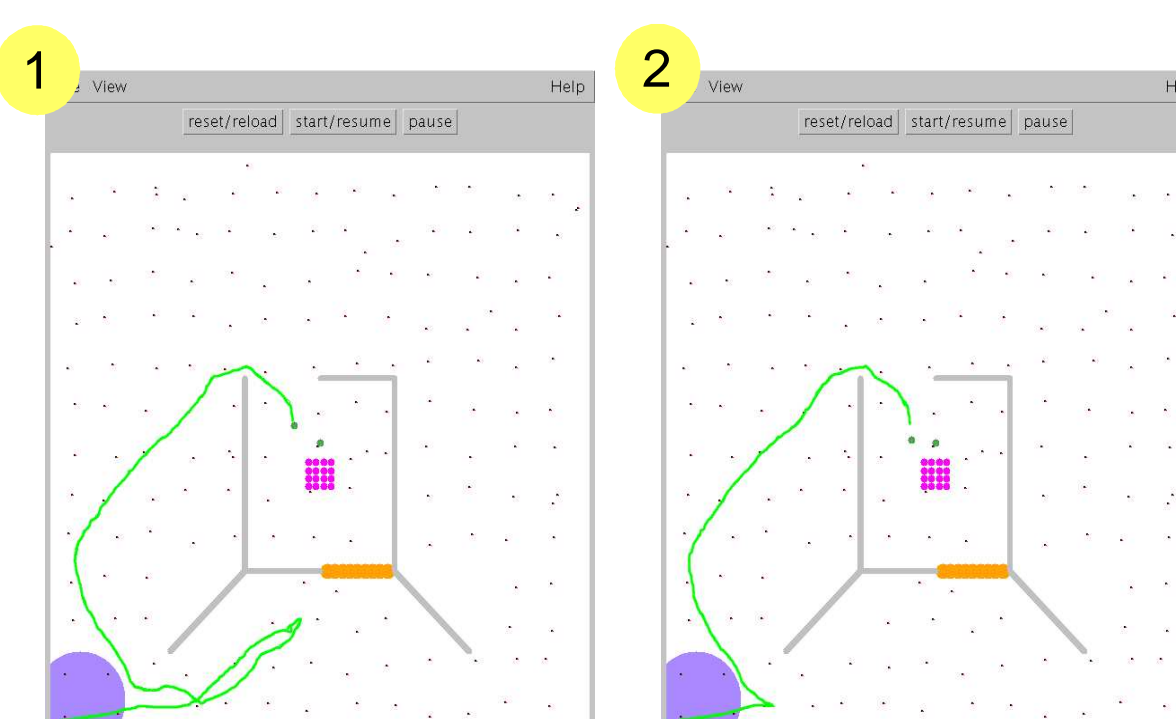


An illustration of the distributed path planning

## Simulation



- Pink - goal location
- Green - robots
- Gray - robot's current path
- Lines between nodes - parent-child relationship
- Numbers - path costs
- (1) the initial plan
- (2) the path becomes blocked
- (3) the final plan

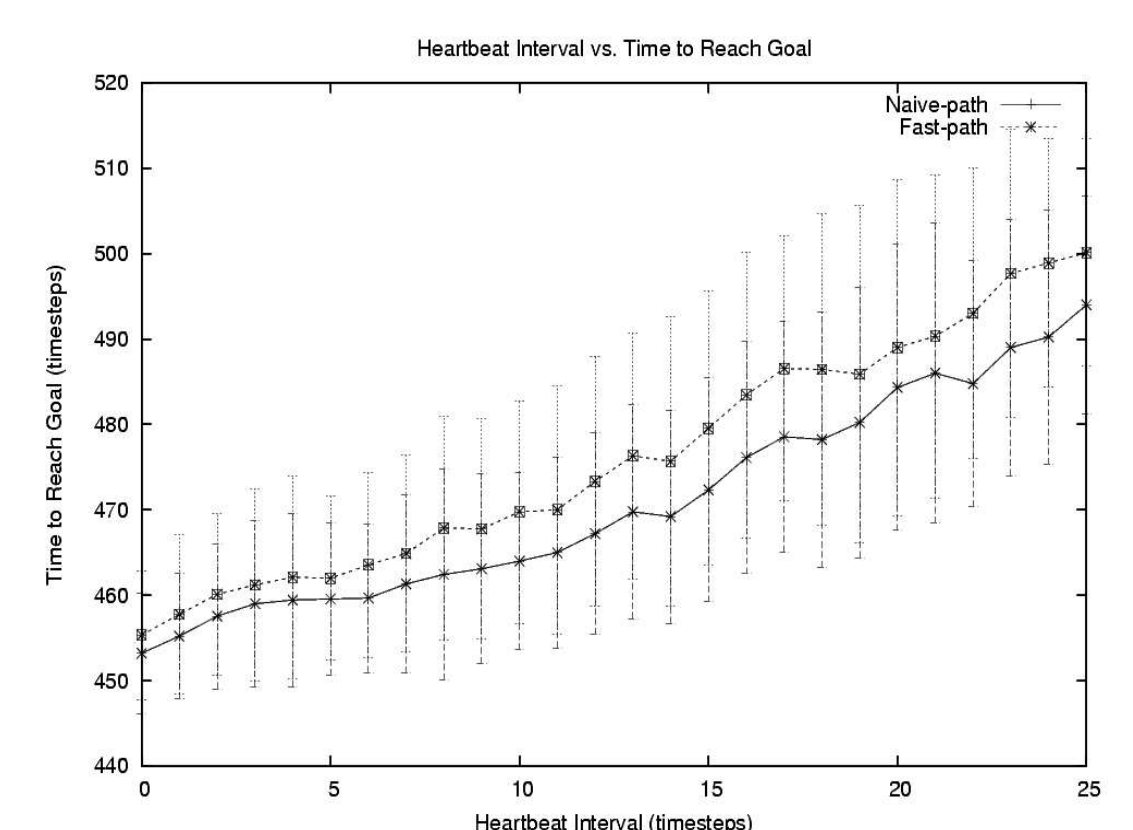
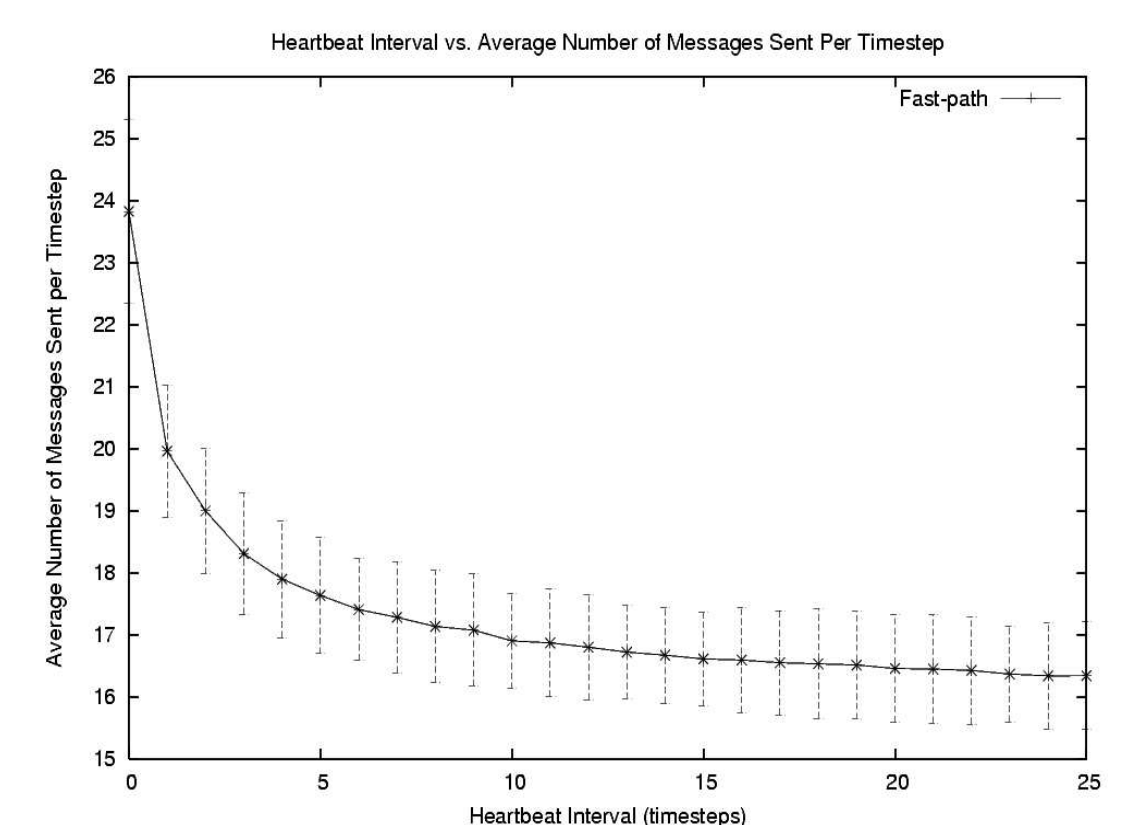
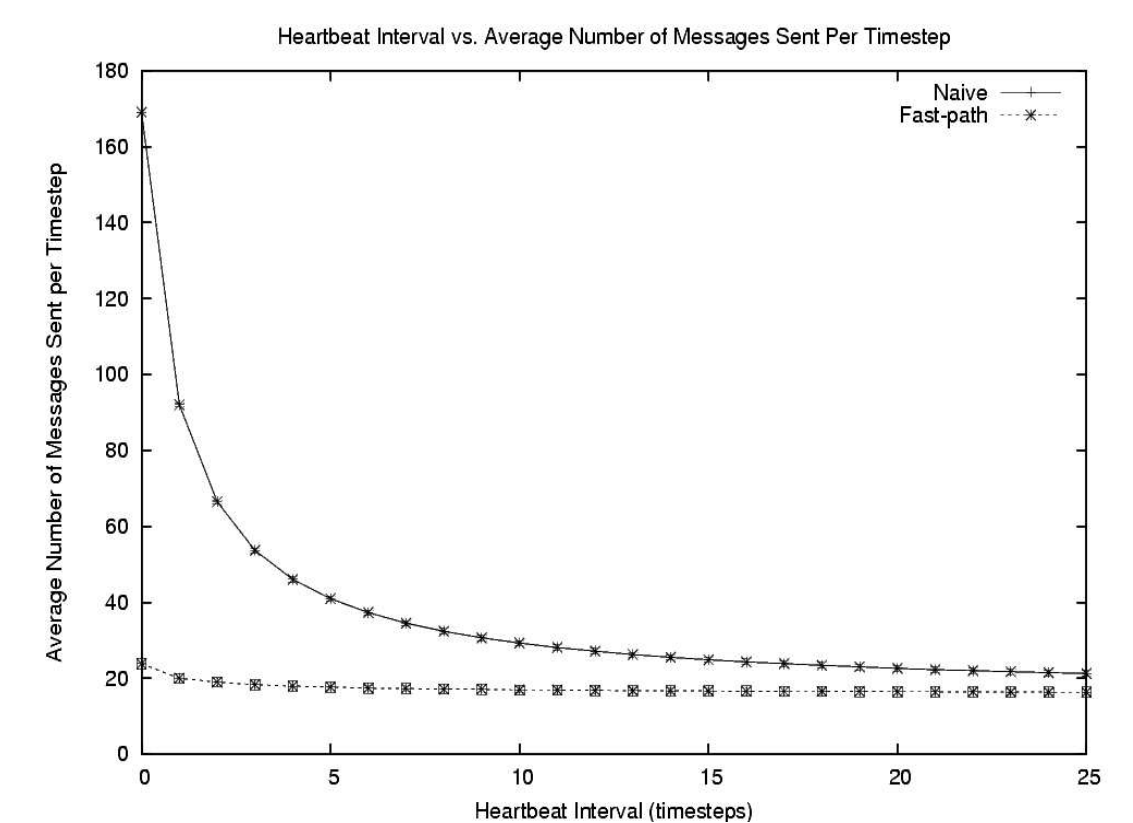


Reconfiguring after environmental changes.

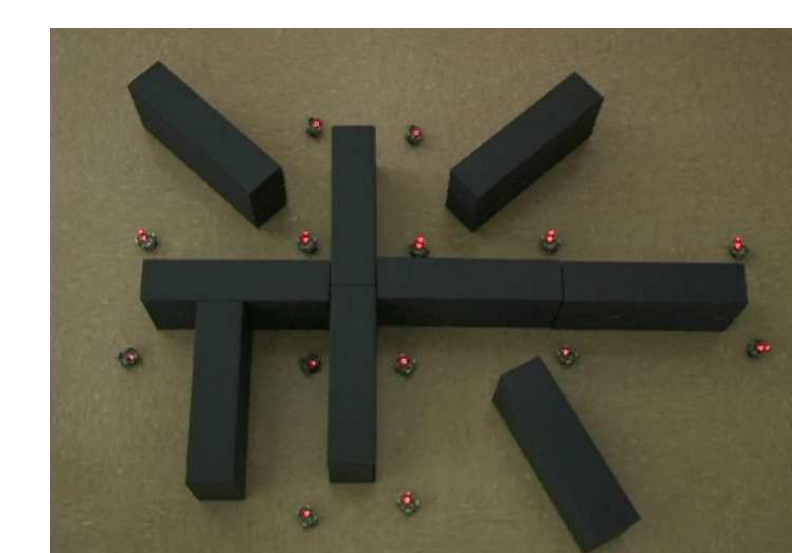
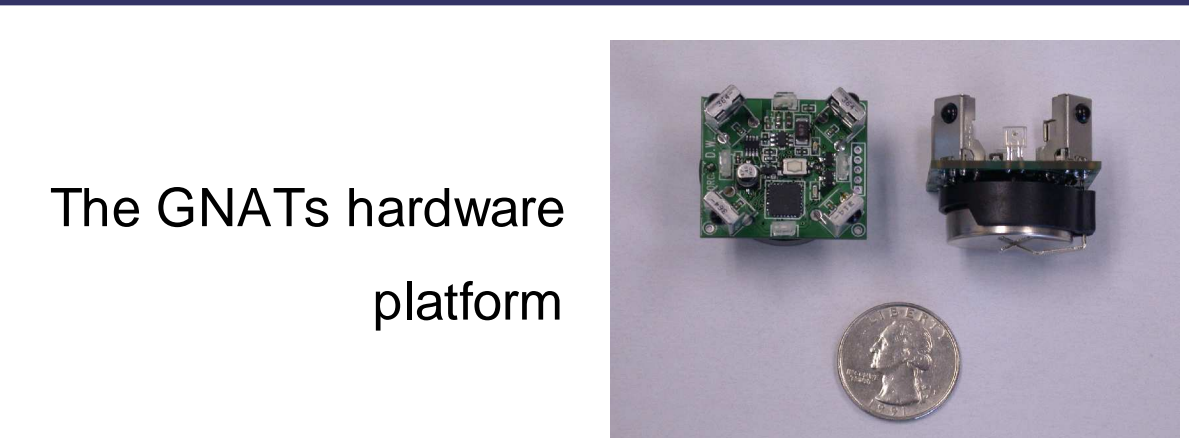
Monitoring neighbors using:

- (1) a slow heartbeat
- (2) a fast heartbeat

## Experimental Results



## Future Work



- Currently evaluating technique on real hardware
- Use real robot navigation experiences to reinforce paths
- Use network for supporting other mobile robot tasks
- Investigate power-aware techniques