GLIDER: Gradient Landmark-Based Distributed Routing for Sensor Networks

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Outline

• Geographic routing for sensor networks
• The concept of GLIDER
• The virtual coordinate
• Naming and routing protocol
• Simulation
• Summary
• Issues
Geographic Routing in Sensornet

- Real geographic coordinates based
  - Only works in 2-D space
  - Sensitive to location inaccuracy and obstacles
  - Accurate coordinates are difficult and expensive to obtain

- Virtual coordinates based
  - Requires global embedding of the link connectivity graph in the plane
GLIDER – the Basics

- A communication graph $G = (V, E)$ on sensor nodes $V$, with path length measured by shortest path hop counts

- Landmark Voronoi cell (LVC)

- Combinatorial Delaunay Triangulation (CDT) – estimate global topology
The concept of GLIDER

The combinatorial Delaunay triangulation

Each sensor has:
1. the unique ID
2. the name: “the ID of the Voronoi cell” and “the virtual coordinate in it”.
The virtual coordinate

• Continuous version

• Discrete version
Continuous version

\[ A(p) = (|p - u_1|, |p - u_2|, \ldots, |p - u_k|) \]

\[ d(p, q) = |A(p) - A(q)|^2 = \sum_{i=1}^{k} (|p - u_i| - |q - u_i|)^2 \]
Continuous version

\[ B(p) = (|p - u_1|^2, |p - u_2|^2, \ldots, |p - u_k|^2) \]
Continuous version

\[ [C(p)]_i = [B(p)]_i - \bar{B}(p) \]

\[ B(p) = (|p - u_1|^2, |p - u_2|^2, \ldots, |p - u_k|^2) \]

\[ \bar{B}(p) \text{ : the mean of the entries of } B(p) \]
Local Coordinates and Greedy Routing

\[ \sigma = \text{mean}(pL_1^2, ..., pL_k^2) \]
\[ c(p) = (pL_1^2 - \sigma, ..., pL_k^2 - \sigma) \]
\[ d(p, q) = |c(p) - c(q)|^2 \]

Greedy strategy: to reach q, gradient descent on the function d(p, q)
Naming protocol

• Construct LVC
• Compute the routing table on the graph of CDT
• assign to each node its local landmark distance coordinate with respect to its reference landmarks
Routing protocol

- Intra-tile routing:
  use the greedy routing algorithm

- Inter-tile routing
Node Density vs. Success Rate of Greedy Routing

2000 nodes distributed on a perturbed grid.

Perturbation $\sim\text{Gaussian}(0, 0.5r)$, where $r$ is the radio range

<table>
<thead>
<tr>
<th>average number of neighbors</th>
<th>2.9</th>
<th>3.2</th>
<th>4.1</th>
<th>$\geq 5.3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>percentage of success</td>
<td>20</td>
<td>70</td>
<td>95</td>
<td>100</td>
</tr>
</tbody>
</table>
Simulations-Load Balancing and Path Length

GLIDER 41 hops

GPSR 53 hops
Simulations-Hot Spots Comparison

(i) total 45 transit paths

(ii) Khaki: 6-8 transit paths
Orange: 9-11 transit paths
Black: >=12 transit paths
Simulation

• For the 45 routes, the average path length generated by GPSR is 40.08.

• The average path length generated by VLIDER is 40.46.
GLIDER-Summary

• makes no attempt to provide a global geometric embedding.

• A topology-enabled naming and routing scheme that based purely on link connectivity information.

• Works by separating the global topology and the local connectivity
  -use topological information to build a routing infrastructure
  -Propose a new coordinate system for a node based on its hop distance to a subset of landmarks

• Advantages
  -location-free
  -routing is efficient
  -takes only connectivity graph as input
  -can be used indoor
some issues

• Criteria and algorithm for landmark selection

• Possible distributed methods for handling network dynamics