GLIDER:
Gradient Landmark-Based Distributed Routing for Sensor Networks

INFOCOM 2005

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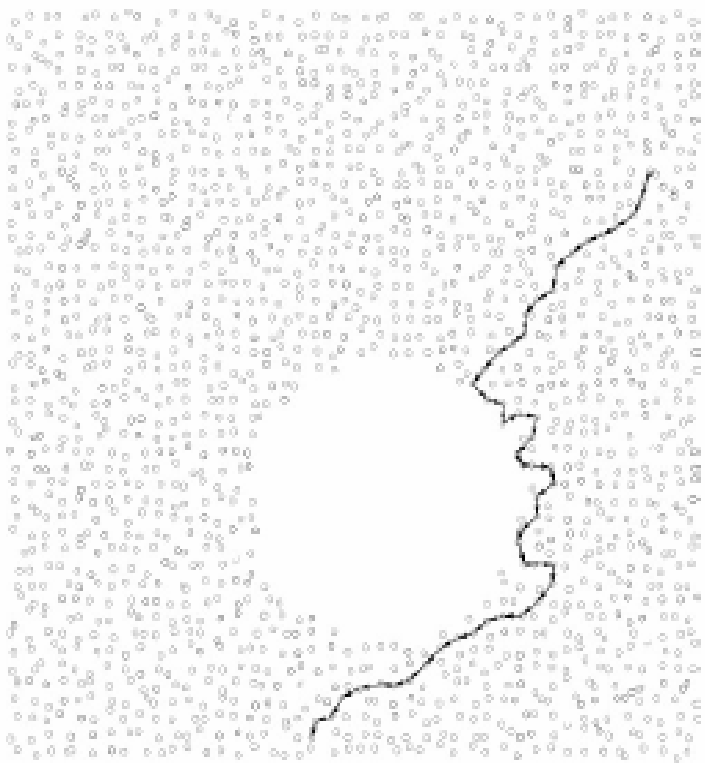
Outline

- Geographic routing for sensor networks
- The concept of GLIDER
- The virtual coordinate
- Naming and routing protocol
- Simulation
- Summary
- Issues

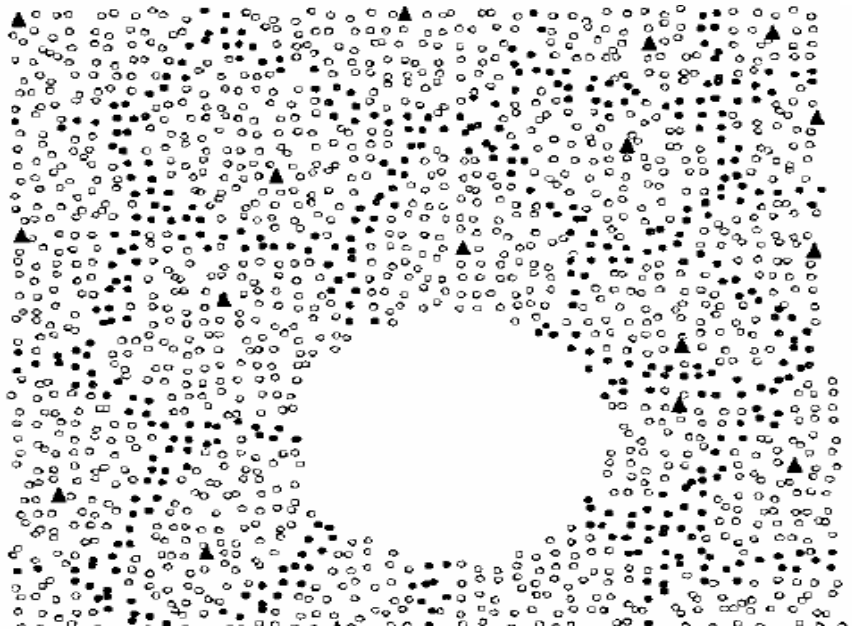
Geographic Routing in Sensornet

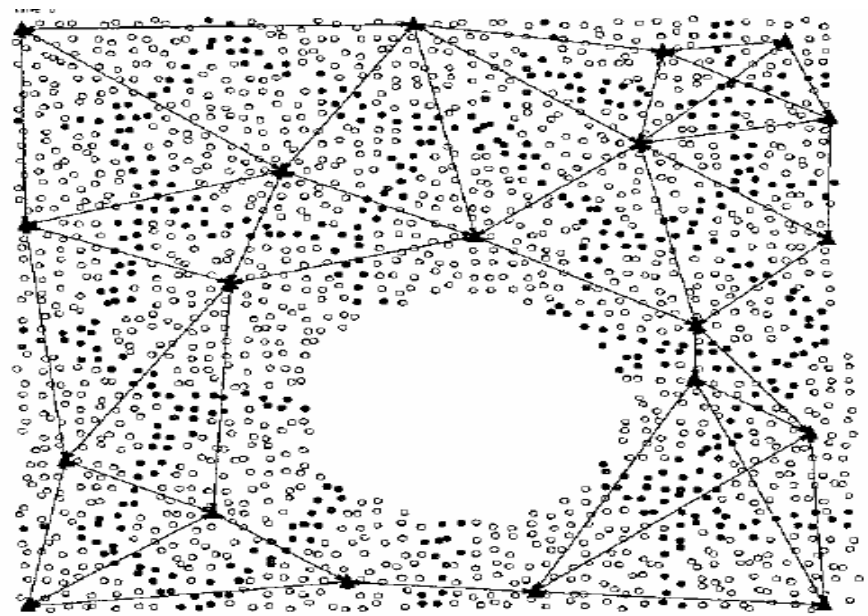


- Real geographic coordinates based
  - Only works in 2-D space
  - Sensitive to location inaccuracy and obstacles
  - Accurate coordinates are difficult and expensive to obtain
- Virtual coordinates based
  - Requires global embedding of the link connectivity graph in the plane

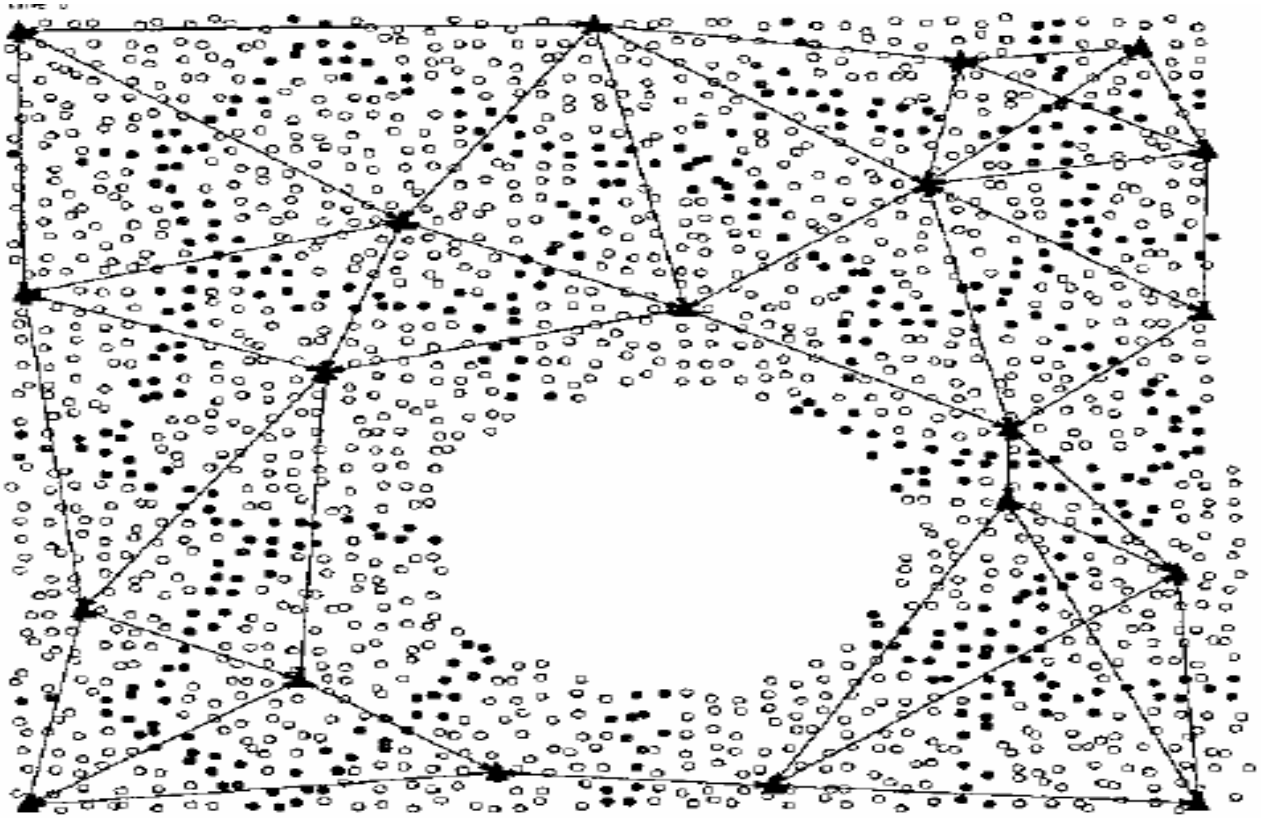
GLIDER – the Basics

- 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” .

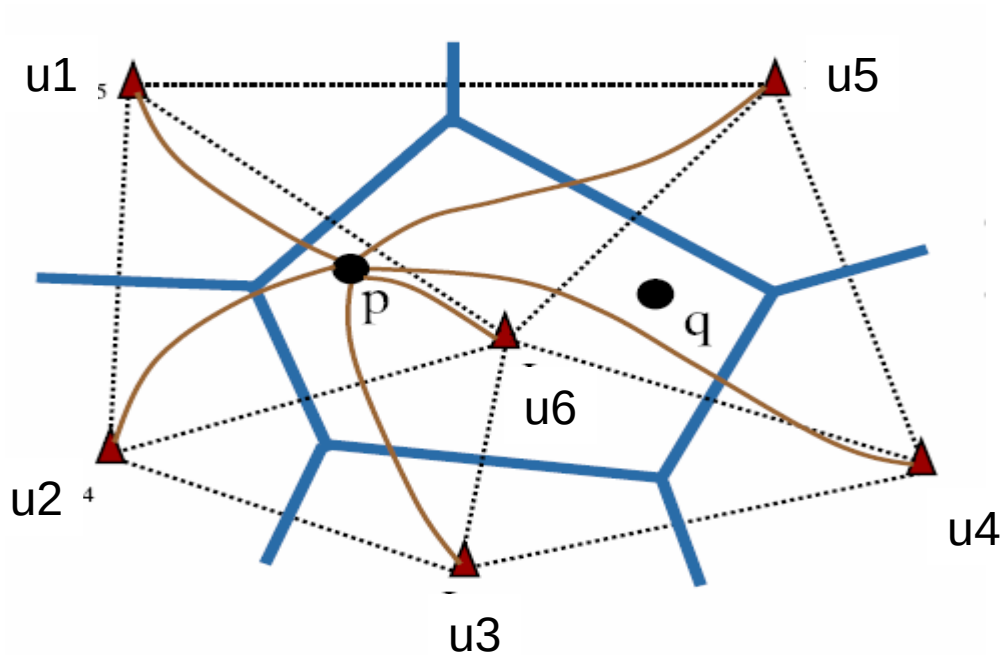
The virtual coordinate

- Continuous version
- Discrete version

Continuous version

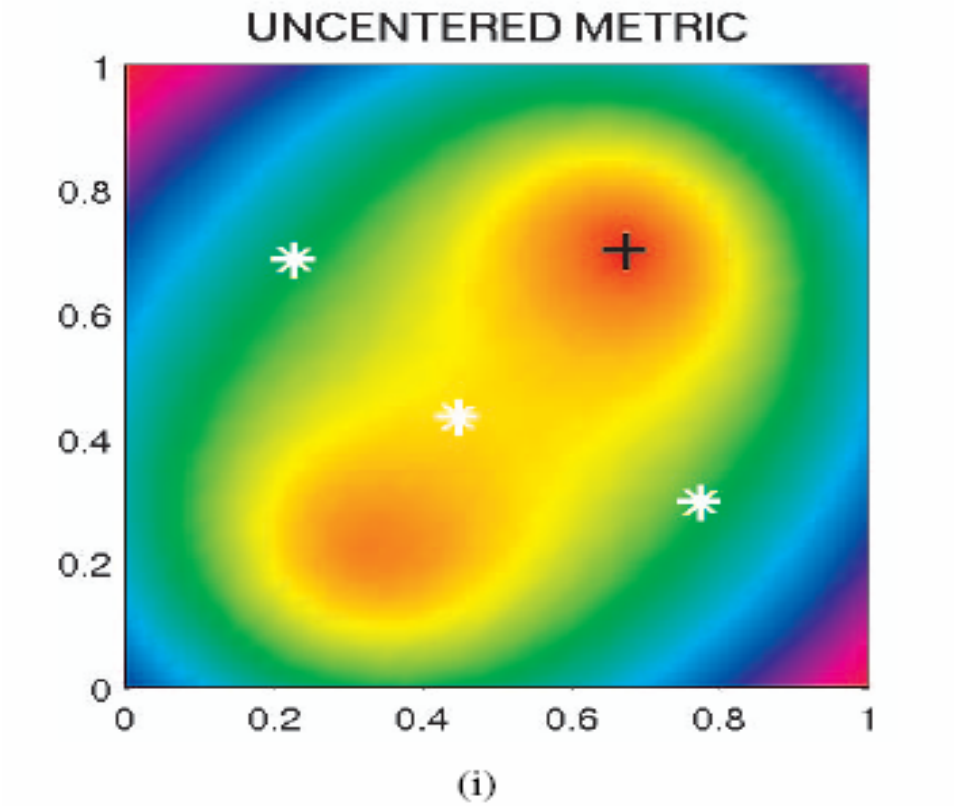
$$A(p) = (|p - u_1|, |p - u_2|, \ldots, |p - u_k|)$$

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



Continuous version

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

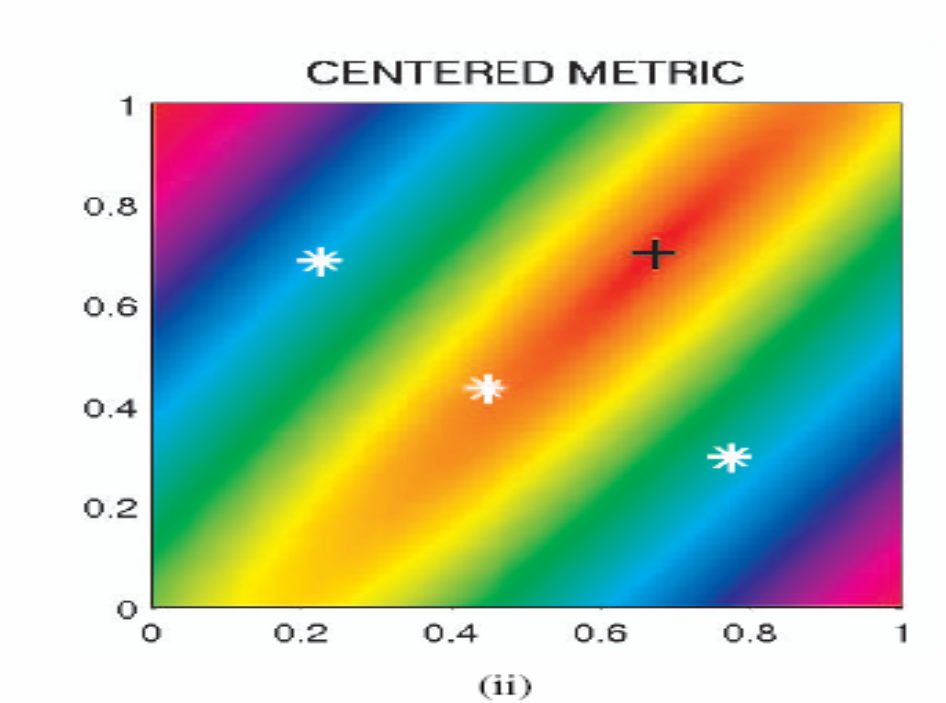


Continuous version

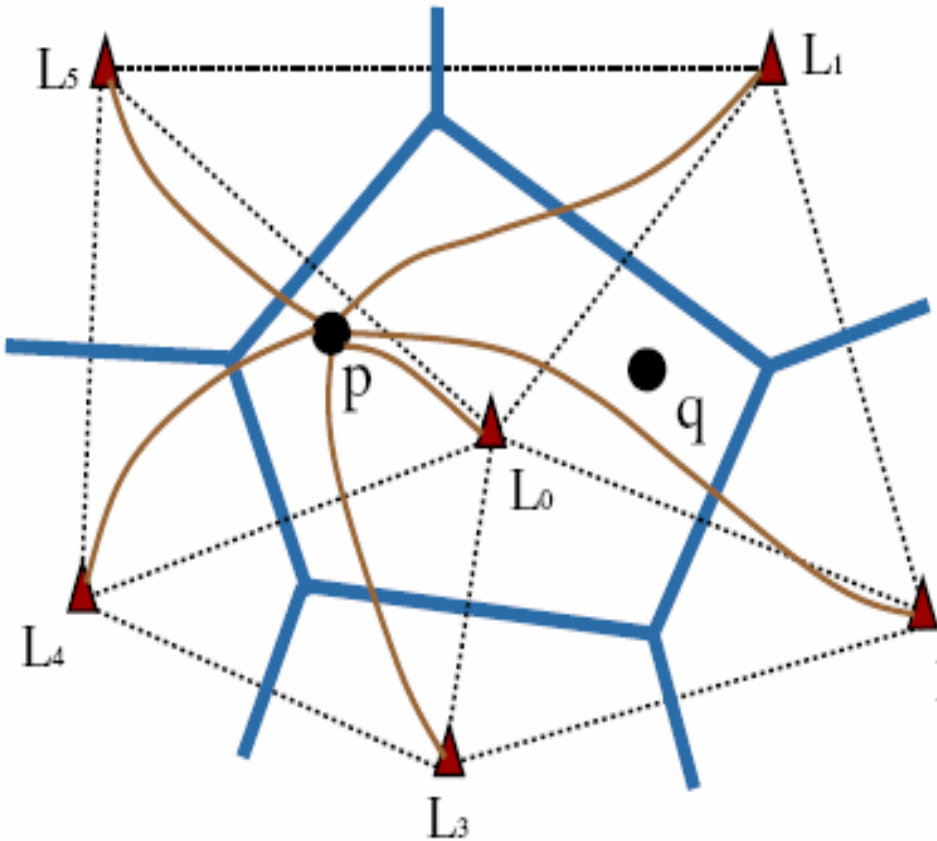
$$[C(p)]_i = [B(p)]_i - \bar{B}(p)$$

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

$\bar{B}(p)$:the mean of the entries of B(p)



Local Coordinates and Greedy Routing



$$\sigma = \text{mean}(pL_1^2, \ldots, pL_k^2)$$

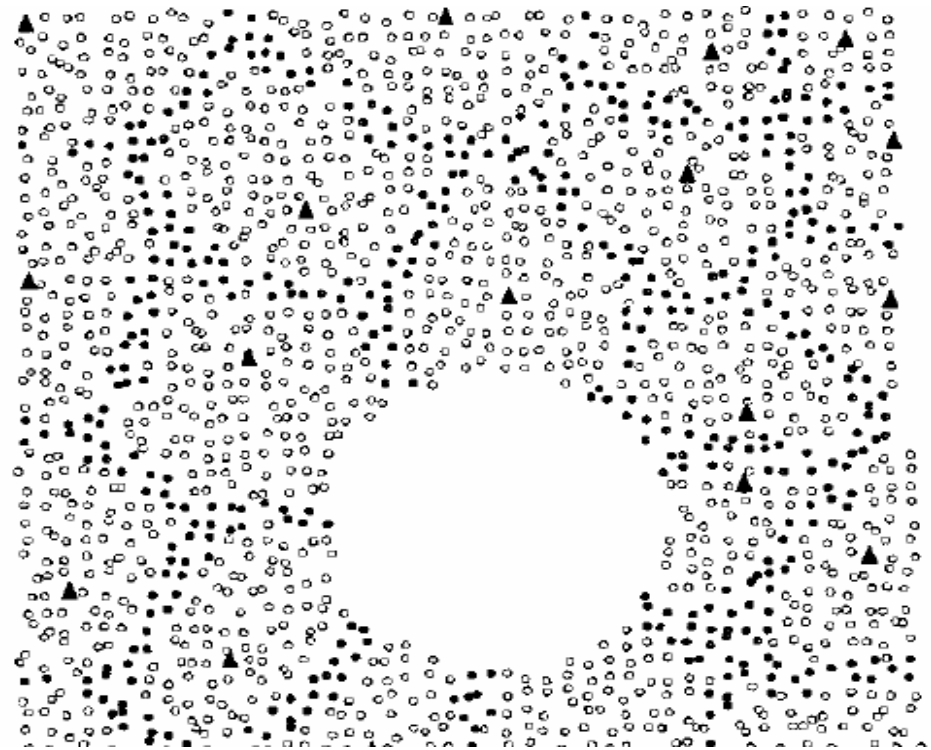
$$c(p) = (pL_1^2 - \sigma, \ldots, pL_k^2 - \sigma)$$

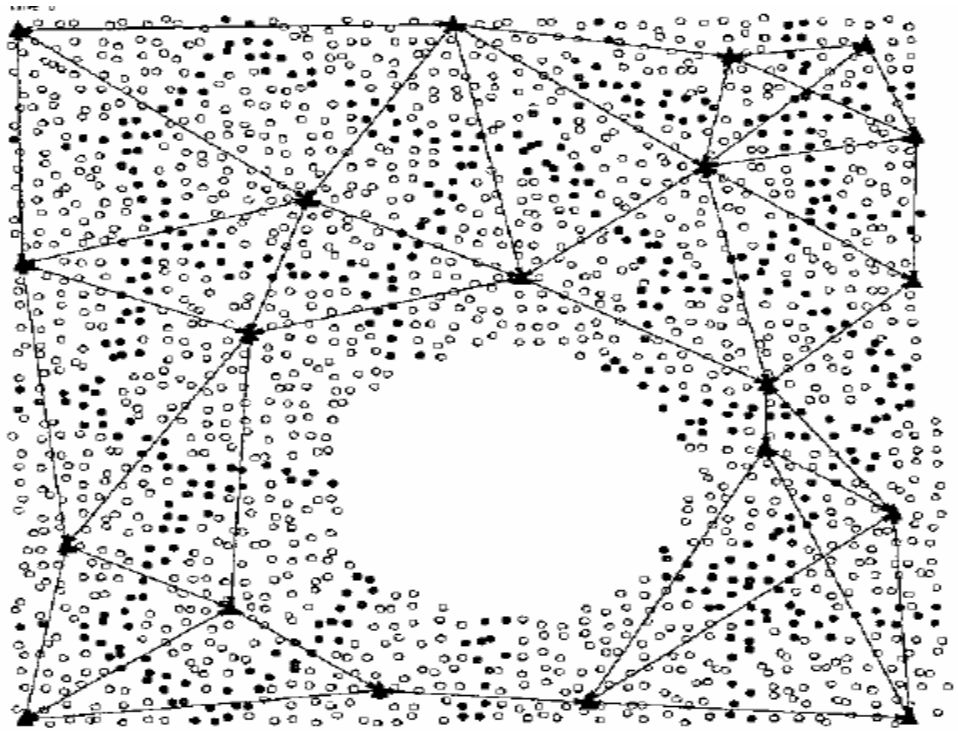
$$d(p, q) = |c(p) - c(q)|^2$$

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

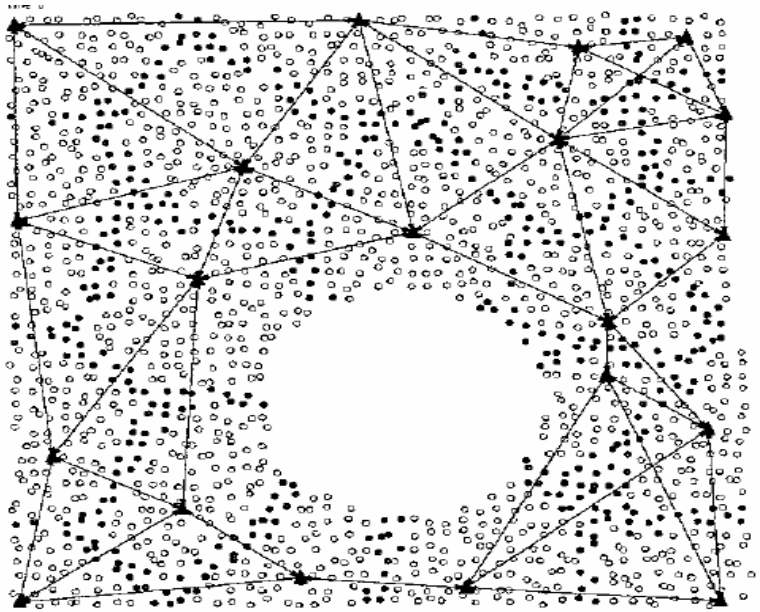




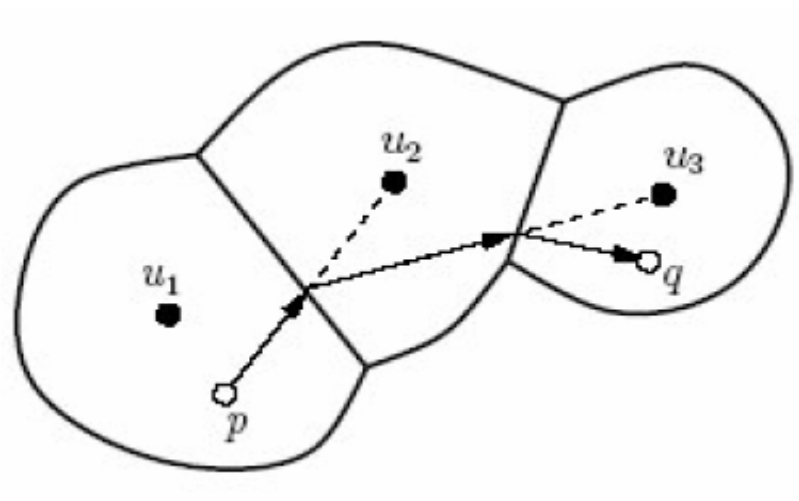
Routing protocol

- Intra-tile routing:

  use the greedy routing algorithm



- Inter-tile routing



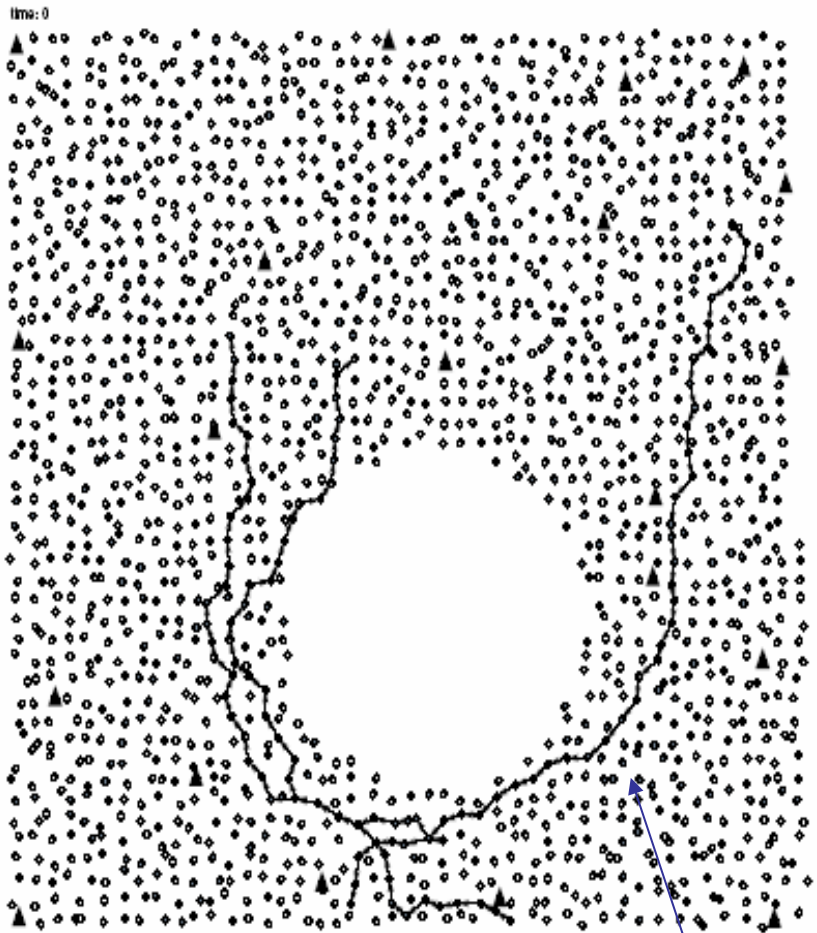
Node Density vs. Success Rate of Greedy Routing

2000 nodes distributed on a perturbed grid.

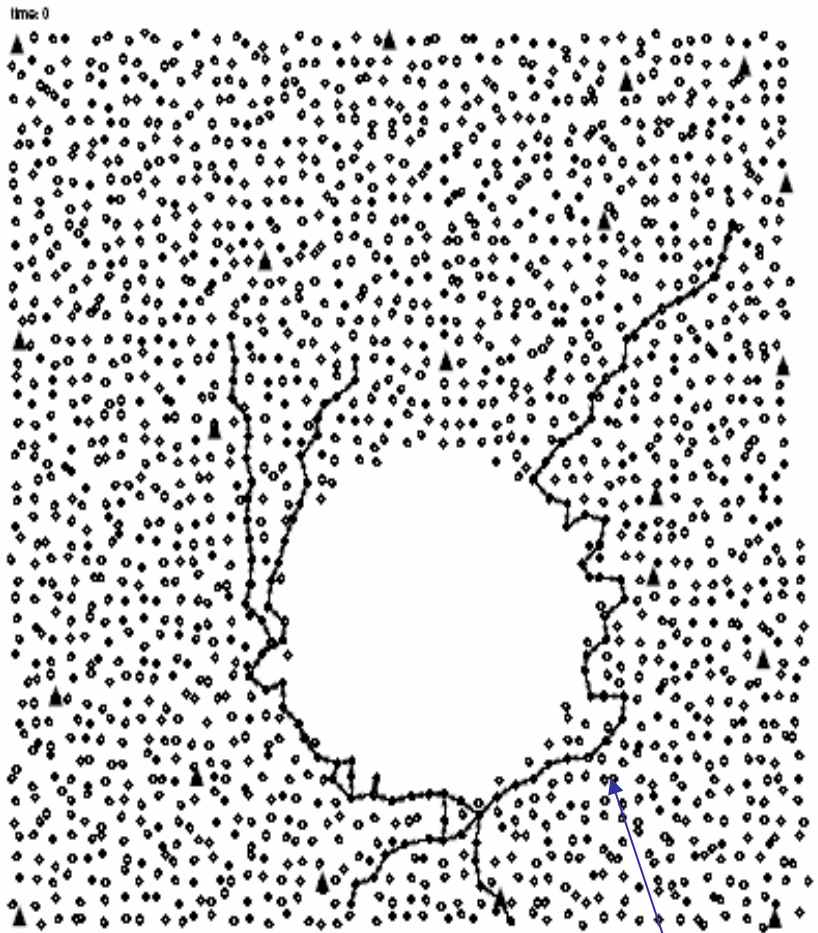
Perturbation ~ Gaussian(0, 0.5r), where r is the radio range

average number of neighbors	2.9	3.2	4.1	≥ 5.3
percentage of success	20	70	95	100

Simulations-Load Balancing and Path Length

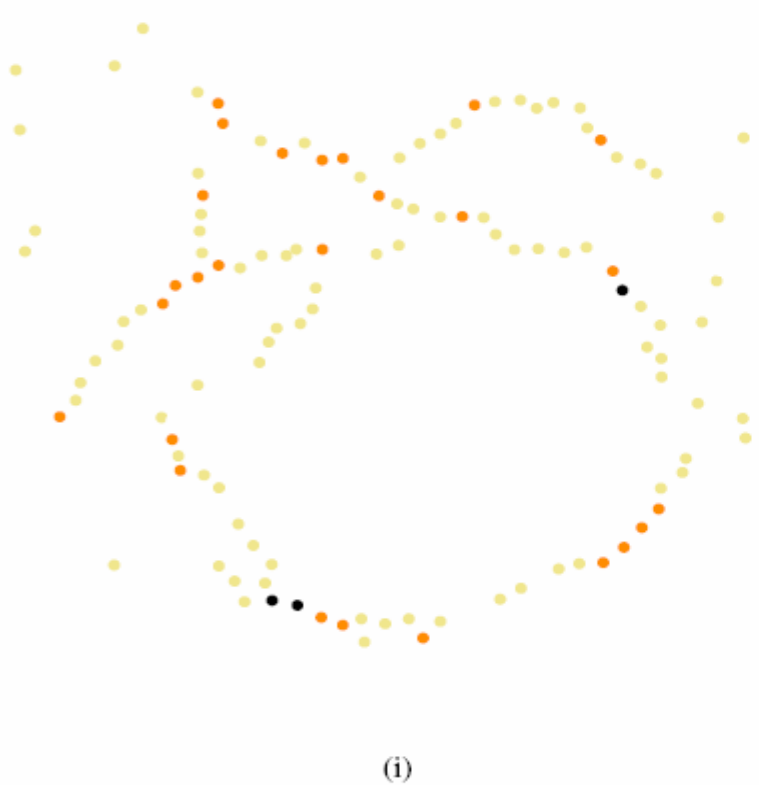


GLIDER

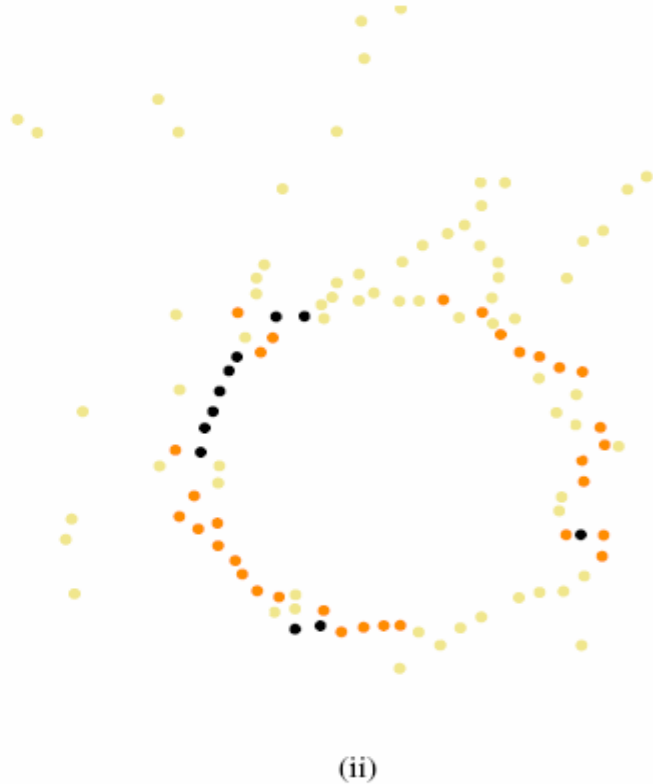


GPSR

Simulations-Hot Spots Comparison



(i)



(ii)

total 45 transit paths

Khaki:6-8 transit paths
Orange:9-11transit 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