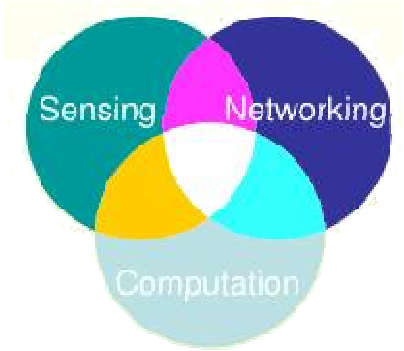
Geographic Routing Made Practical

Y.-J. Kim, R. Govindan, B. Karp and S. Shenker

NSDI 2005, To Appear



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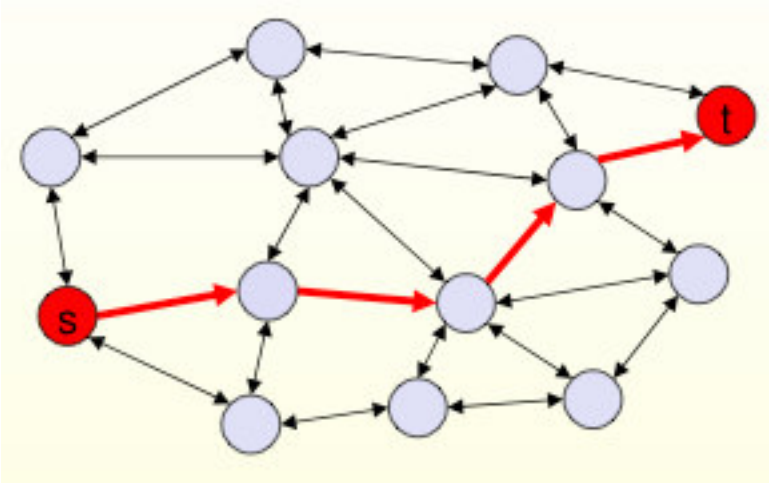
Geographic Routing

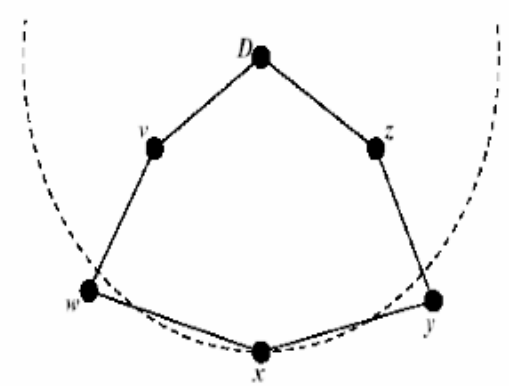
- Each node knows
  - its geographic location
  - its 1-hop neighbors

- Greedy forwarding
  - GPSR, compass routing

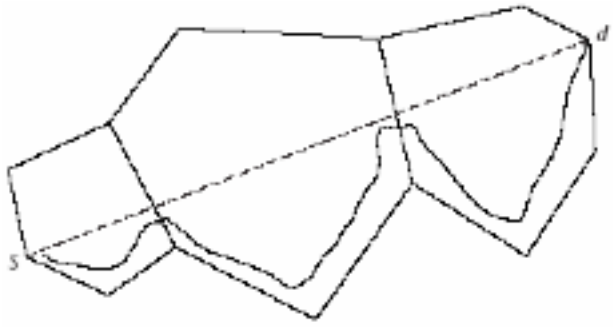


Greedy Protocol Can Get Stuck

- No where to go

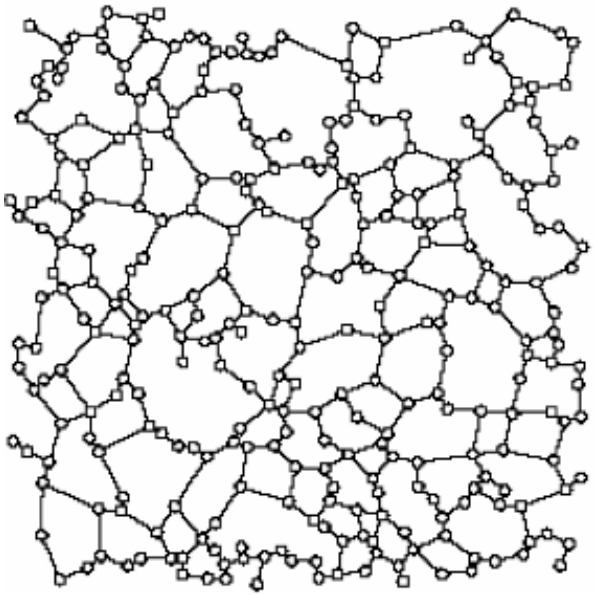


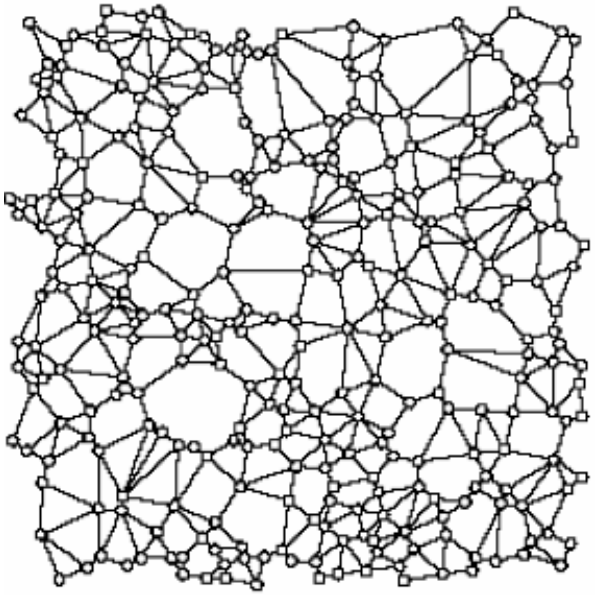
- Recovery strategy for ***planar graph***
  - Perimeter routing
  - Other-face routing



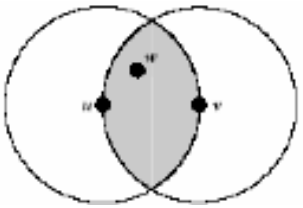
Planarization

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

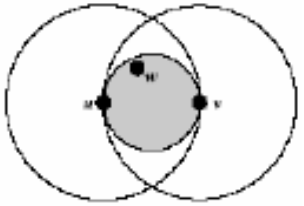




RNG:



Gabriel:



Sensing Networking Computation

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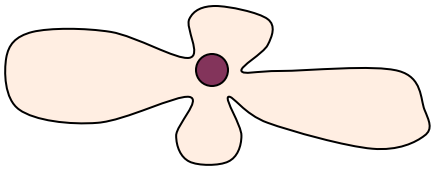
Challenges

Unit-disk graph assumption!

- Nodes communicate if within unit distance
- No communication if longer than unit distance

- Anisotropic

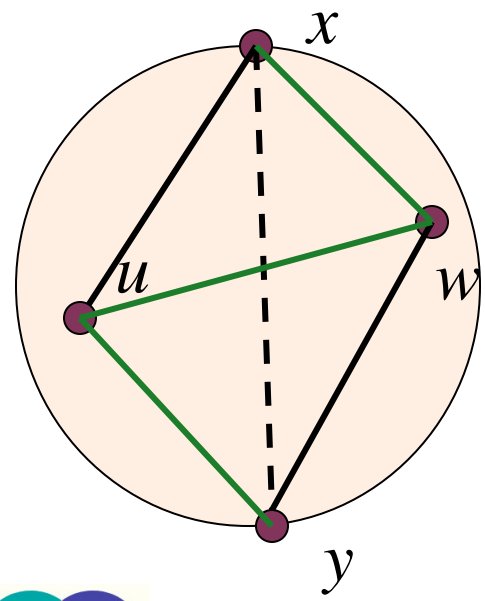


- Obstacles presence
- Unidirectional links

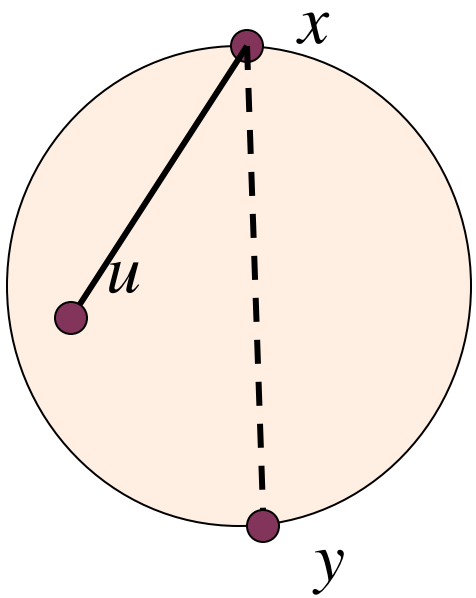
Planarization may fail!

Pathologies

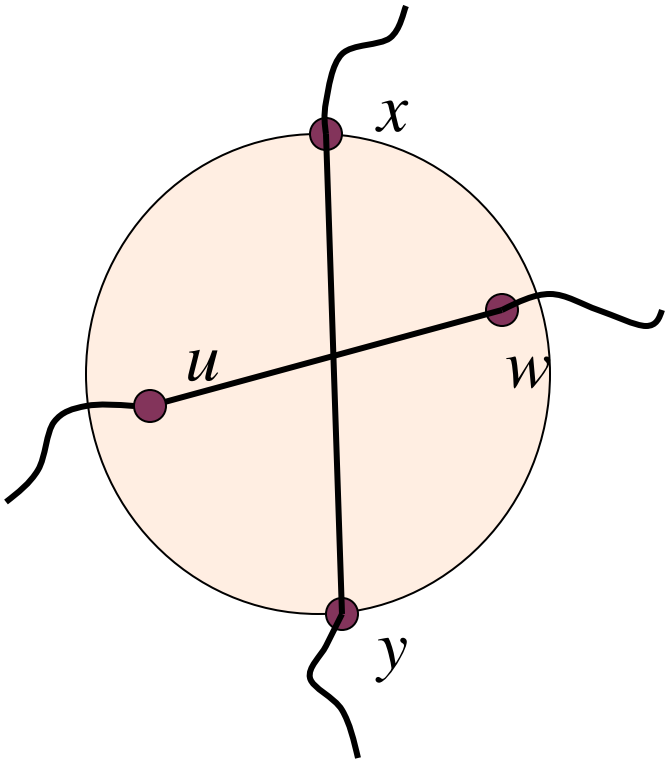
Partition graph



Asymmetric links



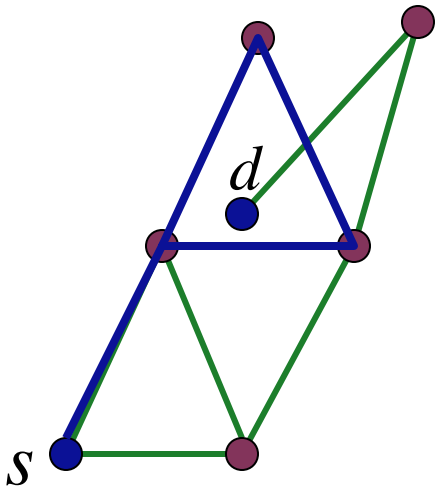
Cross links



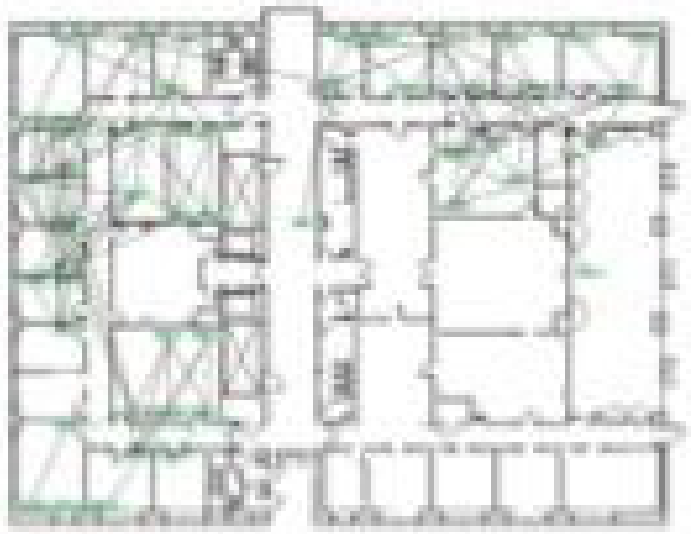
Problems

Pathologies may cause Routing failures!

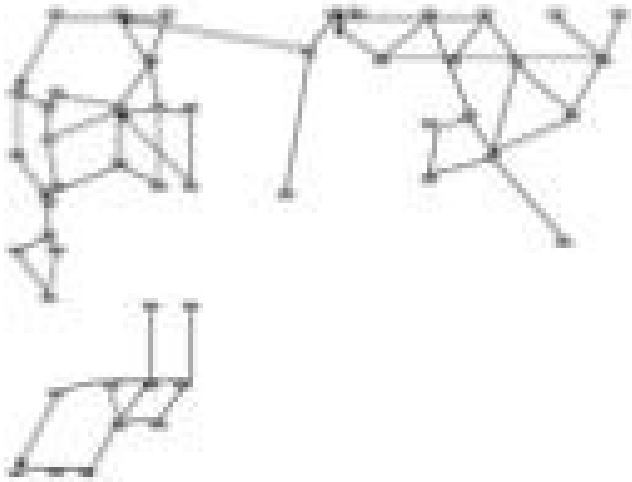
- Partitioned graph
- Cross links



Example



floor plan

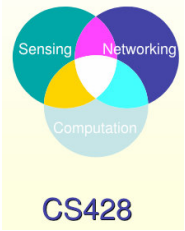


Gabriel graph

This Paper …

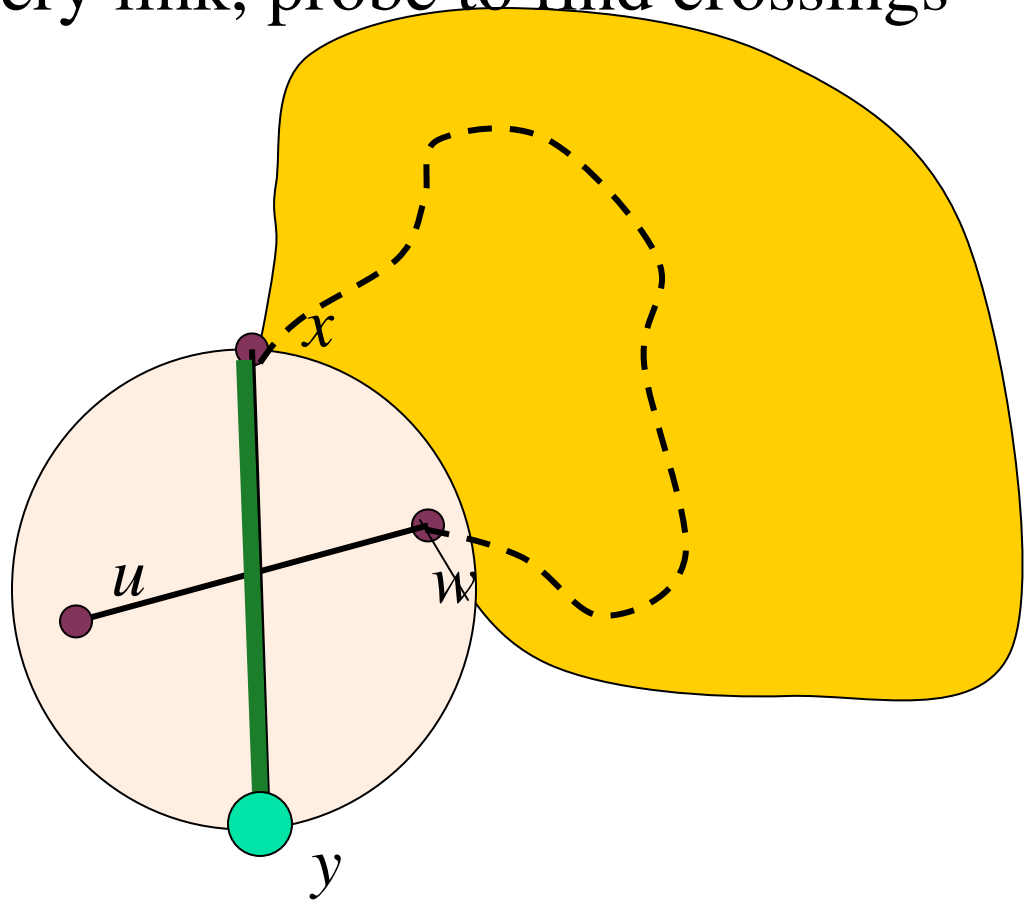
- CLDP
  - ***C***ross-***L***ink ***D***etection ***P***rotocol
- Given an arbitrary communication graph
  - Produce a subgraph that a face routing will not fail

not necessarily planar

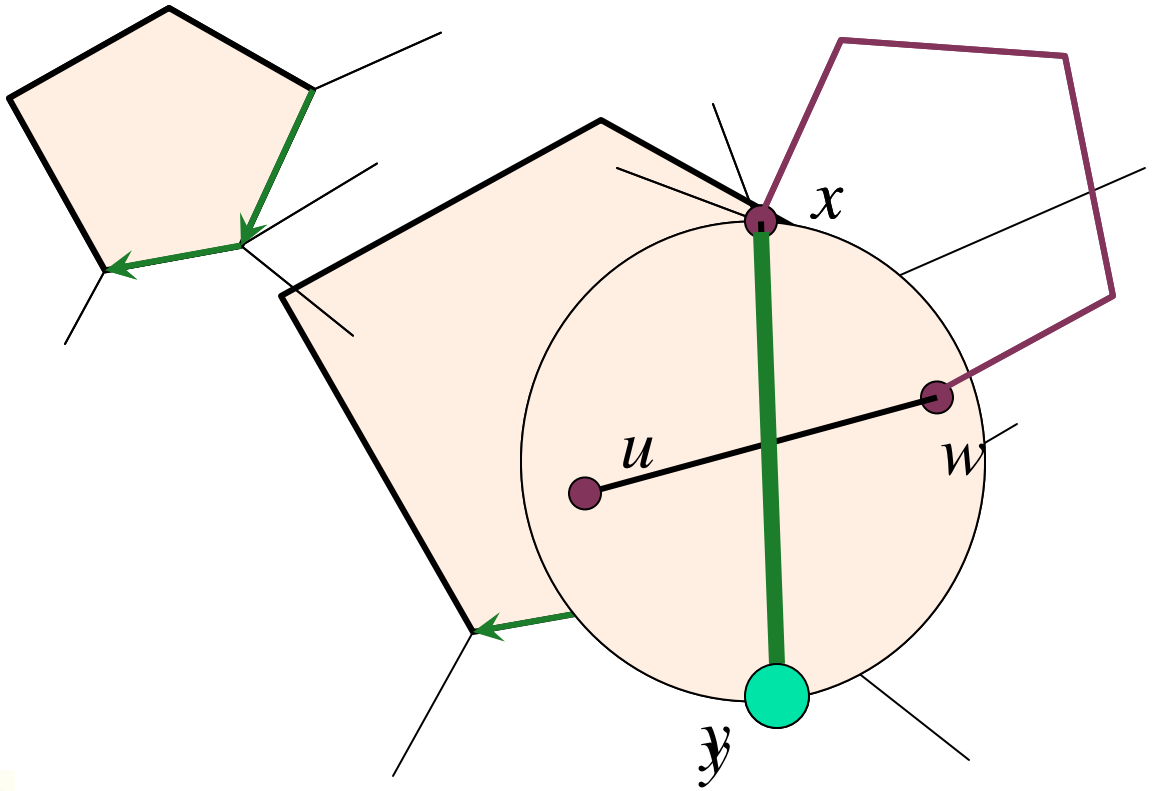


High Level Idea

- For every link, probe to find crossings

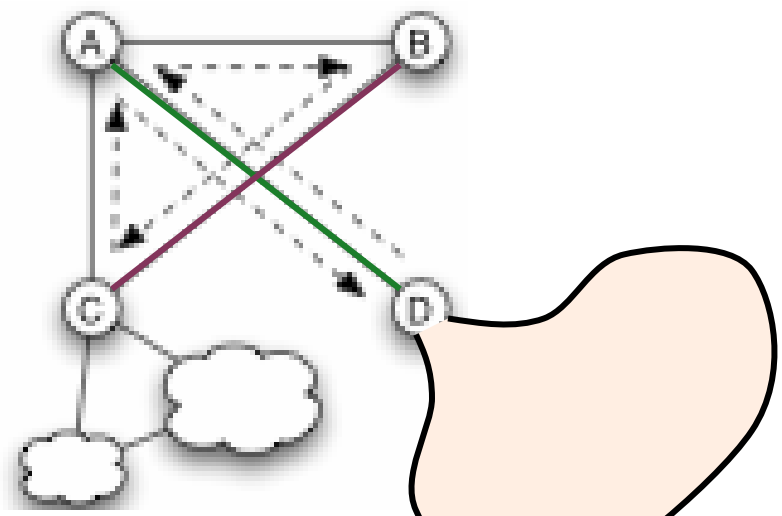


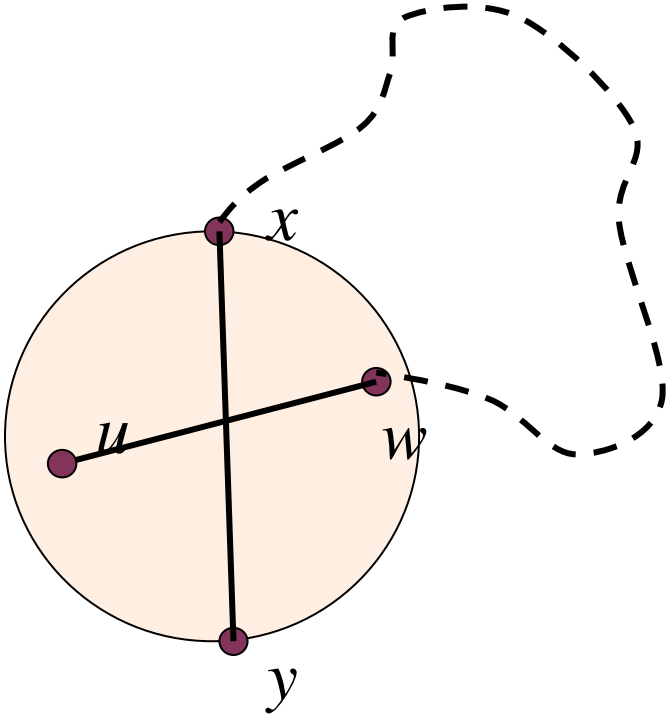
Right-hand Rule



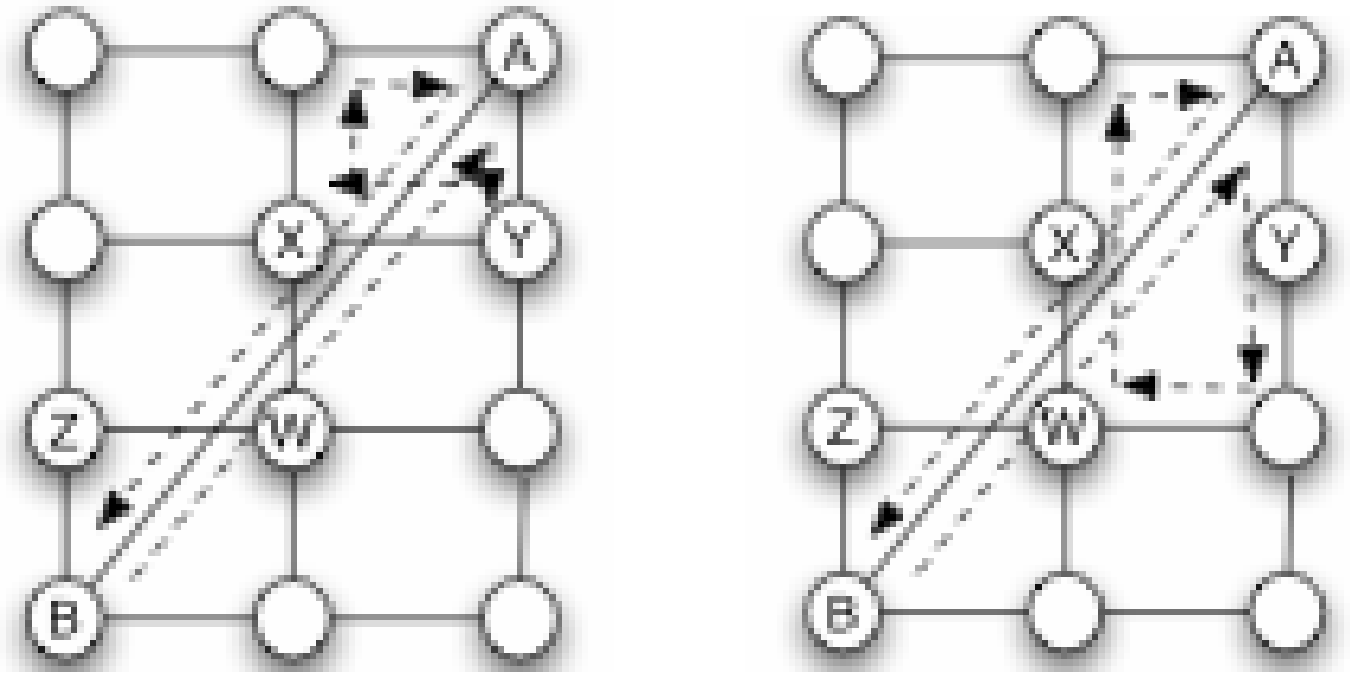
Correct Crossings

- Under the constraint to maintain connectivity

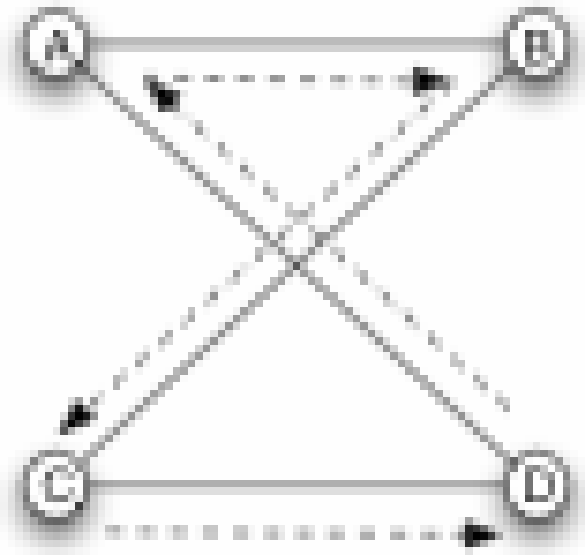




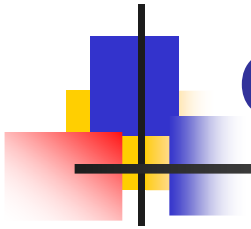
Multiple Cross-links



Concurrent Probing



- Lock links being probed
- Re-probe after face change



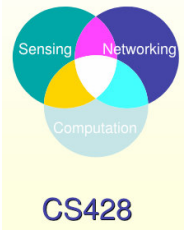
Correctness

Theorem A

If a connected graph G has at least one crossing, then there is at least one face that has a crossing.

Theorem B

Geographic routing never fails on a connected *CLDP-stable* graph.



Simulations Setup

- CLDP Implemented in TinyOS
- Simulator: TOSSIM

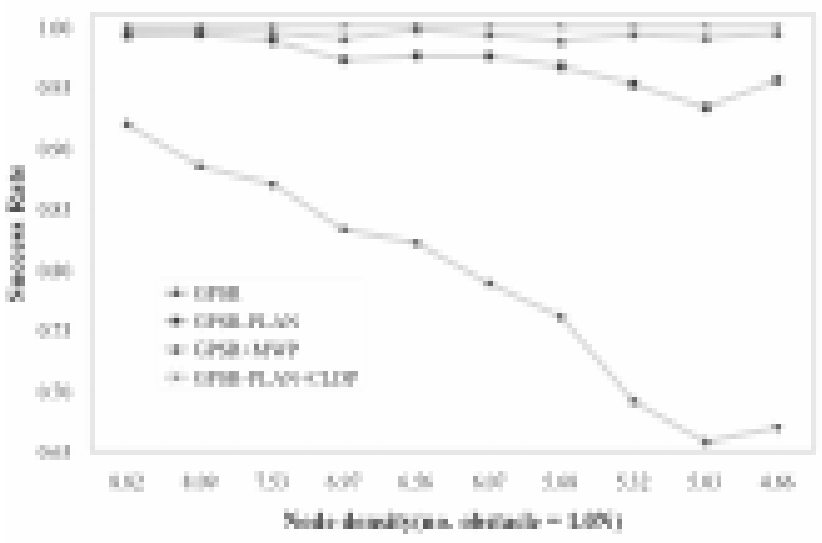
- Performance compared with:
  - GPSR
  - GPSR-PLAN
  - GPSR-MWP
  - GPSR-PLAN-CLDP

mutual witness

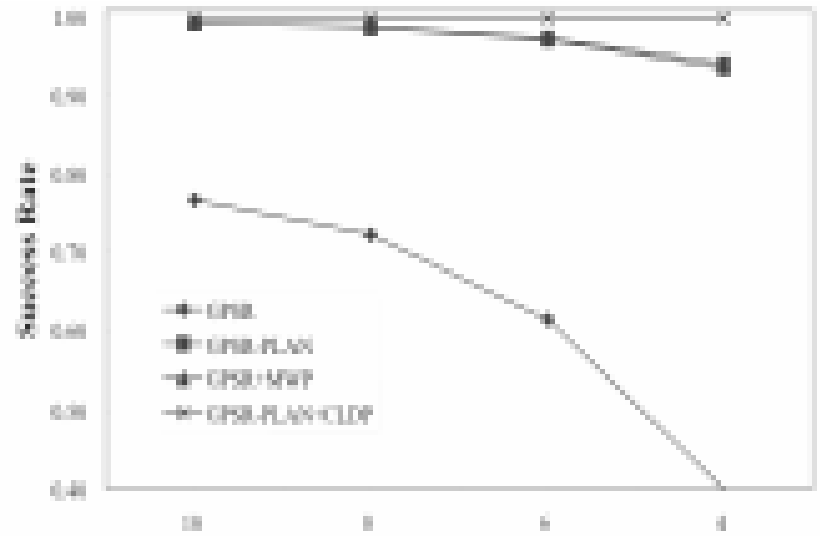
Greedy forwarding on FULL communication graph

Success Rate vs. Density

Network: 200 nodes, many obstacles

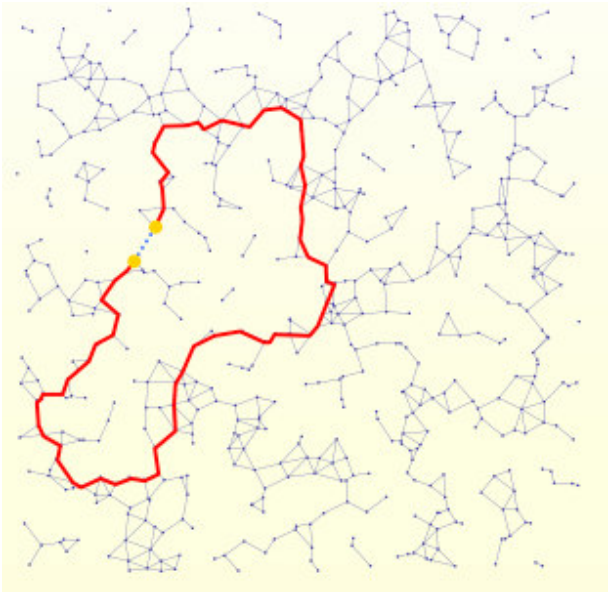


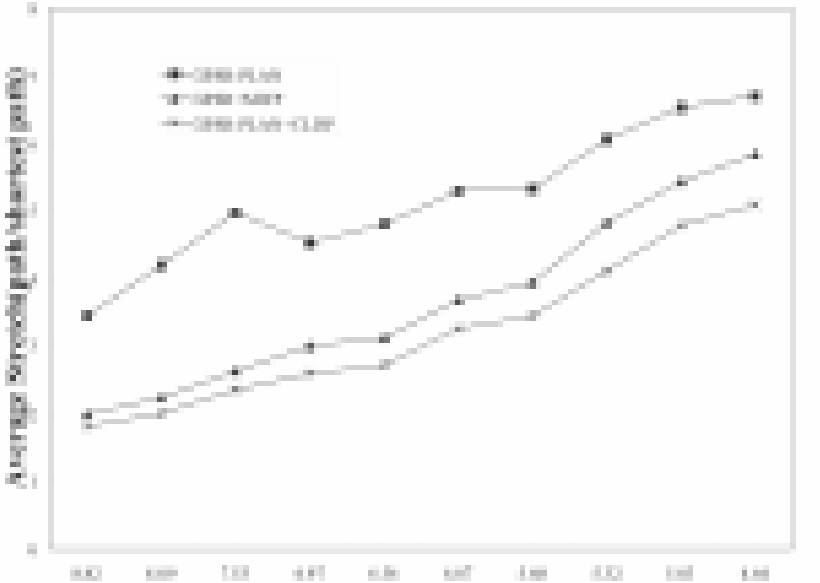
unit radio range



random-linkage graph

Stretch Factor vs. Density

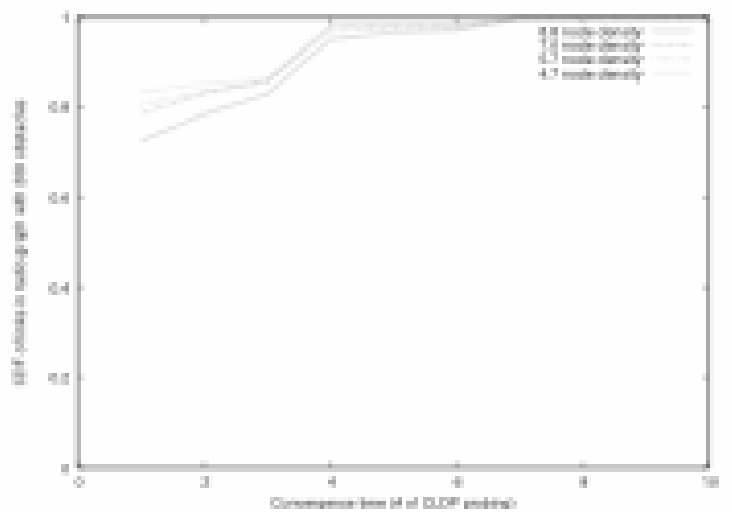


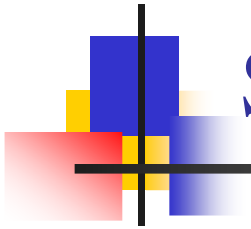


Others

- Overhead:
  - 85 - 90% links see less than 4 messages
  - But ~10% can see up to 100 messages

- Convergence rate





Summary

- Greedy forwarding + CLDP
  - Remove unrealistic assumptions on communication
  - Always guarantee routing success
  - Reasonable routing paths
  - Low overhead, converge fast
  - Works under network dynamics