On the Pitfalls of Geographic Face Routing

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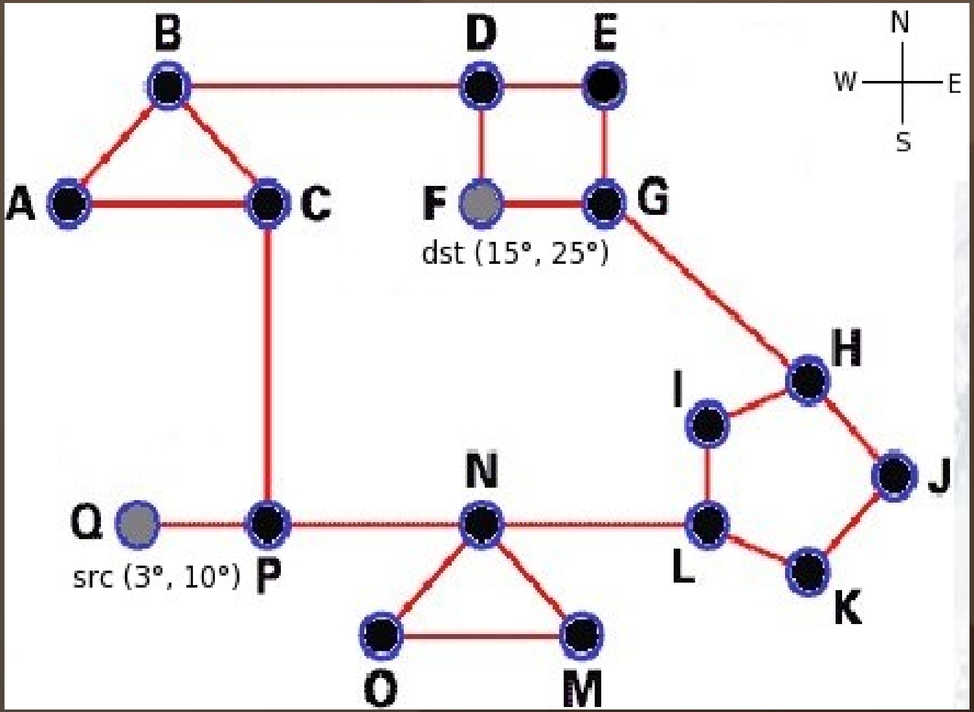
Outline

- Introduction
- Planarization
- Face Traversal
- Practical Experiments
- Conclusion

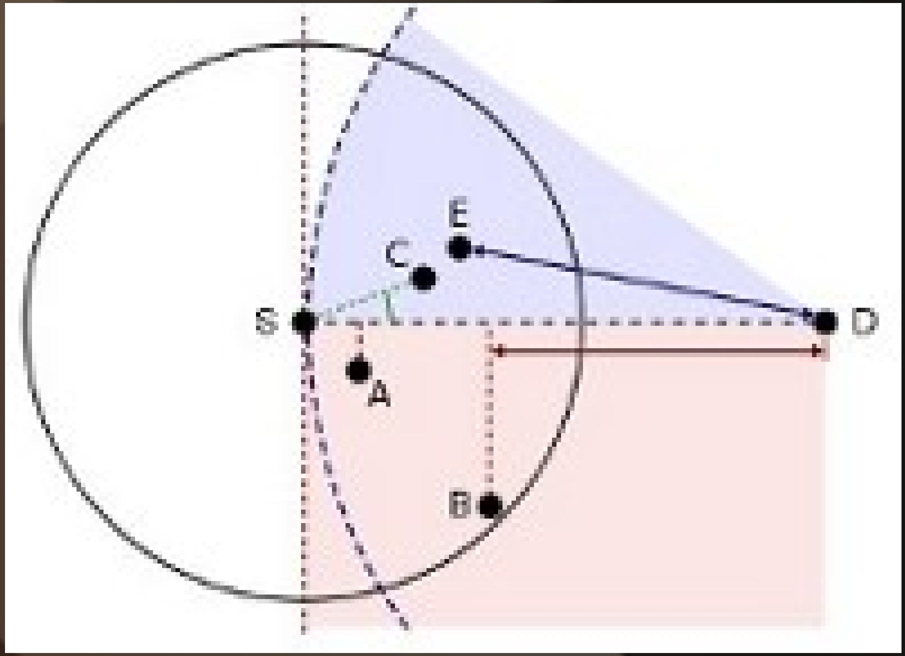
Geographic Routing?



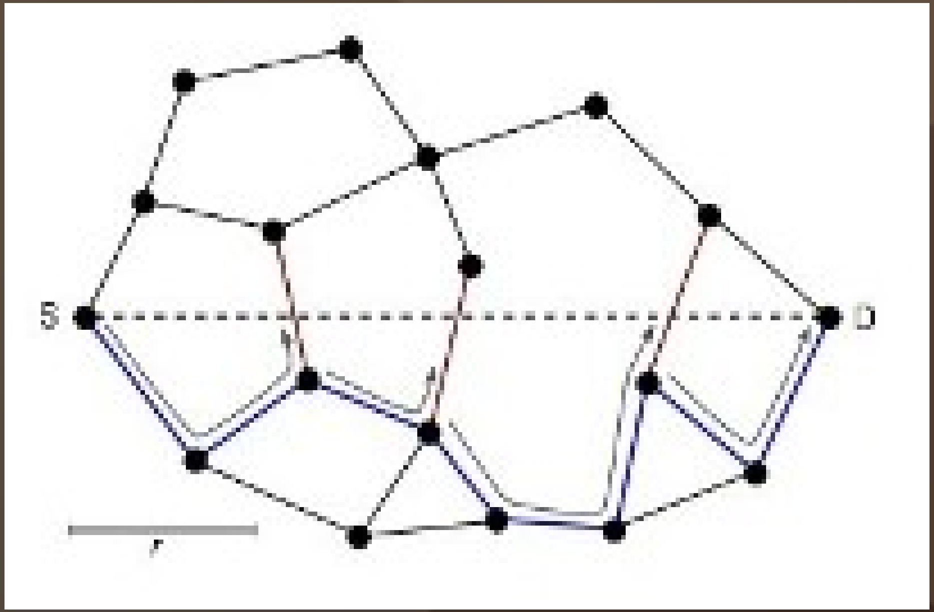
- Network address <u>not used</u>
- Routing is done via <u>geographical coordinates</u> of the nodes
- Various algorithms

Greedy Overview

- Greedy forwarding tries to bring the message closer to the destination in each step using only local information



Face Routing Overview



- A message is routed along the interior of the faces of the communication graph, with face changes at the edges crossing the S-D-line. The final routing path is shown in blue.

Combined Approach

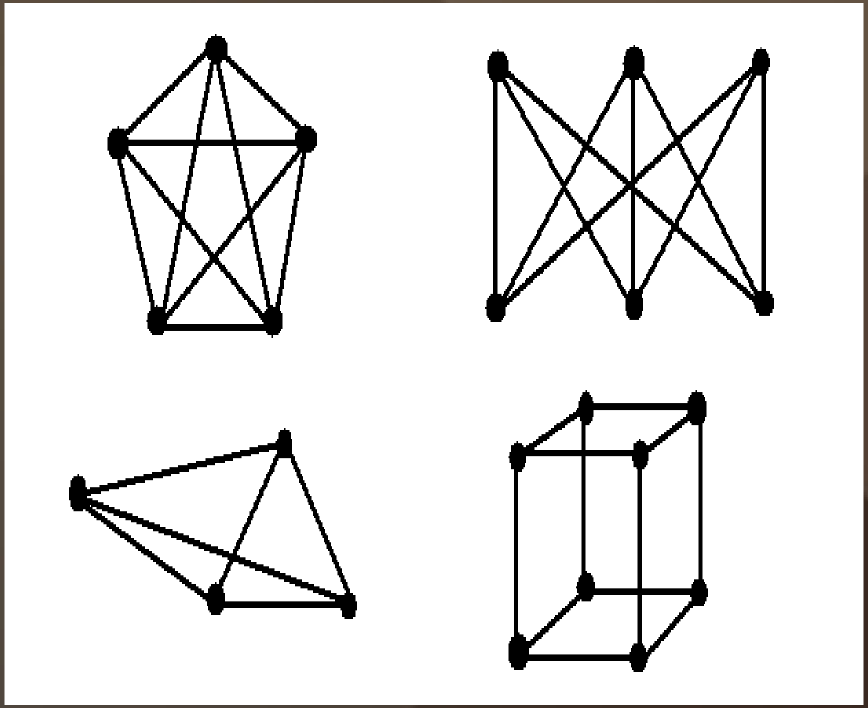
1. Use “Greedy” and try to reach destination
2. If got stuck then use “Face Routing”
3. If “first closure” occurred then go to 1

- Implementing protocols: *GFG, GPSR, GOAFR+*
- *Main blocks: Greedy, Planarization, Face traversal*

Paper Overview

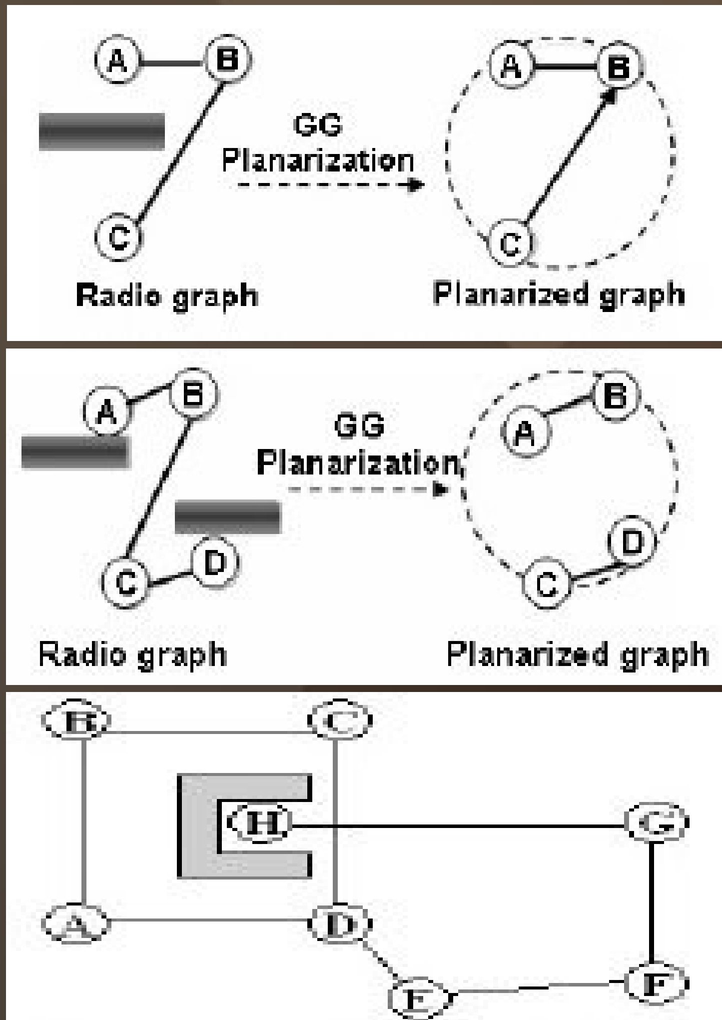
- Definition of weakest points of Geographic Routing protocols
- Classification of failure situations in common approaches
- Measurement of pathologies caused by failures
- Suggestions for increase of routing success rate
- Practical experiments proving efficiency of suggested approaches

Planarization in detail



- Common algorithms: GG, RNG, RDG
- Main idea: eliminate cross links via “witnesses” lying in a fixed geometric region
- Strictly rely on unit-disk graph assumption

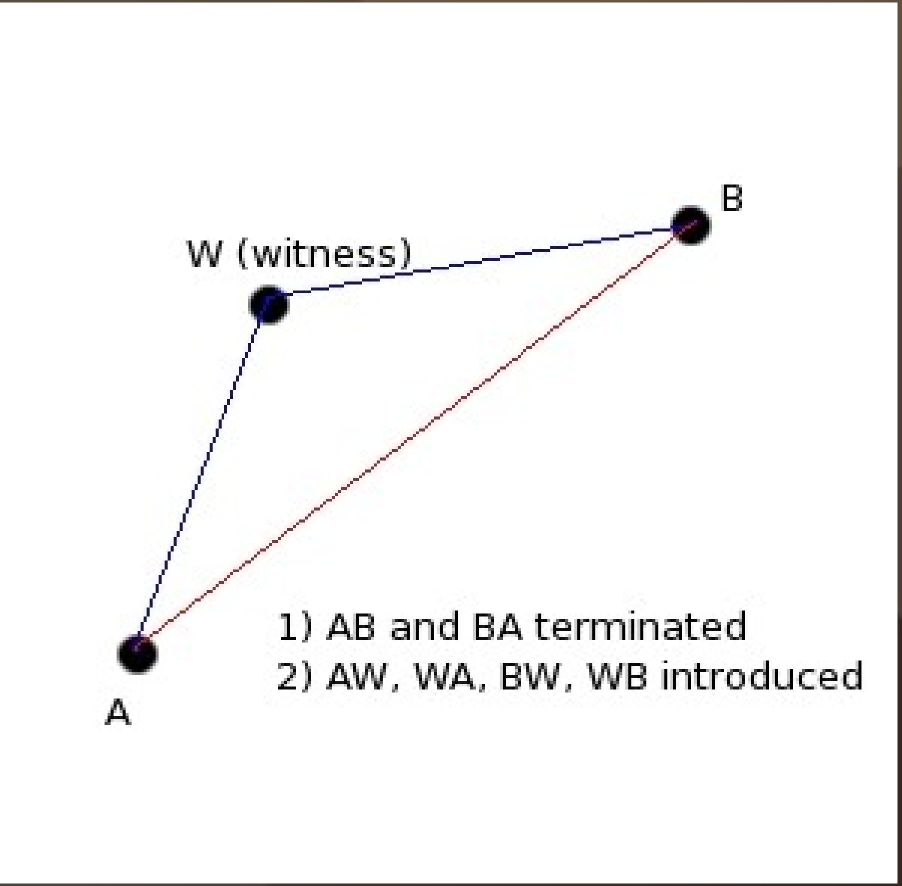
Planarization failure cases



- Reasons: radio blocking obstacles, incorrect self location estimate etc

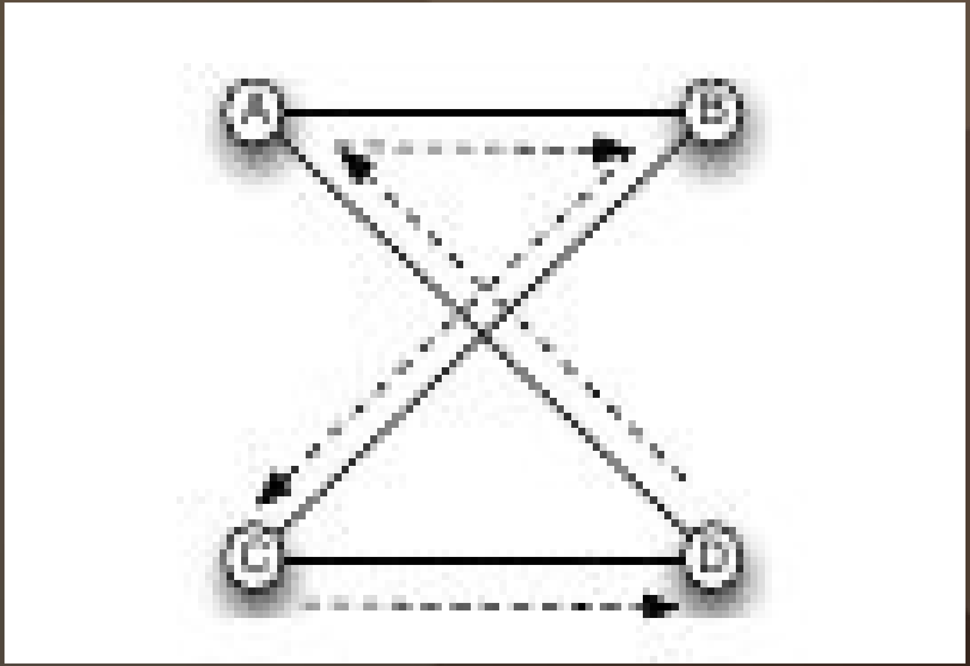
- Arising problems:
  - Unidirectional links
  - Disconnected links
  - Cross links

Mutual Witness Procedure



- Communication between nodes by sending lists of the neighbors in order to identify mutual ones
- Just slightly increases efficiency of the protocol

Cross Link Detection Protocol

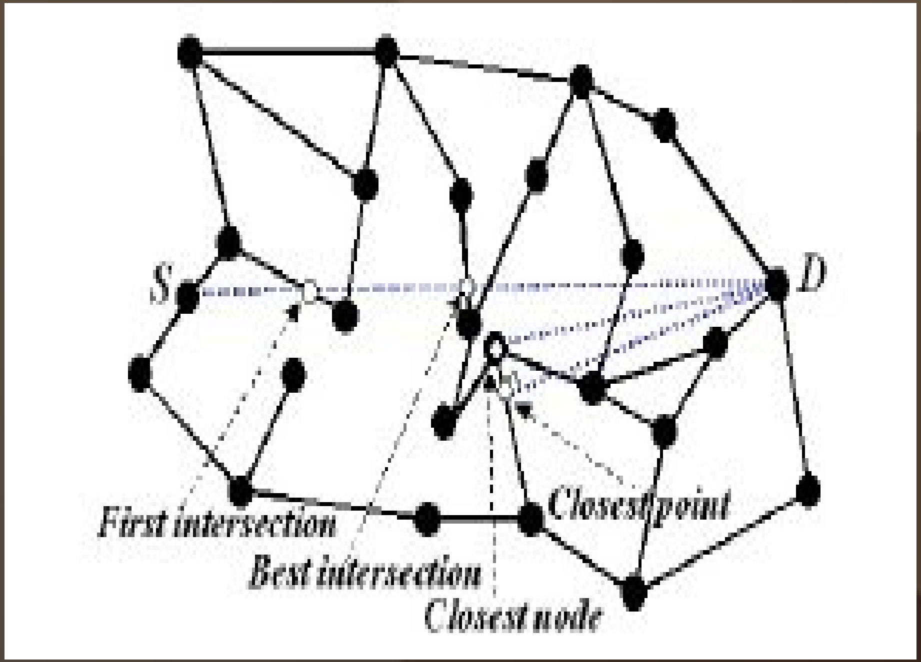


- Idea: send “probe” to travel the graph in order to detect cross links, since it can be checked whether probe has been in one point two times during travel
- Each link of each node must be checked

CLDP vs. MWP

- CLDP theoretically eliminates all cross links and has showed 100% efficiency during experiments on topology with 23 and 50 static nodes
- CLDP doesn't solve the collinear links problem
- MWP can leave some cross links in sub-graph and showed rather poor performance of 87.8% leaving some nodes disconnected
- MWP can convert some cross links into collinear ones

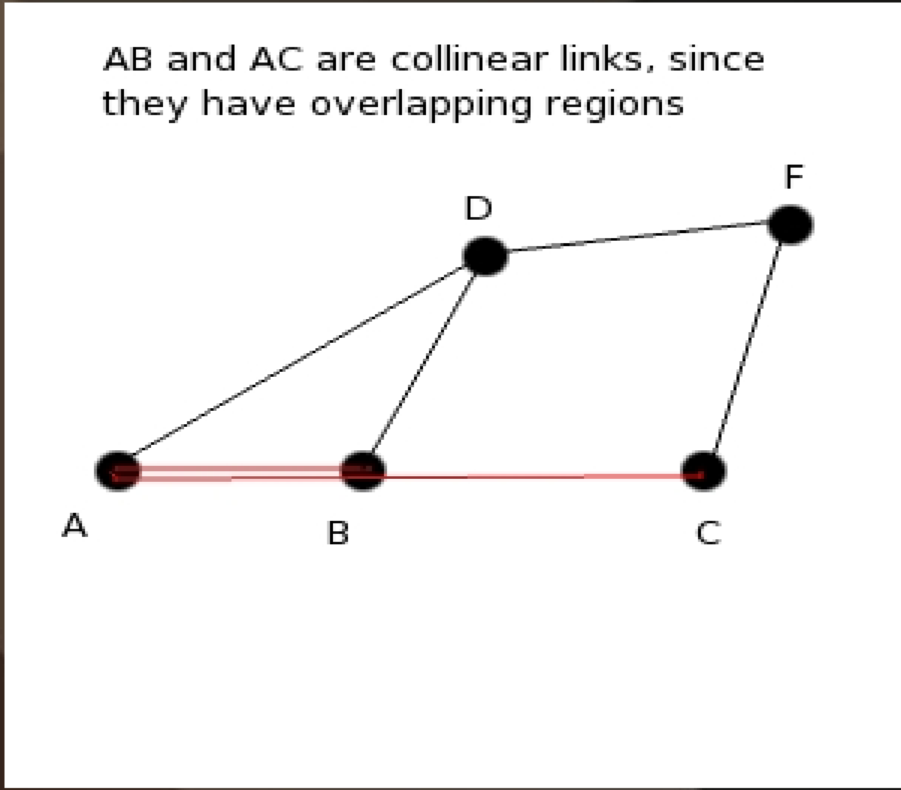
Face Traversal in detail



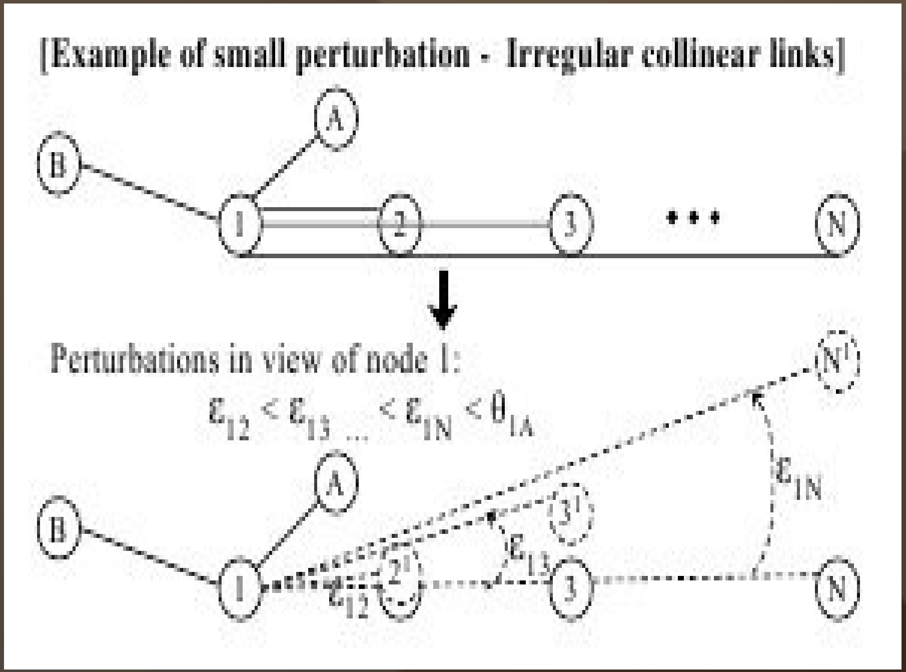
- Algorithms: Best Intersection, First Intersection, Closest-Node, Closest-Point
- Only Best Intersection and Closest-Point guarantee correct results

Collinear links

- Links that have overlapping regions with one or more other links
- Introduce difficulty for right-hand rule to change face



Small perturbations of node positions



- Modify node positions at another endpoint in such way that links move counterclockwise.
- Should be done for all collinear links using different angles

Improved right-hand rule

- When links are collinear it is unclear whether the angle between them is 0 or 2π
- If packet came from collinear link “a” which is shorter than current collinear link “b” then angle is considered to be 0, otherwise 2π
- If there are several collinear links to travel from the current one then the one with the minimal length is chosen as a next hop

Small perturbations vs. Improved right-hand rule

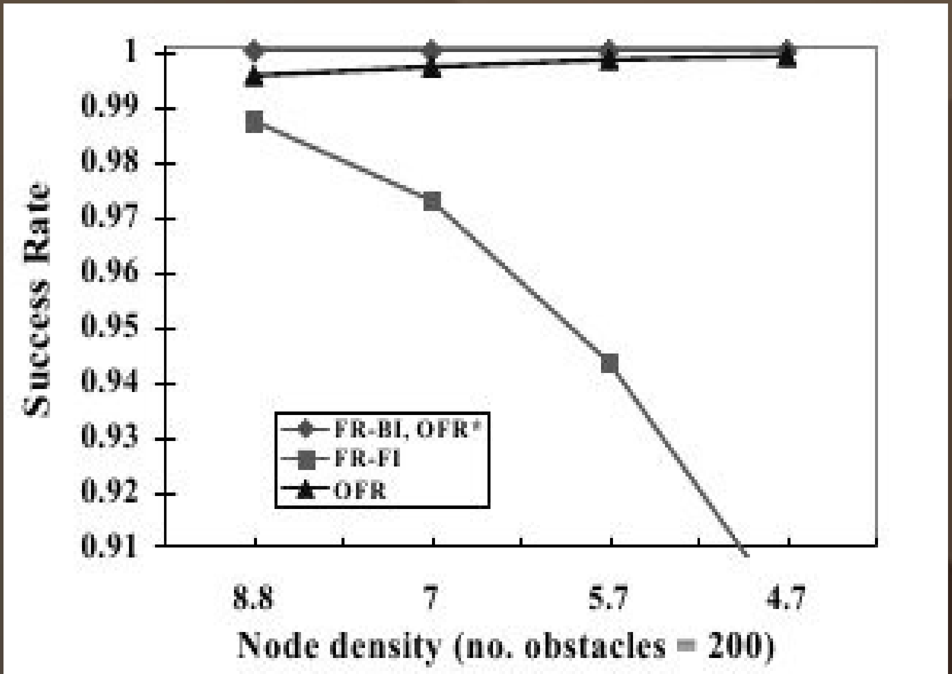
- Small perturbations approach requires very small values of rotation angles, which is not always practically achievable

- Improved right-hand rule seems to show the equivalent results as the aforementioned approach, but doesn't require any small values thus not introducing difficulties in implementation

Experiments overview

- Environment: 200 radio-opaque obstacles, random node position generation
- Results are mean values between 50 experiments
- Success rate indicates the percentage of successfully delivered packets
- Average stretch indicates the number of hops between source and destination divided by minimal number of hops in optimal path

Table of results (face change rules)



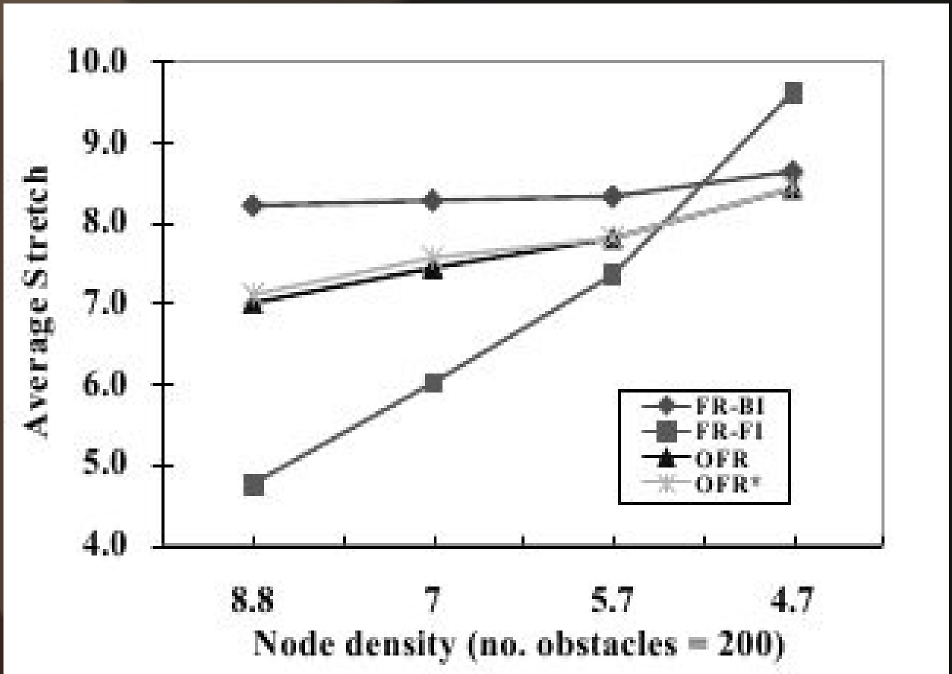
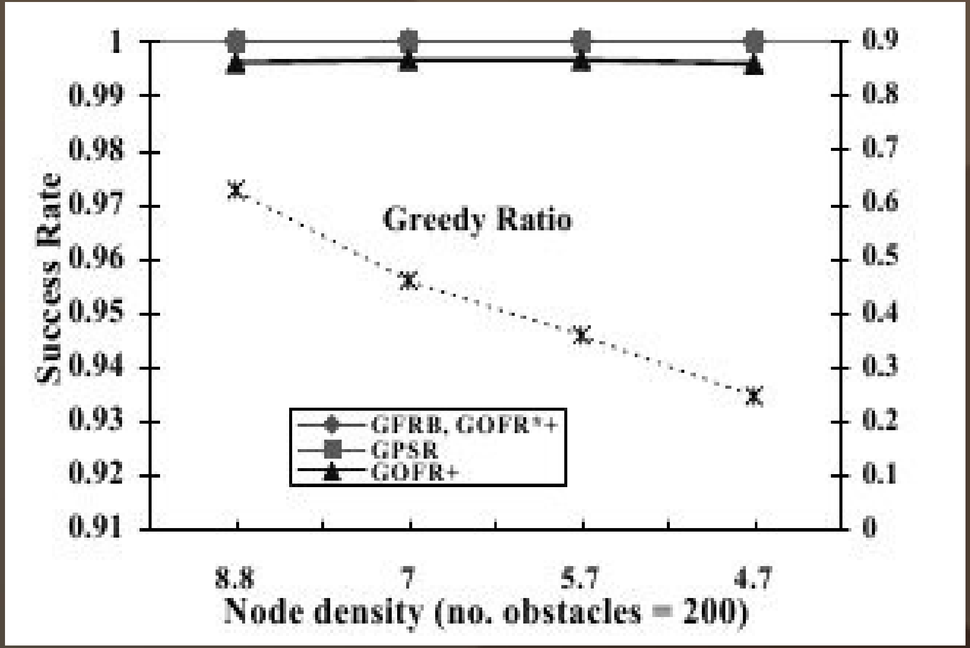
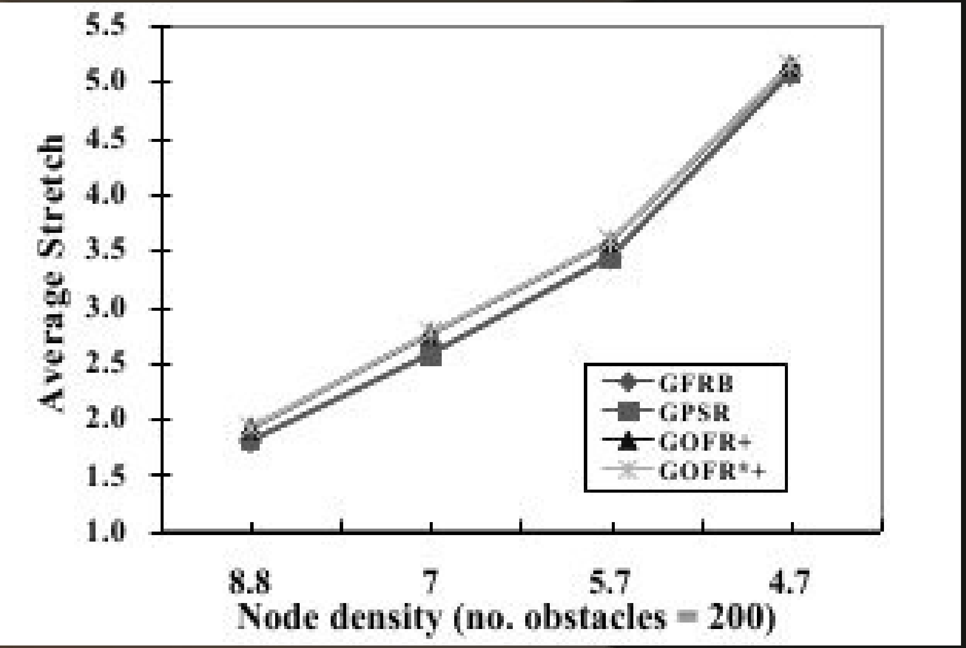


Table of results (protocols)





Results discussion

- Face Traversal algorithms with the highest success rate(100%) – Best Intersection, Closest-Point
- Protocols with the highest success rate(100%) - GFRB(Greedy + Best Intersection), GPSR(Greedy + First Intersection), GOFR*+(Greedy + Closest-Point)
- Average stretch is almost equal in all of the algorithms due to usage of Greedy

Conclusion

- Robust Geographic Routing is practically achievable
- Theoretical researches and practical experiments have shown that best results were achieved through using CDLP for cross link elimination, Improved right-hand rule for collinear links elimination and Best-Intersection/Closest-Point for successful face change

References

1. http://en.wikipedia.org/wiki/Geographic_routing, 2009-12-18
2. On the Pitfalls of Geographic Face Routing. Y.-J. Kim, R. Govindan, B. Karp, S. Shenker, 2005
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  - http://en.wikipedia.org/wiki/Geographic_routing, 2009-12-18
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Thank you for your attention

Questions