Geographic Routing

GPSR & GEAR

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Papers

- GPSR: Greedy Perimeter Stateless Routing for Wireless Networks
  - Brad Karp, H.T. Kung

- Geographical and Energy Aware Routing: a recursive data dissemination protocol for wireless sensor networks
  - Yan Yu, Ramesh Govindan, Deborah Estrin

GPSR: Motivation

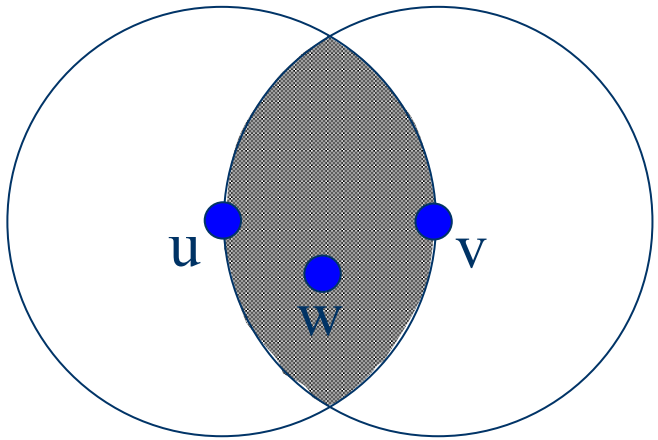
- Ad-hoc routing algorithms (DSR, AODV)
  - Suffer from out of date state (DV)
  - Torrents of link status messages (LS)
- Can use geographic information for routing
  - Assume every node knows position (x,y)
  - Keep a lot less state in the network
  - Require fewer update messages

GPSR: Algorithm

- Whenever possible, use Greedy forwarding.
  - Look at all neighbors, select closest to destination
- When all neighbors are further away
  - Use the right hand rule and walk around the obstacle
  - Resume greedy forwarding as soon as possible to deliver message to destination
- Note: no attempt is made to conserve energy

GPSR: Details

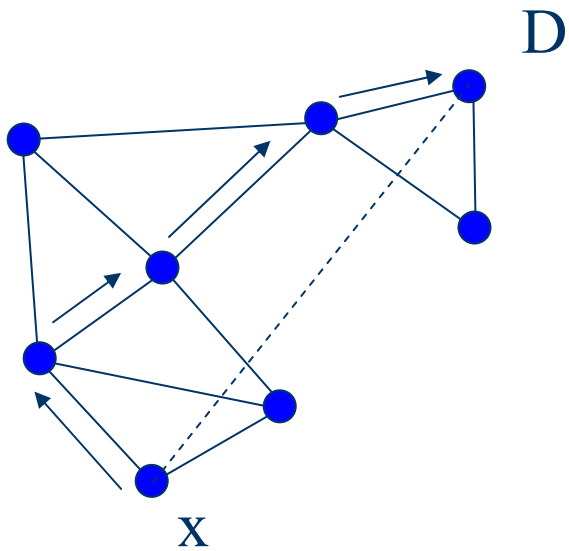
- How to route around an obstacle?
  - Locally discover a connected planar graph as subset of network graph.



- Edge (u,v) can be safely removed.

GPSR: Details (2)

- When stuck, use right hand rule to go around obstacles.



- Always go along the face that is crossed by xD

GPSR: Results

- GPSR delivered > 98% of packets successfully, similar to DSR
- Protocol overhead was 50% less: 15,000 vs. 30,000 packets
- GPSR used shorter paths.
- Heuristic results, no theoretical guarantees.

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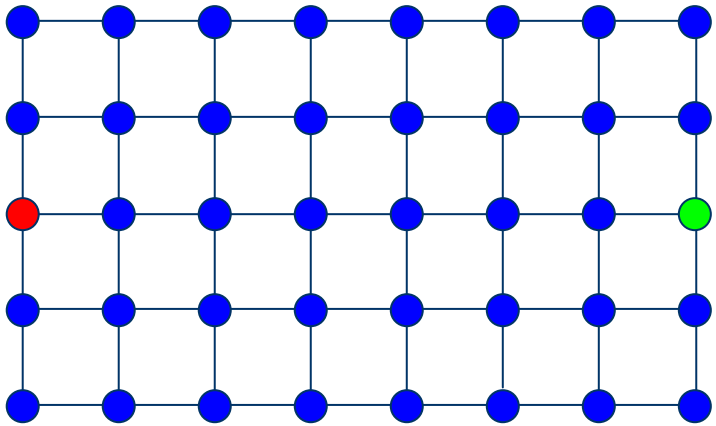
GEAR: Motivation

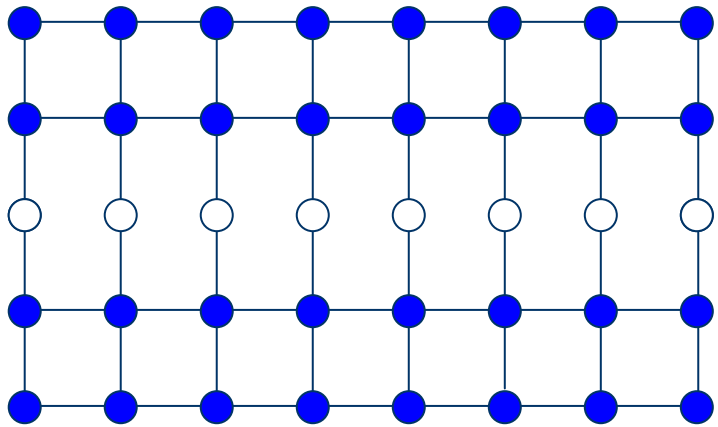
- Automatic Load Balancing in Routing



Original Network

GEAR: Motivation (2)

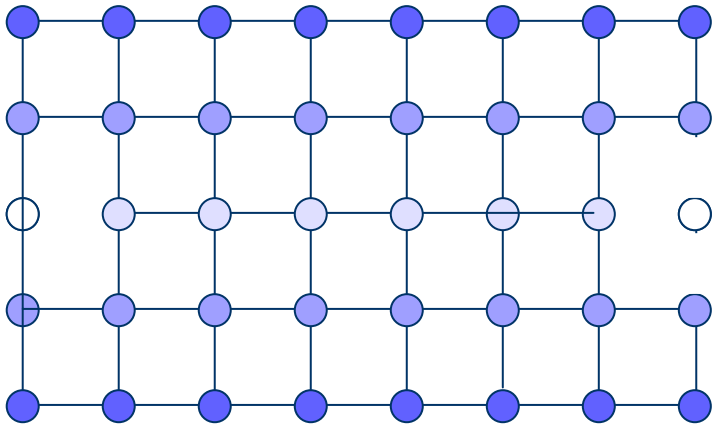
- Automatic Load Balancing in Routing



Not Balanced Network

GEAR: Motivation (3)

- Automatic Load Balancing in Routing



Load Balanced Network

GEAR: Algorithm (1)

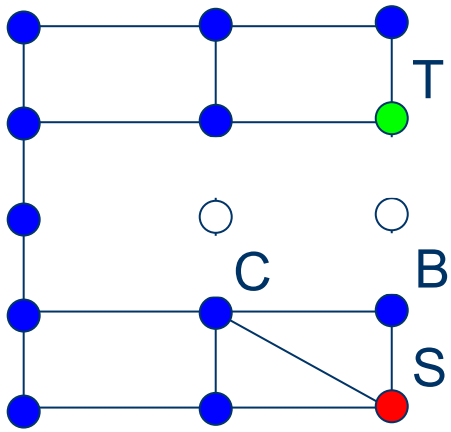
- Assumptions
  - Nodes know location, energy level of themselves and neighbors
  - Bidirectional links
  - Routing to a region R
- Trick
  - Maintain and update, a cost $h(N_i, R)$ for each neighbor & destination region.

GEAR: Algorithm (2)

- Routing:
  - Look at all neighbors closer to the destination, pick one with lowest learned cost.
  - If all neighbors are further away, pick the neighbor with the lowest learned cost, update the cost.
- Initial Cost
  - $H(N,R) = \alpha\ dist(N,R) + (1-\alpha)\ Energy(N)$
- Cost Update Rule
  - $H(N, R) = h(N_{min}, R) + C(N, N_{min})$

GEAR: Example

- H(B,T) =2, H(C,T)= √5

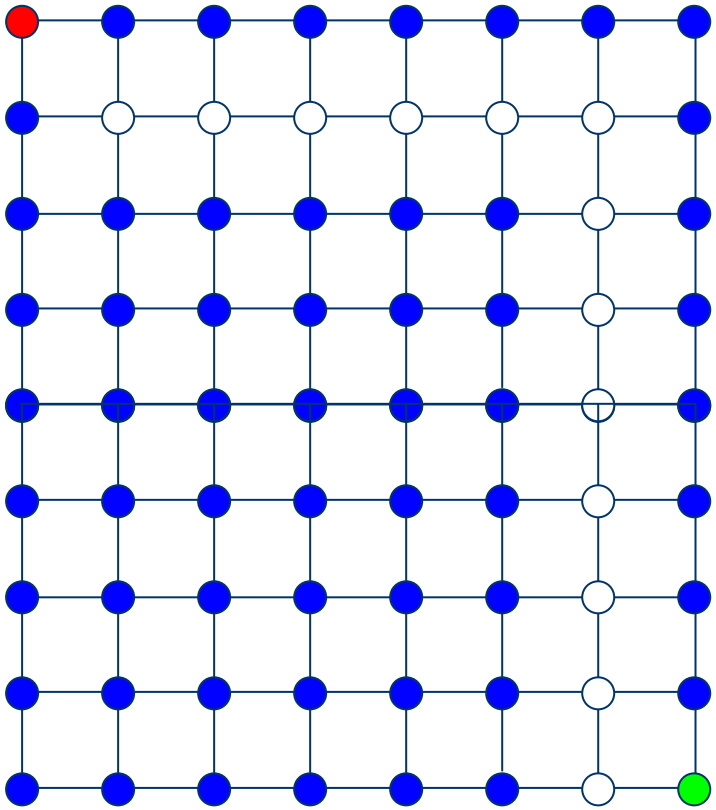


- Update H(B,T)= 2 + C(C,B).
- Next Round: S→B

GEAR: Analysis

- ☑ Delivery Guarantee
- ☑ Load Balancing
- ☑ Routing around Holes
- But
  - Can get stuck in local minima while routing
  - Basically implements Q-Learning (AI)
  - $\Omega(n^2)$ Convergence time in worst case.

GEAR: Bad Case



GEAR: Results

- 50 to 100% increase over GPSR in number of packets transmitted before network partition.
- 50% increase over GPSR in number connected pairs after network partition.
- 25 to 45% increase in the average path length taken by a packet.

Conclusion

- Both rely on geographic information to speed up routing.
- Use different techniques to route around holes.
- GEAR tries to automatically load balance the network traffic when routing around holes.

- Any questions?