Overview of Unicast Routing Protocols for Multihop Wireless Networks

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Controlling Flooding Using Location Information

Flooding of Control Packets

- How to reduce the scope of the route request flood ?
  - LAR [Ko98Mobicom]
  - Query localization [Castaneda99Mobicom]
- How to reduce redundant broadcasts ?
  - The Broadcast Storm Problem [Ni99Mobicom]

Location-Aided Routing (LAR) [Ko98Mobicom]

- Exploits location information to limit scope of route request flood (similar to *paging* in cellular)
  - Location information may be obtained using GPS

- *Expected Zone* is determined as a region that is expected to hold the current location of the destination
  - Expected region determined based on potentially old location information, and knowledge of the destination's speed

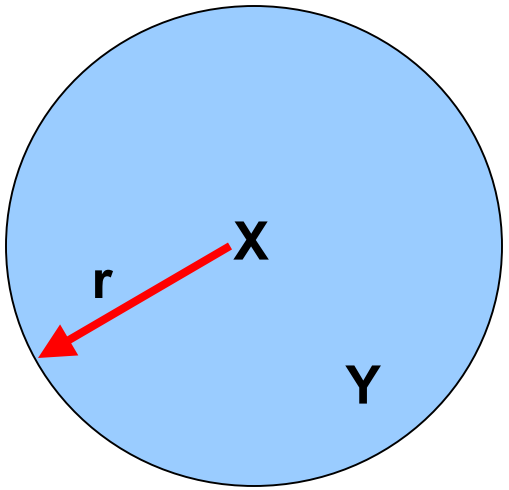
- Route requests limited to a *Request Zone* that contains the Expected Zone and location of the sender node

Expected Zone in LAR

X = last known location of node
D, at time t0

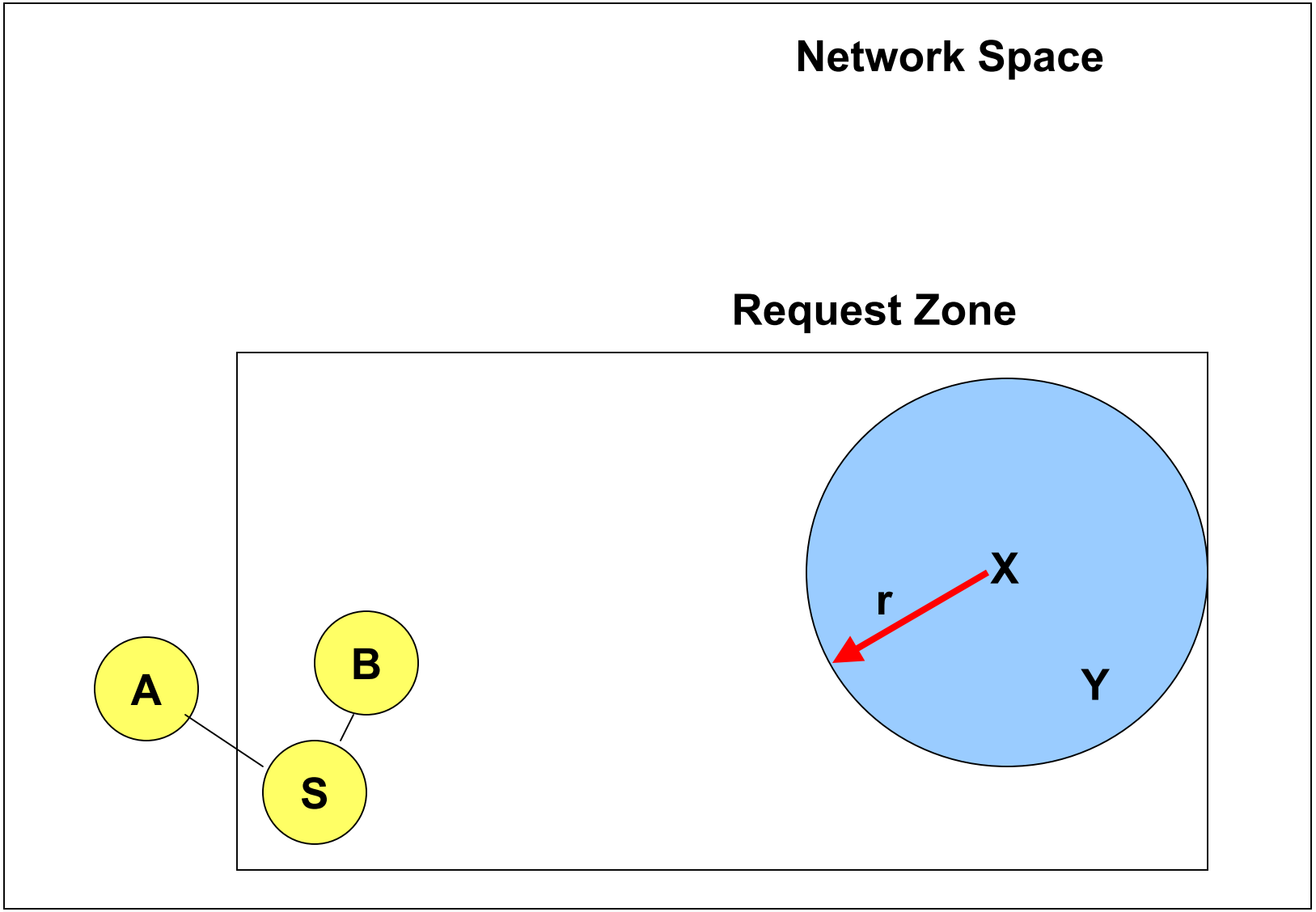
Y = location of node D at current
time t1, unknown to node S

r = (t1 - t0) * estimate of D's speed



Expected Zone

Request Zone in LAR



LAR

- Only nodes within the request zone forward route requests
  - Node A does not forward RREQ, but node B does (see previous slide)
- Request zone explicitly specified in the route request
- Each node must know its physical location to determine whether it is within the request zone

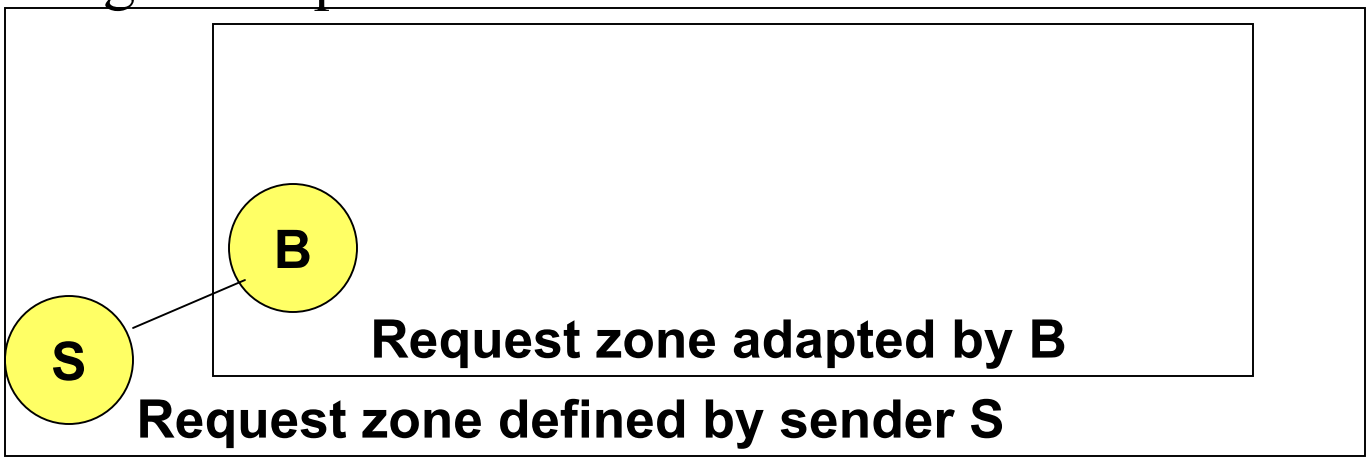
LAR

- Only nodes within the request zone forward route requests
- If route discovery using the smaller request zone fails to find a route, the sender initiates another route discovery (after a timeout) using a larger request zone
  - the larger request zone may be the entire network
- Rest of route discovery protocol similar to DSR

LAR Variations: Adaptive Request Zone

- Each node may modify the request zone included in the forwarded request

- Modified request zone may be determined using more recent/accurate information, and may be smaller than the original request zone



LAR Variations: Implicit Request Zone

- In the previous scheme, a route request explicitly specified a request zone
- Alternative approach: A node X forwards a route request received from Y if node X is deemed to be closer to the expected zone as compared to Y
- The motivation is to attempt to bring the route request physically closer to the destination node after each forwarding

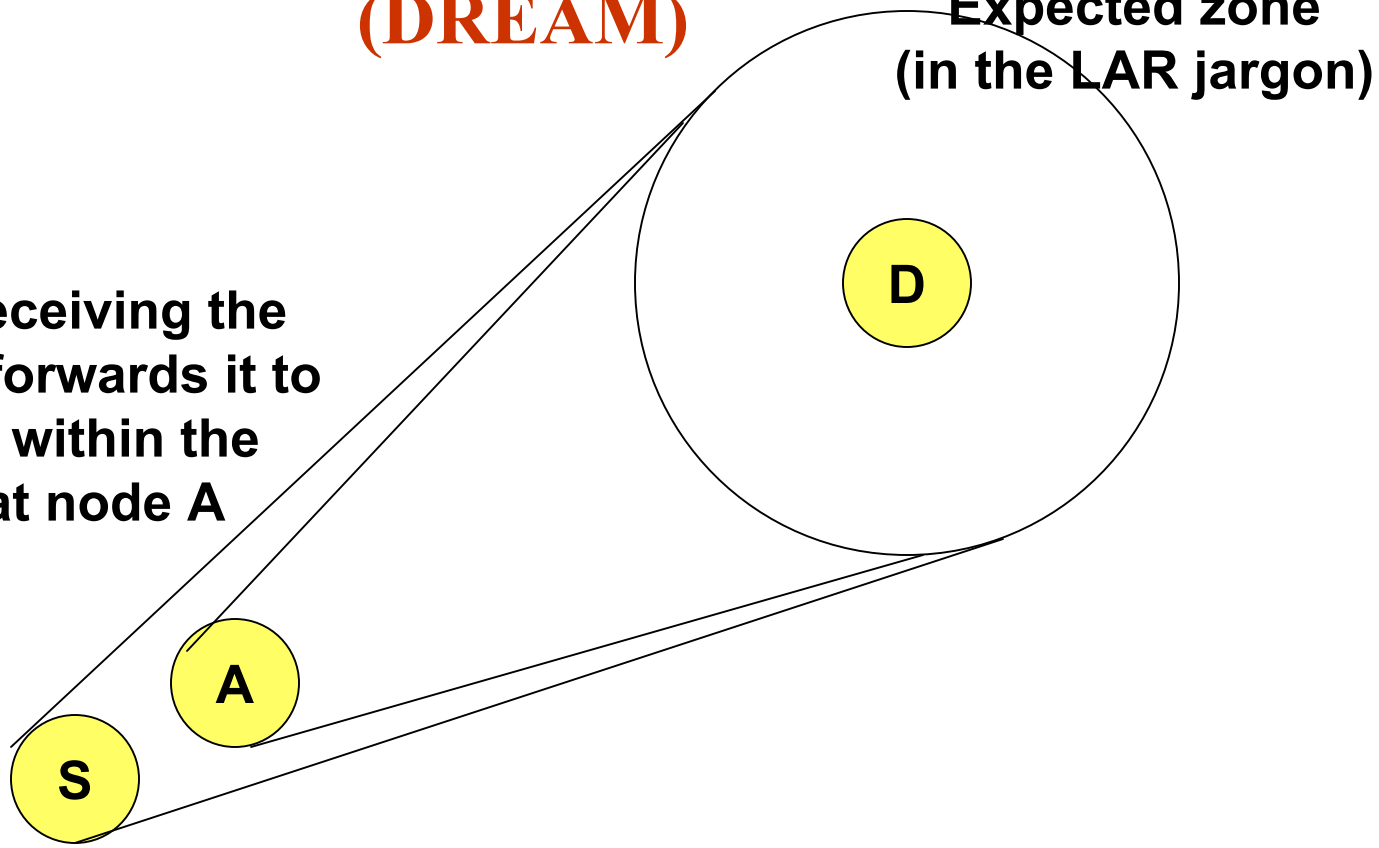
Location Aided Routing (LAR)

- Advantages
  - reduces the scope of route request flood
  - reduces overhead of route discovery
- Disadvantages
  - Nodes need to know their physical locations
  - Does not take into account possible existence of obstructions for radio transmissions

Distance Routing Effect Algorithm for Mobility (DREAM) [Basagni98Mobicom]

- Uses location and speed information (like LAR)
- DREAM uses flooding of *data packets* as the routing mechanism (unlike LAR)
  - DREAM uses location information to limit the flood of data packets to a small region

Distance Routing Effect Algorithm for Mobility (DREAM)



Node A, on receiving the data packet, forwards it to its neighbors within the cone rooted at node A

S sends *data packet* to all neighbors in the cone rooted at node S

Distance Routing Effect Algorithm for Mobility (DREAM)

- Nodes periodically broadcast their physical location
- Nearby nodes are updated more frequently, far away nodes less frequently
- Distance effect: Far away nodes seem to move at a lower angular speed as compared to nearby nodes

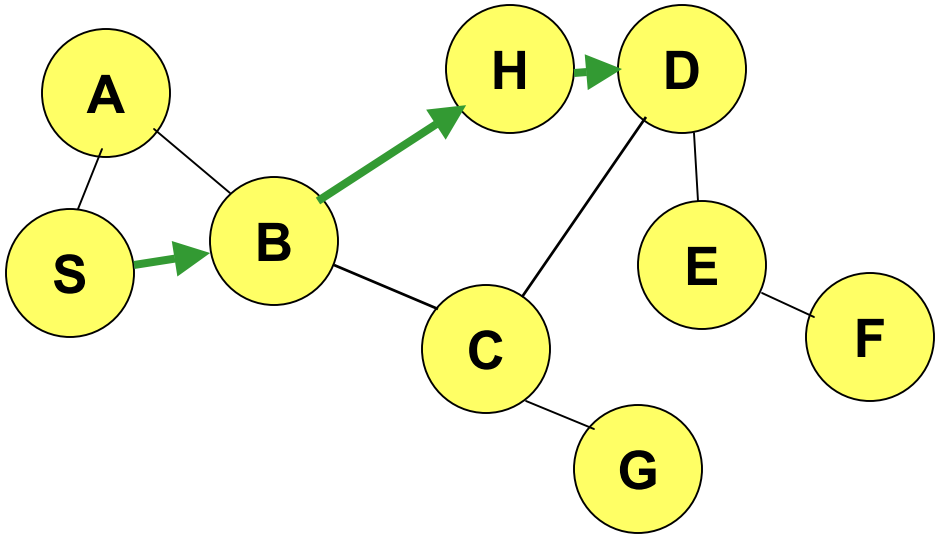
Geographic Routing

Geographic vs. Topology- based Routing

- Two extremes:
  - Topology-based routing e.g. DSR and AODV (initial slide set)
  - Geographic routing e.g. GEDIR, TBF (next slides)
- Middle ground:
  - Location aided routing e.g. DREAM (previous slides)

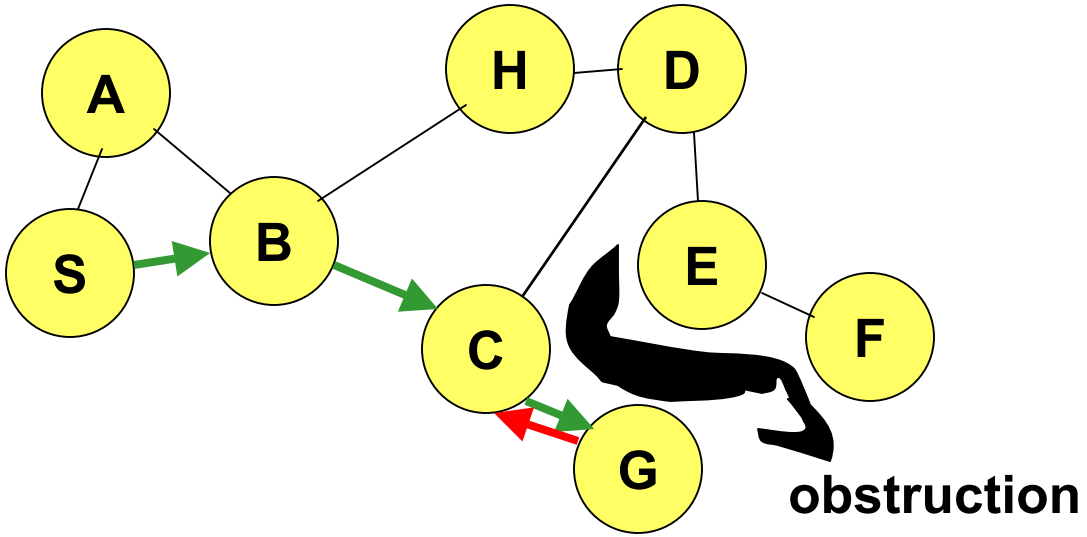
Geographic Distance Routing (GEDIR) [Lin98,Stojmenovic01]

- Location of the destination node is assumed known
- Each node knows location of its neighbors
- Each node forwards a packet to its neighbor closest to the destination
- Route taken from S to D shown below



Geographic Distance Routing (GEDIR)

- The algorithm terminates when same edge traversed twice consecutively
- Algorithm fails to route from S to E
  - Node G is the neighbor of C who is closest from destination E, but C does not have a route to E



Routing with Guaranteed Delivery

- Improves on GEDIR [Lin98]
- Guarantees delivery (using location information) provided that a path exists from source to destination
- Routes *around* obstacles if necessary
- A similar idea also appears in [Karp00Mobicom]

Trajectory-Based Forwarding [Nieuleseu03]

- Route a packet along a predefined curve
- Intended use: Dense sensor networks
- Similar to source-routing (the source defines the curve)
- Nodes that happen to be around the curve use Cartesian-based information to forward packets

References

1. [Basagni98Mobicom] **AS. Basagni et al., "A distance routing effect algorithm for mobility (DREAM),"** *Proceedings of Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom'98)*, 1998, p 76-84
2. [Ko98Mobicom] Young-Bae Ko and Nitin H. Vaidya, "Location-Aided Routing (LAR) in mobile ad hoc networks," Wireless Networks, Vol.6, 2000.
3. [Niculescu03] D. Niculescu and B. Nath, "Trajectory based forwarding and its applications," Proceedings of MobiCom 2003, San Diego, CA, September 2003.
4. [Stojmenovic01] *Stojmenovic, I.; Xu Lin* "**Loop-free hybrid single-path/flooding routing algorithms with guaranteed delivery for wireless networks**" Parallel and Distributed Systems, IEEE Transactions on , Volume: 12 Issue: 10 , Oct. 2001 Page(s): 1023 -1032
5. [Karp00Mobicom] Brad Karp , H. T. Kung **GPSR: greedy perimeter stateless routing for wireless networks** **Proceedings of the sixth annual international conference on Mobile computing and networking** August 2000