Mobile Networking

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ROUTING PROTOCOLS IN MOBILE AD HOC NETWORKS

Distance Vector Based Routing

- Each node maintains a table giving the distance from itself to all possible destination.
- Periodically broadcasts update packets to each of the neighbors.
- Bellman-Ford algorithm
  - Finding the shortest path to determine the correct next hop of its neighbors.
- Routers forward the packet to the correct next hop router given their tables
- **Problem**: “route looping” and “count to infinity”

Link State Routing Algorithm

- Each node maintains a view of the network topology with a cost for each link.
- Each node periodically broadcasts the cost of its outing links to all other nodes.
- Using a shortest-path algorithm to choose its next hop for each destination.

Ad hoc Routing Protocols: Classification

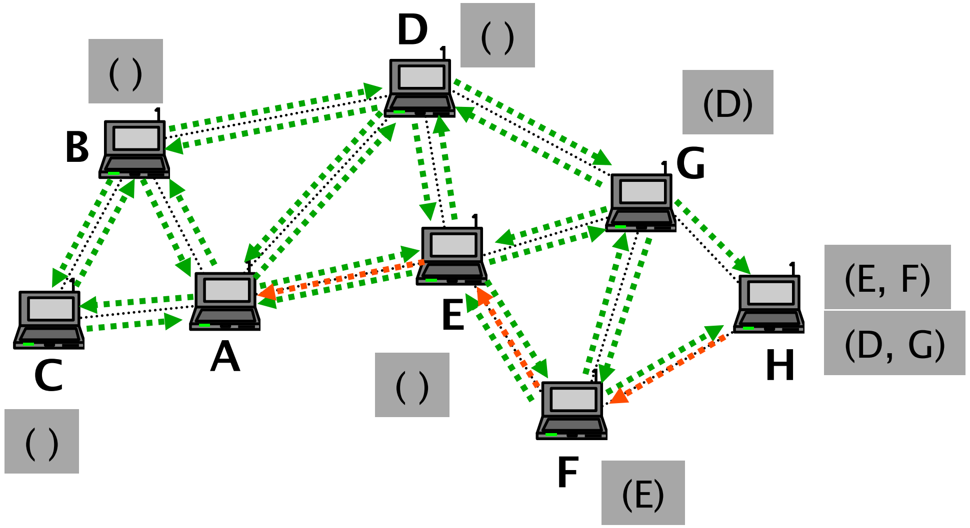
- **Topology-based protocols**
  - Proactive (Always up-to-date routing information)
    - Distance vector based (e.g., DSDV)
    - Link-state (e.g., OLSR)
  - Reactive (on-demand)
    - Distance vector based (e.g., AODV)
    - Source routing (e.g., DSR)
- **Position-based protocols**
    - greedy forwarding (e.g., GPSR, GOAFR)
    - restricted directional flooding (e.g., DREAM, LAR)
- **Hybrid approaches**

Dynamic Source Routing (DSR)

- On-demand source routing protocol

- Two components:
  - Route discovery
    - used only when source S attempts to send a packet to destination D
    - based on flooding of Route Requests (RREQ) and returning Route Replies (RREP)
  - Route maintenance
    - makes S able to detect route errors (e.g., if a link along that route no longer works)

DSR Route Discovery Illustrated



A → *: [RREQ, id, A, H; ()]
B → *: [RREQ, id, A, H; (B)]
C → *: [RREQ, id, A, H; (C)]
D → *: [RREQ, id, A, H; (D)]
E → *: [RREQ, id, A, H; (E)]
F → *: [RREQ, id, A, H; (E, F)]
G → *: [RREQ, id, A, H; (D,G)]

H → A: [RREP, <source route>; (E, F)]

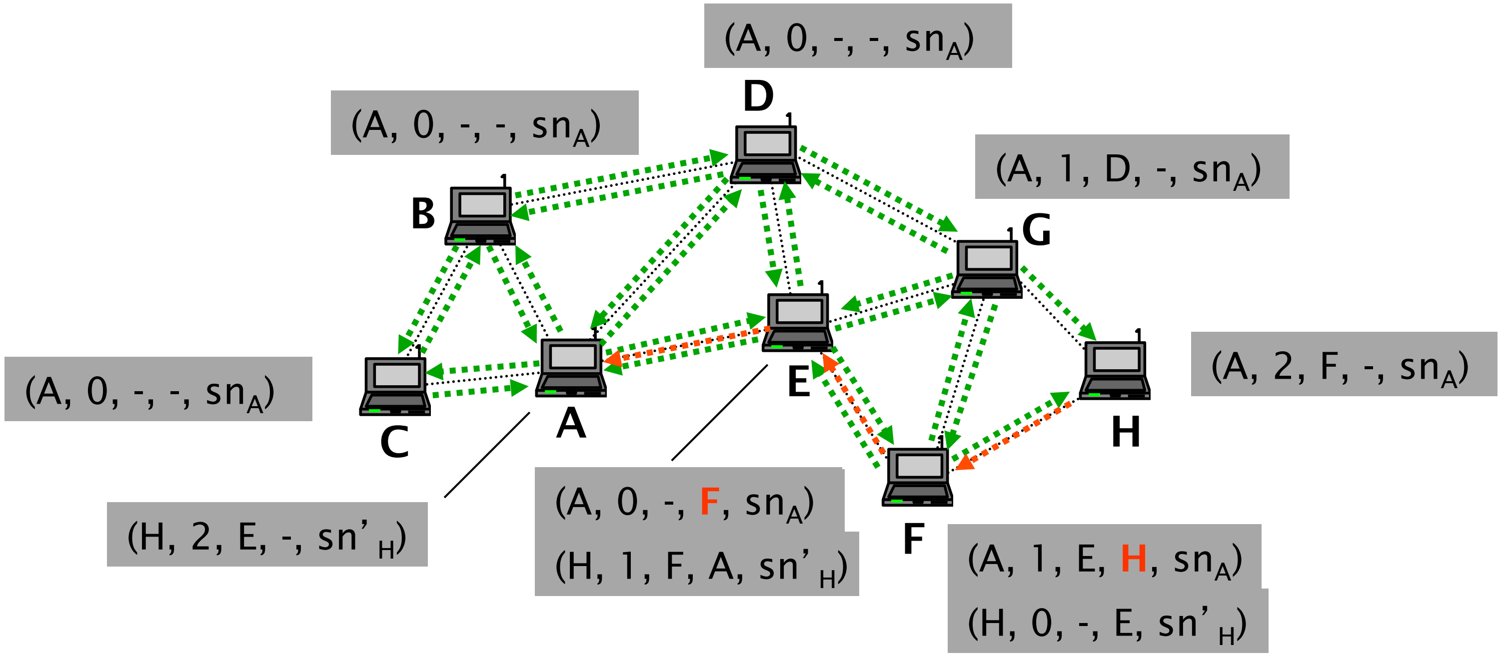
where <source route> is obtained

1. From the route cache of H
2. By reversing the route received in the RREQ
   - works only if all the links along the discovered route are bidirectional
   - IEEE 802.11 assumes that links are bidirectional
3. by executing a route discovery from H to A
   - discovered route from A to H is piggy backed to avoid infinite recursion

Ad-hoc On-demand Distance Vector Routing (AODV)

- On-demand distance vector routing
- Uses sequence numbers to ensure loop-freedom and to detect out-of-date routing information
- Operation is similar to that of DSR **but the nodes maintain routing tables** instead of route caches
- **A routing table entry contains the following:**
  - destination identifier
  - number of hops needed to reach the destination
  - identifier of the next hop towards the destination
  - list of precursor nodes (that may forward packets to the destination via this node)
  - destination sequence number

AODV Route Discovery Illustrated



A → *: [RREQ, id, A, H, 0, sn_A, sn_H]
B → *: [RREQ, id, A, H, 1, sn_A, sn_H]
C → *: [RREQ, id, A, H, 1, sn_A, sn_H]
D → *: [RREQ, id, A, H, 1, sn_A, sn_H]
E → *: [RREQ, id, A, H, 1, sn_A, sn_H]
F → *: [RREQ, id, A, H, 2, sn_A, sn_H]
G → *: [RREQ, id, A, H, 2, sn_A, sn_H]

H → F: [RREP, A, H, 0, sn'_H]
F → E: [RREP, A, H, 1, sn'_H]
E → A: [RREP, A, H, 2, sn'_H]

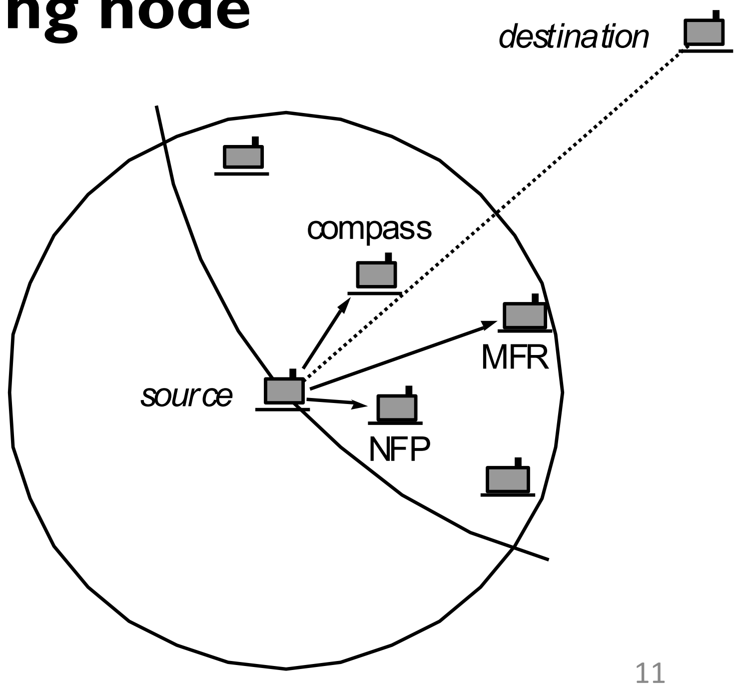
Proactive Routing

1. **Link-State Protocols**
   – Each node periodically floods the network with a message that contains the state of the links of that node (OLSR in MANET)
2. **Distance Vector Protocols**
   – Nodes execute a distributed shortest path algorithm to determine the best route to every other node in the network (DSDV in MANET)

Example: Position-based Greedy Forwarding

- **Assumptions**
  - nodes are aware of their own positions and that of their neighbors
  - packet header contains the position of the destination

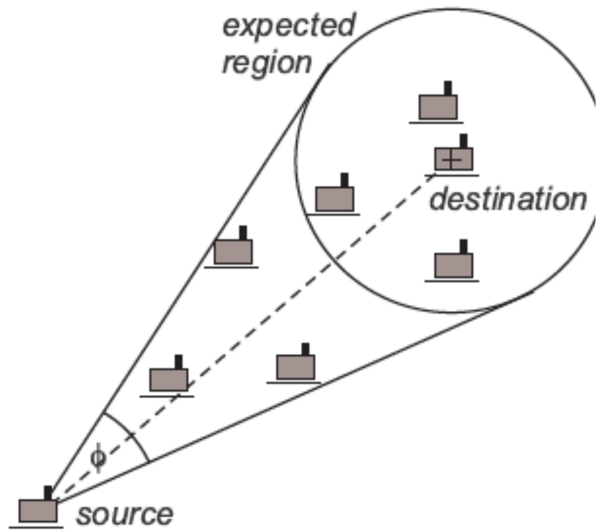
- **Packet is forwarded to a neighbor that is closer to the destination than the forwarding node**
  - Most Forward within Radius (MFR)
  - Nearest with Forward Progress (NFP)
  - Compass forwarding
  - Random forwarding



- **Additional mechanisms are needed to cope with local minimums (dead-ends)**

Distance Routing Effect Algorithm for Mobility (Dream)

- An expected region of the destination is calculated.
- The direction to the destination is defined by the line between the forwarding node and the center of the destination's expected region, and the angle Φ.
- Each neighbor of the forwarding node that lies within this angle must re-broadcast the packet.
- These calculations are repeated by each intermediate node that receives the packet until it reaches the destination.



Location Aided Routing (LAR)

- The source of the data packet calculates an expected region of the destination, and then the packet is flooded within the rectangular region.
- Nodes outside this region will drop packets