

# Lecture 13: Routing in multihop wireless networks

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# Routing in multihop networks

- Figure out a path from source to destination.
- Basic techniques of routing over multiple hops (wired or wireless):
  - Link-state (LS) routing: propagate information about your neighbors to everyone in the network. With the complete network topology, every node computes shortest paths. Lots of overhead in flooding information, but no convergence issues. The default protocol used for intra-domain routing (e.g., OSPF) in wired networks.
  - Distance vector (DV) routing: propagate information about all destinations you know (including yourself) to your neighbors. Suffers from the “count to infinity” problem in the basic version. Split horizon and other techniques fix the count to infinity problem. A variant of distance vector called path vector is used for inter-domain routing (BGP) in wired networks.

# Routing protocols in multihop wireless networks

- In this lecture, we will learn about the following protocols:
  - Destination Sequenced Distance Vector (DSDV): a variation of DV that overcomes the count-to-infinity problem in wireless networks.
  - Dynamic Source Routing (DSR): A source routing based scheme.
  - Adhoc On-demand Distance Vector (AODV): combines ideas from DSR and DSDV.
- Briefly discuss other topics: routing metrics (hop count vs. ETX), geographic routing, routing security.
- Please see the references for more detail on each of these routing protocols.

# Basic terminology

- A route has 3 main components:
  - The destination to which it leads to
  - The next hop along the path to the destination, to which we must forward data
  - A metric (e.g., hop count) that indicates the desirability of the route
- A routing table is a list of routes to all possible destinations.
- A forwarding table is a summary of the routing table by considering the best routes to be used for forwarding.

# DSDV

- Classic DV suffers from count-to-infinity problem. The standard fix is split horizon routing, where you do not announce a route advertised by router X back on the link to X. However, wireless broadcast medium has no notion of a link, so split horizon does not work.
- Fix in DSDV: use sequence numbers to denote freshness of routes. Destinations update sequence numbers if some major change in their state has occurred.
- Update your routing table entry only if:
  - A route of a higher sequence number appears OR
  - A route of the same sequence but better metric appears

## DSDV (2)

- Periodically, every node broadcasts for each destination (including itself):
  - Destination address
  - Sequence number
  - Metric
- Routing updates are also triggered by significant events such as updated best routes.
- Pro: finds good paths in a loop-free manner
- Con: Lots of overhead in terms of periodic routing broadcasts.

# DSR

- Source routing: the source discovers the route and places the complete path in each packet. Intermediate routers only need to follow the path.
- DSR has two steps: route discovery and route maintenance.
- Route discovery: when a source S has to send a packet to destination D, it broadcasts a route request (RREQ) packet to all its neighbors. Every RREQ has a unique id.
- Every neighbor appends itself to the path, increments metric, and forwards the route request.
- A node does not follow a route request if it has already seen it.
- When the route request reaches destination D, it picks the best path, and sends this path back to the source in a route reply (RREP).

## DSR (2)

- Route maintenance: if any node notices large losses while using a route, it informs the source, which starts a new route discovery with the next sequence number.
- Pro: Every packet has the complete path, so intermediate routers keep no state. Con: extra overhead in each packet.
- Pro: Route discovery is only initiated when there is a need, and only at the routers that are likely to be in the path. Con: first packet has a large delay due to the overhead of route discovery.



# AODV

- Combines the best of DSDV and DSR.
- Route discovery only when needed (RREQ, RREP)
- However, distance vector type routing table entries are setup during route discovery.
  - Every node that receives the RREQ from source sets up reverse path routing table entries pointing to the source.
  - Similarly, every node that receives RREP sets up routing table entries pointing to the destination on the forward path.
- That is, RREQ and RREP also serve as route advertisements in DV.
- There is also a sequence number associated with source and destination corresponding to the seq no. in DSDV.

# Multihop routing metrics

- Many possible metrics.
- Simple: HOP count between two nodes. Pick the path with least number of hops.
- More sophisticated metrics: expected number of transmissions ETX (accounting for link-layer losses), or expected transmission time ETT (accounting for different bit rates)
- Load based metrics like RTT are not preferred as they cause oscillations.

# Geographic routing

- Another routing technique where you use geographic coordinates to forward traffic.
- All nodes know the geographic coordinates of each other.
- To send a packet to a destination, you send it to a node that is geographically closer than yourself.
- Many proposals in this space. We will not cover these. The goal here is to introduce the basic notion.

# Security

- Multihop routing protocols are vulnerable to many security attacks (much like wired routing protocols like BGP)
- For example, a malicious node can falsely announce that it has a short path to a destination, and attract traffic to flow through it (after which it can eavesdrop, alter, or drop the traffic).
- Implementing hop-by-hop authentication (to check validity of next hop) or source authentication (to check a node is who it claims to be) requires cryptographic solutions that depend on knowing cryptographic keys of each other.