Routing in Ad Hoc Networks

Networks of nodes that just happen to be near each other are called **ad hoc networks** or **MANETs** (**Mobile Ad hoc NETworks**). In all these cases, and others, each node communicates wirelessly and acts as both a host and a router.

- With an ad hoc network, the topology may be changing all the time, so the desirability and even the validity of paths can change spontaneously without warning. Needless to say, these circumstances make routing in ad hoc networks more challenging than routing in their fixed counterparts.

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AODV

- We will look at one of the most popular routing algorithms, **AODV** (**Ad hoc On-demand Distance Vector**) (Perkins and Royer, 1999). It is a relative of the distance vector algorithm that has been adapted to work in a mobile environment, in which nodes often have limited bandwidth and battery lifetimes.

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AODV: Route Discovery

- In AODV, routes to a destination are discovered on demand.
- At any instant, the topology of an ad hoc network can be described by a graph of connected nodes. Two nodes are connected (i.e., have an arc between them in the graph) if they can communicate directly using their radios.

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AODV: Route Discovery

- Suppose that a process at node *A* wants to send a packet to node *I*. *A* looks in its table and does not find an entry for *I*. It now has to discover a route to *I*.
- To locate *I*, *A* constructs a **ROUTE REQUEST** packet and broadcasts it using flooding.
- Eventually, the request reaches node *I*, which constructs a **ROUTE REPLY** packet. This packet is unicast to the sender along the reverse of the path followed by the request.

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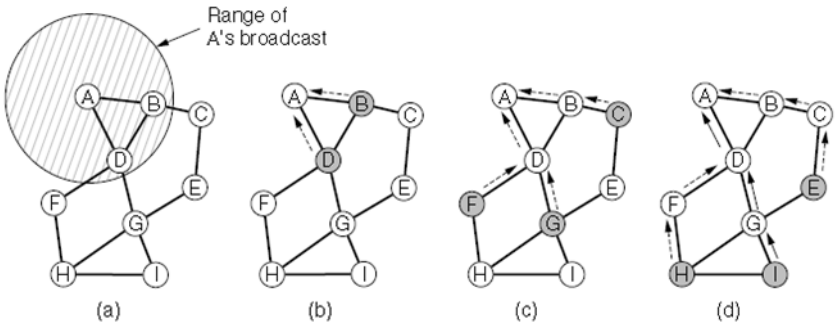
AODV: Route Discovery



- each intermediate node must remember the node that sent it the request. The arrows in Fig. show the reverse route information that is stored.

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AODV: Route Discovery

- In a large network, the algorithm generates many broadcasts, even for destinations that are close by. To reduce overhead, the scope of the broadcasts is limited using the IP packet's ***Time to live*** **field.**
- The route discovery process is then modified as follows. To locate a destination, the sender broadcasts a ROUTE REQUEST packet with *Time to live* set to 1. If no response comes back within a reasonable time, another one is sent, this time with *Time to live* set to 2. Subsequent attempts use 3, 4, 5, etc.

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AODV: Route Maintenance

Because nodes can move or be switched off, the topology can change spontaneously.

1. Periodically, each node broadcasts a *Hello* message. Each of its neighbors is expected to respond to it. If no response is forthcoming, the broadcaster knows that that neighbor has moved out of range or failed and is no longer connected to it.
2. Similarly, if it tries to send a packet to a neighbor that does not respond, it learns that the neighbor is no longer available.

"This information is used to purge routes that no longer work."

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AODV: Route Maintenance

- For each possible destination, each node, *N*, keeps track of its active neighbors that have fed it a packet for that destination during the last ΔT seconds.
- When any of *N*'s neighbors becomes unreachable, it checks its routing table to see which destinations have routes using the now-gone neighbor.
- For each of these routes, the active neighbors are informed that their route via *N* is now invalid and must be purged from their routing tables.
- In the general case, the active neighbors tell their active neighbors, and so on, recursively, until all routes depending on the now-gone node are purged from all routing tables.

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AODV: Route Maintenance

In the spirit of an on demand protocol, intermediate nodes only store the routes that are in use. Other route information learned during broadcasts is timed out after a short delay.

- Discovering and storing only the routes that are used helps to save bandwidth and battery life compared to a standard distance vector protocol that periodically broadcasts updates.

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AODV: Route Maintenance

To further save resources, route discovery and maintenance are shared when routes overlap.

- For instance, if *B* also wants to send packets to *I*, it will perform route discovery. However, in this case the request will first reach *D*, which already has a route to *I*. Node *D* can then generate a reply to tell *B* the route without any additional work being required.

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