Routing in Ad Hoc Networks

Anne Saaranen
Routing Protocols, Categories

Table-driven or proactive protocols
- WRP
- DSDV
- DREAM
- GSR
- HSR
- FSR
- LANMAR
- Spine based routing protocols
- OLSR

On demand or reactive protocols
- AODV
- SARA
- TORA
- SSA
- LAR
- CBRP
- ROAM
- RDMAR

Hybrid protocols
- CEDAR
- ZRP

The lower protocol is a descendant of the upper protocol
Proactive protocols

- Also known as table-driven protocols
- Routes searched and maintained to all destinations in the network
- Optimal routes
- Hop-by-hop routing
- Periodic updates
- OLSR, TBRPF, DSDV, FSR, HSR, ...
Proactive protocols (cont.)

- Mechanisms to limit the number of nodes forwarding routing information
  - Multipoint Relay
  - “fisheye”
Reactive protocols

- On demand protocols
- Route searched after there are packets to the destination
- Routes not necessarily optimal
- Both source routing and hop-by-hop routing used
- AODV, DSR, TORA,...
Reactive Protocols (cont.)

- Route request/reply procedure
  - Return route stored or
  - Route accumulation to RREQ
    - QoS routing, route selection by destination node

- Route break
  - RERR
  - Route repair
Reactive Protocols (cont.)

- Expanding Ring Search
  - DSR
  - AODV
Hierarchical approach

- Network divided into clusters
- Selected clusterhead node in each cluster forms the upper layer of the hierarchy
- Two or more layers
- HSR, CBRP
Hierarchical approach (cont.)

- **Clusterhead election algorithms**
  - Address based
  - Connectivity based

- **Advantages**
  - addressing

- **Disadvantages**
  - complexity
  - clusterhead re-election after topology changes
Proactive Protocols
Destination-Sequence Distance-Vector Routing (DSDV) [Perkins]

- proactive routing protocol, one of the first ones proposed for ad hoc networks
- quite straightforward adaptation of distance vector routing to wireless environment
- sequence numbers used to ensure loop freedom

Distance vector routing: The nodes exchange the information of distance of the destinations. The next hop node towards the destination is the neighbor that reports shortest distance to it.

Routing Information Protocol (RIP) in fixed networks is a distance vector protocol. More information available in [Huitema].
DSDV (cont.)
DSDV (cont.)
Optimized Link State Routing (OLSR) [Clausen]

- Proactive protocol
- Link state routing with optimisations for wireless networks
- Multipoint relays
  - Forward broadcasted topology information
  - Report topology information

Link state routing: The nodes know the entire topology of the network and calculate the routes using this information.

Open Shortest Path First (OSPF) protocol is a link state routing protocol used in fixed networks. [Huitema]
Topology Broadcast Routing with Path Forwarding (TBRPF)[Ogier]

- Proactive protocol
- Neighbour discovery and routing modules
- Only partial topology information exchanged
  - A node reports only nodes for which its neighbours are likely to use this node as a relay
Fisheye State Routing (FSR) [Iwata]

- A proactive routing protocol
- Link state routing
- Based on the usage of fisheye scopes to limit the update frequency
- Routing information gets more accurate near the destination
Landmark Routing Protocol (LANMAR) [Gerla]

- Based on FSR
- Nodes divided into groups
- Landmark associated with each node
- Packets sent towards the landmark
- Routing information more accurate near the destination (as in FSR)
Reactive Protocols
Ad Hoc On-Demand Distance Vector Routing (AODV) \cite{Perkins2}

- reactive routing protocol
- based on DSDV
  - distance vector
  - sequence numbers
- hop-by-hop routing
- route request propagation restrictions
- gratuitous route replies to destination
Dynamic Source Routing (DSR) [Johnson]

- reactive routing protocol
- source routing
- promiscuous mode
- route request
- propagation restrictions
- route shortening
Temporally Ordered Routing Algorithm (TORA) [Park, Perkins3]

- Reactive routing protocol
- Based on link reversal routing algorithm
- Destination oriented directed acyclic graph (DAG) maintained for each destination separately
  - Each node maintains its height to destination
  - Next hop towards the destination is the neighbour that has lower height to destination
- Clock synchronisation
- Can detect partitions
TORA (cont.), link failure
TORA (cont.), network partition
TORA (cont.), network partition (cont.)
Signal Stability based Routing Protocol (SSA) [Dube]

- a reactive protocol
- hop-by-hop routing
- between link and network layers
  - MAC addresses used instead of IP addresses
SSA (cont.)

- Periodic beacons to find neighbours
- Strong channel links vs. weak channel links
  - Based on received signal strength
- Uses only links that are strong enough
  - Under certain circumstances, also weaker links can be used
SSA (cont.)

- RREQ not forwarded, if received over a weak link
- Destination replies to first received RREQ (coming over strong link)
SSA (cont.)

- **RREQ** can have "any link" flag on
  - Also weak links accepted
- **SSA broadcast**
  - Every node processes the packet before rebroadcasting it
Hybrid Protocols
Zone Routing Protocol (ZRP) [Perkins3, Haas]

- hybrid routing protocol
- Routing zones
  - These are not clusters!
- Three components
  - Intrazone Routing Protocol (IARP)
  - Interzone Routing Protocol (IERP)
  - Bordercast Resolution Protocol (BRP)
ZRP IARP

- Proactive component
- Used for nodes inside the routing zone
ZRP I ERP[Haas3]

- Reactive component
- Used for nodes outside the routing zone
ZRP BRP [Haas4]

- Used to reduce the number of nodes forwarding the route request message.
- Message propagated from the node to its peripheral nodes.
ZRP BRP (cont.)

- Propagation restricted using query detection
  - Early Termination (ET)
    - Nodes along the bordercast tree (QD1)
    - All nodes overhearing the bordercast (QD2)
  - No standard IP forwarding for BRP
ZRP BRP (cont.)

Example (QD & ET possibility)
Core-Extraction Distributed Ad hoc Routing (CEDAR) [Sivakumar]

- Selected core nodes
  - Minimum dominating set of the graph
  - Virtual links between core nodes
CEDAR (cont.)

- Increase and decrease waves for link bandwidth changes
- Route request/reply for non-core nodes
  - Core broadcast
Hierarchical Protocol
Hierarchical Link State Routing (HSR)[Pei]

- Network divided into clusters
  - Clusterhead, gateway, internal node

- Logical and Hierarchical addressing
  - Logical
    - <subnetwork, host> like in IP
    - Subnets created using some common characteristic
  - Hierarchical
    - Sequence of MAC addresses of cluster heads and the node itself in different levels
**HSR (cont.)**

- **Home agent**
  - Mobile
  - Identified by network part of logical address
  - Nodes in the top level know the hierarchical addresses of the home agents
HSR (cont.)

- **Advantages**
  - No need to store the topology of the whole network
  - Overhead reduced

- **Disadvantages**
  - Long hierarchical addresses
  - Complexity from cluster formation
Current trends

- Location information in routing
- Power-awareness
- Security issues
- QoS
- Multicasting
- MAC layer issues (directional antennas)
- Cross-layer interaction
- Scalability
- Group communications
References


References


References


References


References


A few web sites

General
http://www.antd.nist.gov/wctg/manet/adhoclinks.html
http://www.cwc.oulu.fi/~hernia/linkit.html

AODV routing protocol
http://moment.cs.ucsb.edu/AODV/aodv.html

IETF/IRTF
http://www.flarion.com/ans-research/