Efficient Routing in PAN and Sensor Networks

Niklas Steinleitner

Email: steinlei@math.uni-goettingen.de

Telematics Group
Institute for Informatics
University of Göttingen, Germany

Presenting Papers

Efficient Routing in PAN and Sensor Networks

(P. Trakadas, Th. Zahariadis, S. Voliotis, Ch. Manasis)

A Novel Route Update Design for Wireless Sensor Networks

(Xuhui Hu, Yong Liu, Myung J. Lee, Tarek N. Saadawi)

Both appeared in

ACM SIGMOBILE Mobile Computing and Communications Review, 8(1), 2004.

Table of Content

- Routing Problems in ad hoc networks
- Routing algorithms classification
- Overview of most important routing algorithms for ad-hoc networks
- Classify them to their relevancy and efficiency, when applied to PANs and sensor networks
  - The 2nd paper, "ERUP" is also classified into one of these categories

Routing Problems

- selecting the optimal path
- broken-down to the selection of the optimal neighbouring (or next hop)
- prevents loops
- Link failure recovery

Generally routing algorithms classification (1)

- Proactive Routing algorithms
  - calculates proactively consistent and up-to-date routing information
  - store that information in routing tables
  - periodically or on-demand exchanged
  - by network topology changes
    - propagate update messages throughout the network
- Reactive Routing algorithms
  - calculates routing information only when data is ready to be transmitted adopting a lazy routing approach
  - calculated path is considered valid as long as the destination is reachable or until the route is no longer needed

Generally routing algorithms classification (2)

- Proactive Routing Algorithms
  - Destination-Sequenced Distance-Vector (DSDV)
  - Wireless Routing Protocol (WRP)
  - Fisheye State Routing (FSR)
  - Hierarchical State Routing (HSR)

- Reactive Routing Protocols
  - Signal Stability Adaptive Routing (SSR)
  - Temporally Ordered Routing Algorithm (TORA)
  - Ad Hoc On-Demand Distance Vector Routing (AODV)
  - Efficient Route Update Protocol (ERUP)

Destination-Sequenced Distance-Vector (DSDV)

- Proactive, table-driven
- Based on Bellman-Ford Routing (distance-vector-algorithm)
- Maintains in each node
  - routing table
  - the number of hops
  - sequence number
- Sends
  - periodically the full routing table (“full dump”)
  - by changes the modified entries (“incremental update”)
- update packet contains an unique sequence number
  - transmitter assigns this SN
  - receiver selected highest SN (otherwise route with best cost metric is selected)
- Advantage / Disadvantage

  In fast changing networks, like sensor networks, the number of incremental packets increases rapidly, then full dumps are preferred
  - In relative stable networks like Wireless PAN, incremental updates are sent to avoid extra traffic
  - Requires bidirectional links to operate

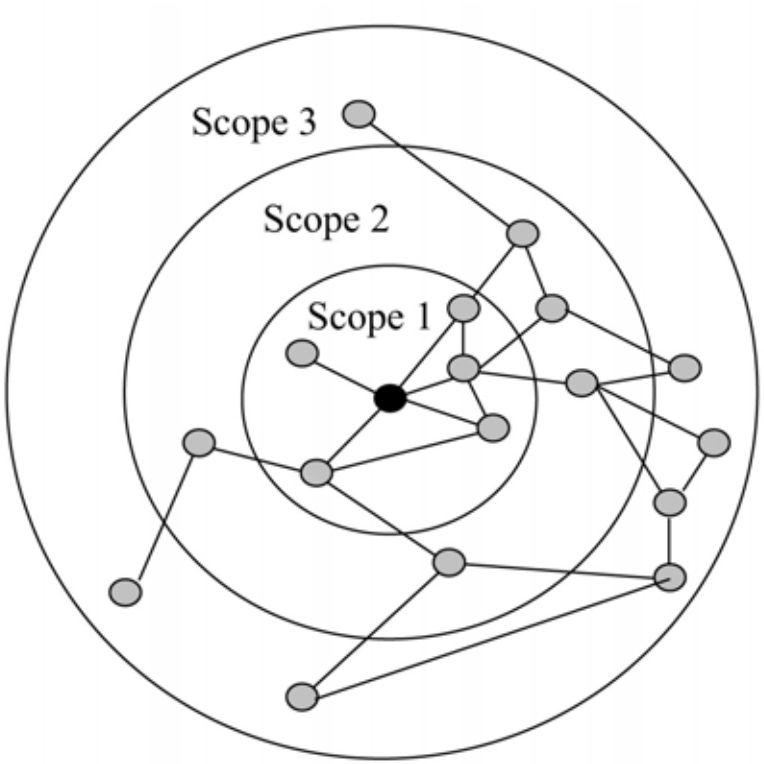
Wireless Routing Protocol (WRP)

- Proactive, table-driven
- Maintains in each nodes
  - the Distance table
  - the Routing table
  - Link Cost table
  - and a Message Retransmission List
- Periodically or by link status changes
  - exchange routing tables with their neighbours using update messages
  - in case of no changes, sends an idle “Hello” message
- By receiving an update message
  - modifies its distance table
  - Acknowledge message is returned to the source
- Message Retransmission List contains information which of its neighbour has not acknowledged its update message

Fisheye State Routing (FSR)

- Proactive, table-driven algorithm
- enhances the Global State Routing (GSR) algorithm (a similar approach to DSDV)
- But lowers updating overheads and enables network scaling with large number of nodes
- Update information about the near (neighbouring) nodes sent more frequently than information about far nodes to reduce the packet size
- Near is defined by a radius, which is expressed as the number of Hops to the node
- Quality of the routing information decreases with each further node

Fisheye State Routing (FSR)



Precision of the information in FSR decreases to the edge

Hierarchical State Routing (HSR)

- Proactive algorithm
- Partitions the network nodes into multi-layer clusters
- In each cluster one node is cluster-parent
- Cluster-parents are organized into a higher-level of clusters and so forth
- Generating a tree-like hierarchy
- Some nodes belong to more than one cluster and are called gateways
- Each node has a network address (gateways more than one)
- If routing information is modified
  - Each node broadcasts information in their cluster
  - Cluster-parent forwards to all neighbouring cluster-parents
  - Which in return flood the information to their lower layers

Signal Stability Adaptive Routing (SSR)

- Now we start with the first reactive routing protocol in discussion
- SSR calculates a route between two nodes based on the stronger connectivity, which is calculated as the signal strength and stability of the nodes
- Maintains two tables
  - A Signal Stability Table (SST), stores the signal strength of neighbouring nodes
  - A Routing Table (RT), stores recent routes
- Routing in SSR is split in two internal protocols
  - Dynamic Routing Protocol (DRP), administers SST
  - Static Routing Protocol (SRP), administers RT
- Routing Steps
  - Received and processed by the DRP
  - DRP updates SST and forwards the packets to the SRP
  - SRP looks up the destination in the RT
    - In case of a valid entry it forwards the packets
    - Otherwise, it initiates a route-search

Signal Stability Adaptive Routing (SSR), cont'd

- If a node receives a route-request packet, it forwards the packet to the next hop only if
  - the packet is received over a channel with stronger signal strength
  - and has not been previously processed
- The destination node sends a route-reply message back to the initiator, in acceptance that the first packet arrived over the shortest path
- Based on this route-reply message, routes along the path update their routing tables

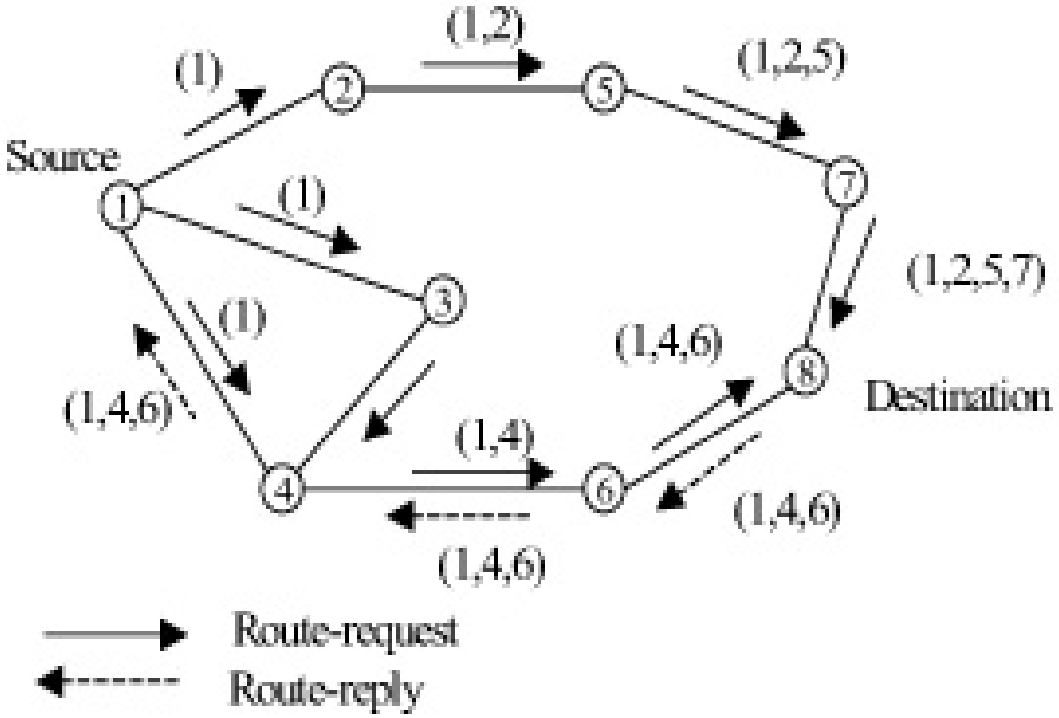
Temporally Ordered Routing Algorithm (TORA)

- Reactive protocol, highly adaptive, distributed and scalable algorithm
- Based on the concept of link reversal
- presupposes same time base on all nodes
- TORA has three basic functions
  - Route creation
  - Route maintenance
  - Route erasure
- This functionality is available with help from three control packets
  - query (QRY) : creates the paths
  - update (UPD) : used for path finding and path maintenance
  - clear : used for path erasure
- Advantages / Disadvantages
  - TORA is the most elegant and complicated approach for solving Routing Problems
  - TORA creates a couple of alternative ways to destination
  - In large, fast changing networks TORA is worse than other protocols
  - Overhead in case of reconfiguration after link failure

Ad Hoc On-demand Distance Vector Routing (AODV)

- Simple Reactive algorithm
- Improves table driven DSDV
- Instead of maintaining a list of tables, AODV minimizes the number of broadcasts by creating routes on demand
- Based only on symmetric bi-directional links
- If route required
  - broadcasts route-request packets (RREQ) to neighbours and so on
  - records the visited nodes in packet
  - destination chooses the shortest path and sends reply packet (RREP)
  - intermediate nodes enter route into their routing tables
- On link failure or source changes, the algorithm is re-initiated (RERR)

Ad Hoc On-demand Distance Vector Routing (AODV)

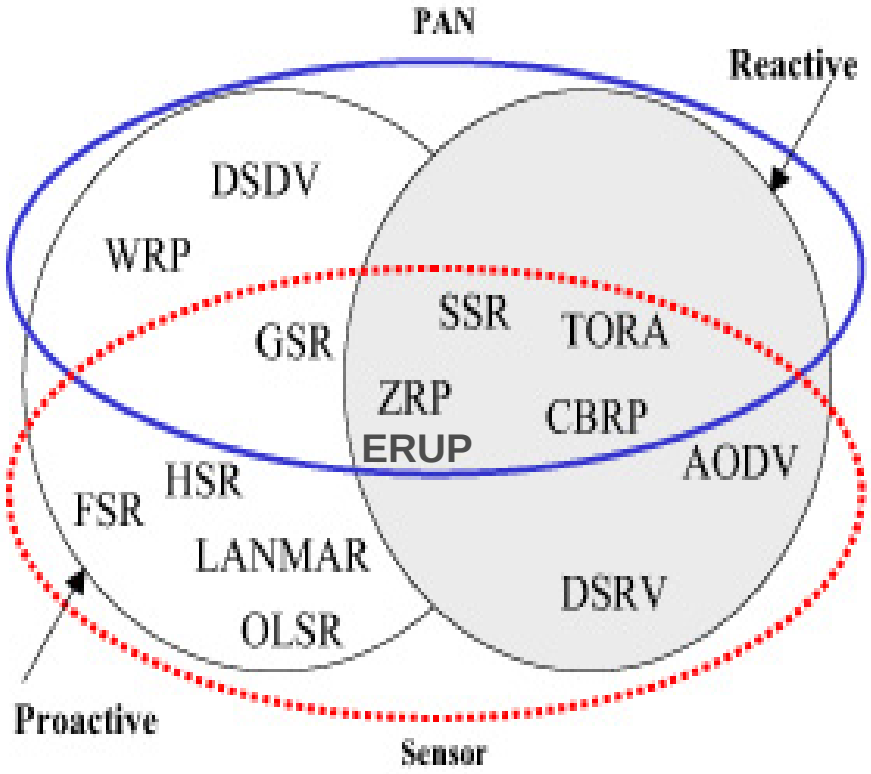


Example of AODV route creation

Efficient Route Update Protocol (ERUP)

- Based on AODV
- Combines routing with power saving
- Route update divided in two steps
  - Node along old route broadcast locally a Route Discovery Region packet (RDR)
  - That defines the spreading area of Route Request packets (RRQ)
  - Source node released RRQ, only nodes within RDR can rebroadcast RRQ
- So update activities are confined to a narrow strip exactly covering the old route
- Makes discovery overhead very small
- New Route mostly overlaps the old route
- Each node sends a warning signal when its power falls down
- source initiate the route update process, when
  - 70 % nodes along the path have sends warnings
  - A “powerful" node enters an active route
  - A node is out of order

Summary


PAN
Reactive
DSDV
WRP
GSR
SSR
TORA
ZRP
CBRP
ERUP
AODV
HSR
FSR
LANMAR
DSRV
OLSR
Proactive
Sensor

Summary, cont'd

- presented the most important algorithms for PAN and sensor networks
- gave a short overview of their functionality, their problems and their solutions
- for the most protocols there are only laboratory setups,
  they are never/rarely tested in the real world

- none of these protocols covers all applications
  they all have their advantages and their disadvantages, for example
  - some protocols required bidirectional links
  - other only can used for sensor or PAN networks
  - or can only for relative stable networks
  - ...

The final selection should be based on the specific network application!

Thank you for your interest !