Power-Aware Ad Hoc Routing

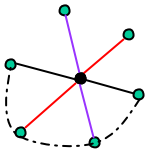
Mobicom98 paper “Power-Aware Routing in Ad Hoc Networks” by Singh, Woo, and Raghavendra

What is ad hoc routing?

- Routing through cooperating wireless nodes that may be mobile (topology changing).
- Goal: reduce the energy consumption of whole communication system, increasing lifetime of nodes/network until partition
- Route discovery, route maintenance, mobility, per-packet overhead, packet transmission.

The Problem

- Shortest hop routes (black, red, purple) all use the middle nodes resources. Its battery will die early.
- Fairness issue
- Routing through lightly loaded nodes also helps contention.



Ad Hoc Routing Protocols and Usual Metrics

Protocol	Metrics	Message Overhead	Convergence	Protocol Type	Summary
DSR	Shortest Path	High	Passive	Source Routing	Route discovery, Snooping
DSDV	Shortest Path	High	Active	Distance Vector	Routing table exchange
DARPA	Shortest Path, Link Quality	High	Active	Distance Vector	Routing table exchange, Snooping
WRP	Shortest Path	High	Active	Distance Vector	Routing table exchanges
SSA	Location Stability, Link Quality	Moderate	Passive	Source Routing	Route Discovery
TORA	Shortest Path	Moderate	Passive	Link Reversal	Route update packets
SSA	Message and Time overhead	Moderate	Active	Hierarchical, Spine	Route discovery within cluster, Spine routing

Product	Lucent WaveLAN	Proxim RangeLAN2	Aironet 4800
Range open/office	400-600' / 1200' 130' / 300'	700' 400'	500-1800' 100-350'
Thruput	2 Mbps	1.6 Mbps	1-11 Mbps
Price Access point/ PC card	$1295/$295	$500/$200	$1695/$595
Power (mA) send/rec/doze	300/250/15 330/280/9	300/150/5/2	490/280/5
Compatibility	Windows *	WinCE	Windows*
Technology	DSSS	FHSS	DSSS/FHSS

The Listening Problem

This work assumes a MAC layer solution in which nodes power off when can not transmit

- Assumes separate signalling channel for RTS/CTS exhange
- RTS/CTS contain info on length of packet
- Other nodes in neighborhood can predict how long to turn off (no power wasted in eavesdropping)
- Related work: (pagers) base transmits beacon and minislot with ID of nodes with messages waiting. Others turn off. Reservations in 802.11 (schedule).

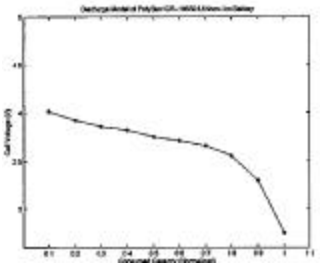
Contribution: New Metrics

- Minimize energy consumed per packet over all packets
  - Light loads same as shortest hop (assumes only variation in energy per hop is due to contention)
  - Routes around congested areas.
- Maximize time to network partition
  - Load balancing among cut-set nodes
- Minimize variance in node power levels
  - Join Shortest Queue (RR if packets of same length)
- Minimize cost per packet over all packets

Cost functions

$f_i(x_i)$ is a function that denotes the node cost of node i (node's reluctance to forward packets)

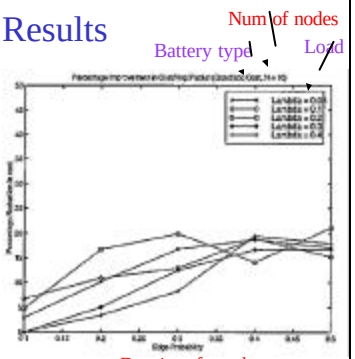
- x_i could be energy used by node so far
- f_i could reflect battery life remaining



Lithium ion discharge

Results

- Simulations comparing shortest-hop and shortest cost
  - no mobility, not simulating route discovery
- metrics: end-to-end delay, ave. cost/packet, ave. max. node cost



Other Factors

- Power consumption requirements increase exponentially with transmission distance.
- Bluetooth power management
  - Receiver Signal Strength Indicator (RSSI) that enables computation of the difference between the received signal and the minimum required signal
- Location Awareness - GPS assisted
  - .75 to 1W active, .03mW backup mode, TTFF 15sec - 3 min (WaveLAN 1.5W receive, 3W send)
  - Role? Reduce flooding in route discovery. More?

Think Globally – Act Locally

- Tension between local resource management and global resource management
  - Goals
  - Ability to influence