Georouting in ad hoc nets

• References:

  • Brad Karp and H.T. Kung “GPSR: Greedy Perimeter Stateless Routing for Wireless Networks”, Mobicom 2000


  • H. Dubois Ferriere et al ”Age Matters: Efficient Route discovery in Mobile Ad Hoc Networks Using Encounter ages”, Mobihoc June 2003
Geo routing – key elements

• Greedy forwarding
  – Each nodes knows own coordinates
  – Source knows coordinates of destination
  – Greedy choice – “select” the most forward node
Finding the most forward neighbor

- Beaconing: periodically each node broadcasts to neighbors own {MAC ID, IP ID, geo coordinates}
- Each data packet piggybacks sender coordinates
- Alternatively (for low energy, low duty cycle ops) the sender solicits “beacons” with “neighbor request” packets
Got stuck? Perimeter forwarding

Figure 2: Greedy forwarding failure. $x$ is a local maximum in its geographic proximity to $D$; $w$ and $y$ are farther from $D$. 
Greedy Perimeter Forwarding

$D$ is the destination; $x$ is the node where the packet enters perimeter mode; forwarding hops are solid arrows;
Figure 9: Packet Delivery Success Rate. GPSR with varying beacon intervals, $B$, compared with DSR. 50 nodes.
GPRS commentary

• Very scalable:
  – small per-node routing state
  – small routing protocol message complexity
  – robust packet delivery on densely deployed, mobile wireless networks

• Outperforms DSR

• Drawback: it requires explicit forwarding node address
  – Beaconsing overhead
  – nodes may go to sleep (on and off)
**Geographic Random Forwarding (GeRaF)**
M. Zorzi and R. R. Rao

- Nodes in turns go to sleep and wake up, source does not know which nodes are on/off

- **Source cannot explicitly address the next hop, must randomly select**

- ideally, the best available node to act as a relay is chosen

- this selection is done a posteriori, i.e., after the transmission has taken place

- it is a receiver contention scheme
Keeping track of on/off nodes

- **Related work**

- **SPAN**: in a dense environment, multiple subnets which guarantee connectivity are present, can be alternated.

- **GAF**: area divided in grids so that within each grid any node will do (equivalent for routing).
GeRaF: Key Idea

- Goal: pick the relay closest to the destination
- broadcast message is sent, all active nodes within range receive it
- contention phase takes place: nodes closer to the destination are likely to win
- the winner becomes itself the source
Practical Implementation

- major problem: how to pick the best relay?
- solution: partition the area and pick relays from slice closest to the destination
- nodes can determine in which region they are
- nodes in highest priority region contend first
Contention Resolution

• Assume 802.11 RTS/CTS
• Source transmits RTS with source and destination coordinates
• Stations in priority region #1 are solicited
• If none responds, stations in region #2 are solicited
Fewer Hops than GAF

all distances normalized to the coverage radius
Conclusions

• nodes who receive a message volunteer and contend to act as relays

• advantages:
  – no need for complicated routing tables or routing-related signaling
  – near-optimal multihop behavior, much better than alternative solutions (eg GAF, SPAN)
  – significant energy/latency gains if nodes are densely deployed
Mobility assisted routing

• Mobility (of groups) was helpful to scale the routing protocol – see LANMAR
• Can mobility help in other cases?
  • (a) Mobility induced distributed route/directory tree
  • (b) Destination discovery (if coordinates not known)
Mobility Diffusion and “last encounter” routing

- Imagine a **roaming node** “sniffs” the neighborhood and learns/stores neighbors’ IDs
- Roaming node **carries around the info** about nodes it saw before
- If nodes **move randomly and uniformly** in the field (and the network is dense), there is a **trail of nodes** – like pointers – tracing back to each ID
- The superposition of these trails is a tree – it is a **routing tree** (to send messages back to source); or a distributed directory system (to map node ID to geo-coordinates, for example)
- “Last encounter” routing: next hop is the **node that last saw** the destination
- **Ref: H. Dubois Ferriere et al” Age Matters: Efficient Route discovery in Mobile Ad Hoc Networks Using Encounter ages, Mobihoc June 2003.**
Fresh algorithm – H. Dubois Ferriere, Mobihoc 2003
Mobility induced, distributed embedded route/directory tree

Benefits:
- (a) avoid overhead of periodic advertising of node location (eg, Landmark routing)
- (b) reduce flood search O/H (to find ID)
- (c) avoid registration to location server (to DNS, say)

Issue:
- Motion pattern impact (localized vs random roaming)