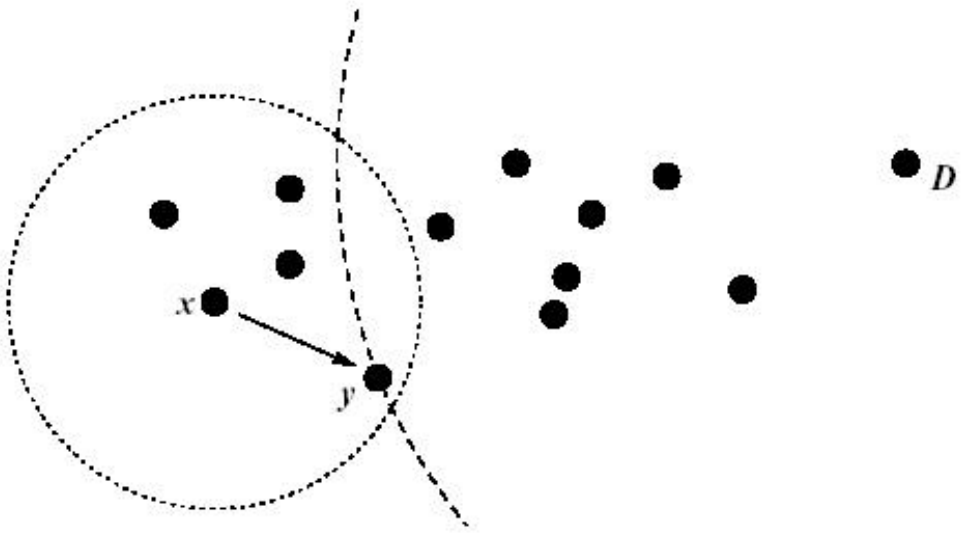
Georouting in ad hoc nets

- References:
- **Brad Karp and H.T. Kung “GPSR: Greedy Perimeter Stateless Routing for Wireless Networks”, Mobicom 2000**
- **M. Zorzi, R.R. Rao, ``Geographic Random Forwarding (GeRaF) for ad hoc and sensor networks: energy and latency performance,'' *IEEE Trans. on Mobile Computing,* vol. 2, Oct.-Dec. 2003**
- **H. Dubois Ferriere et al ”Age Matters: Efficient Route discovery in Mobile Ad Hoc Networks Using Enounter 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

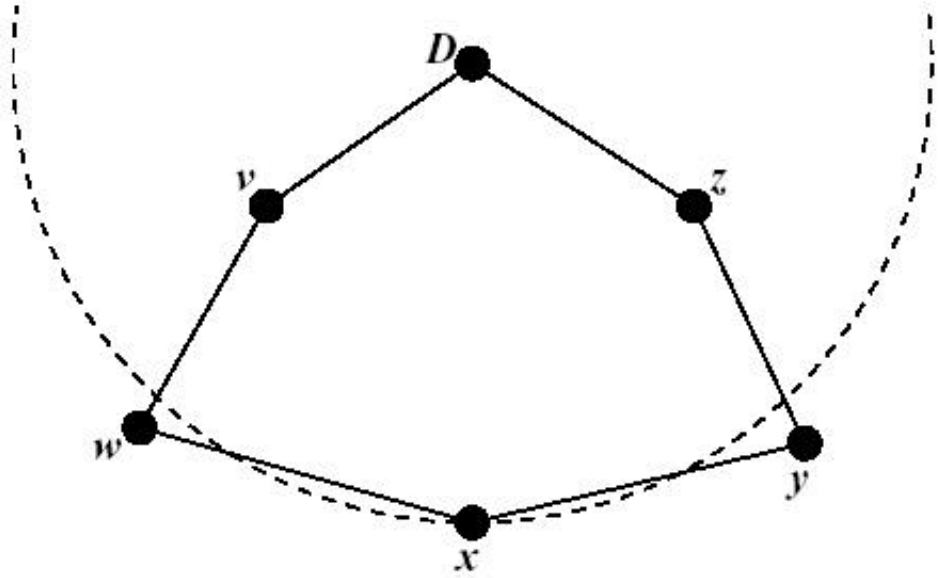
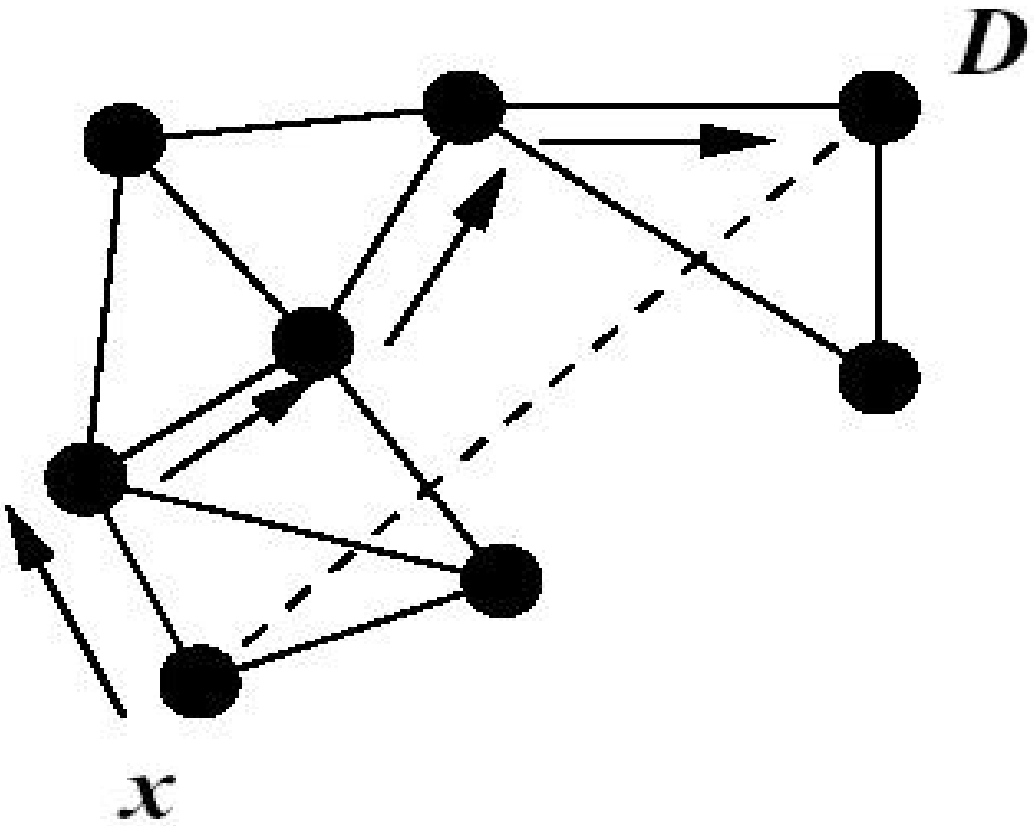


Figure 2: Greedy forwarding failure. x is a local maximum in its geographic proximity to D; w and y are farther from D.

Greedy Perimeter Forwarding



***D* is the destination; *x* is the node where the packet enters perimeter mode; forwarding hops are solid arrows;**

GPSR vs DSR

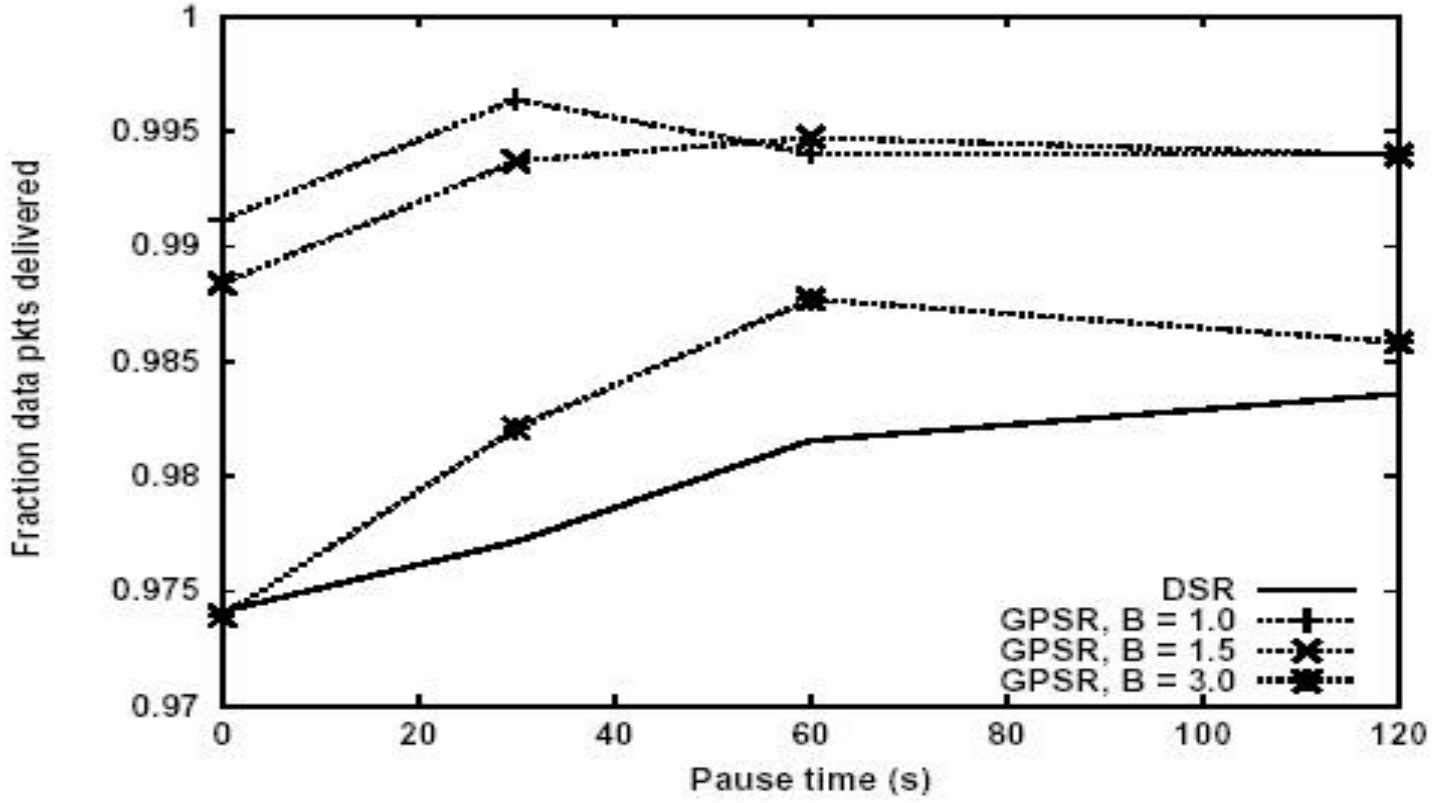


Figure 9: Packet Delivery Success Rate. GPSR with varying beacon intervals, B, compared with DSR. 50 nodes.

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
  - Beaconing overhead
  - nodes may go to sleep (on and off)

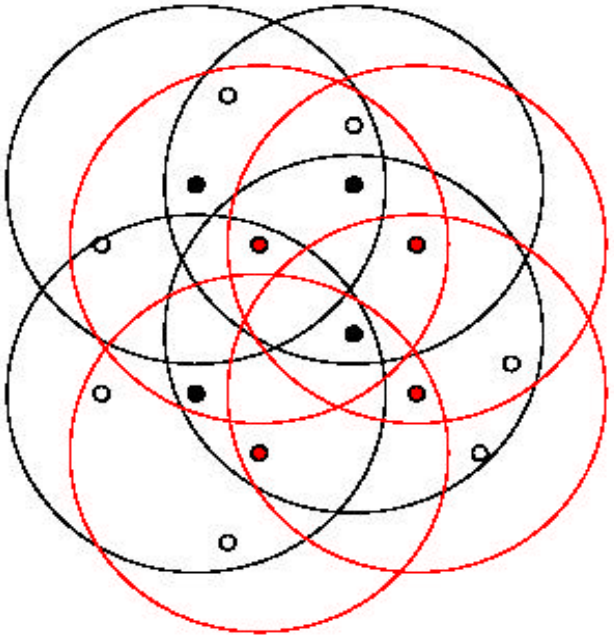
Geographic **Ra**ndom **F**orwarding (GeRaF)

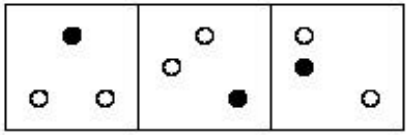
M.Zorzi and R.R.Rao

- 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

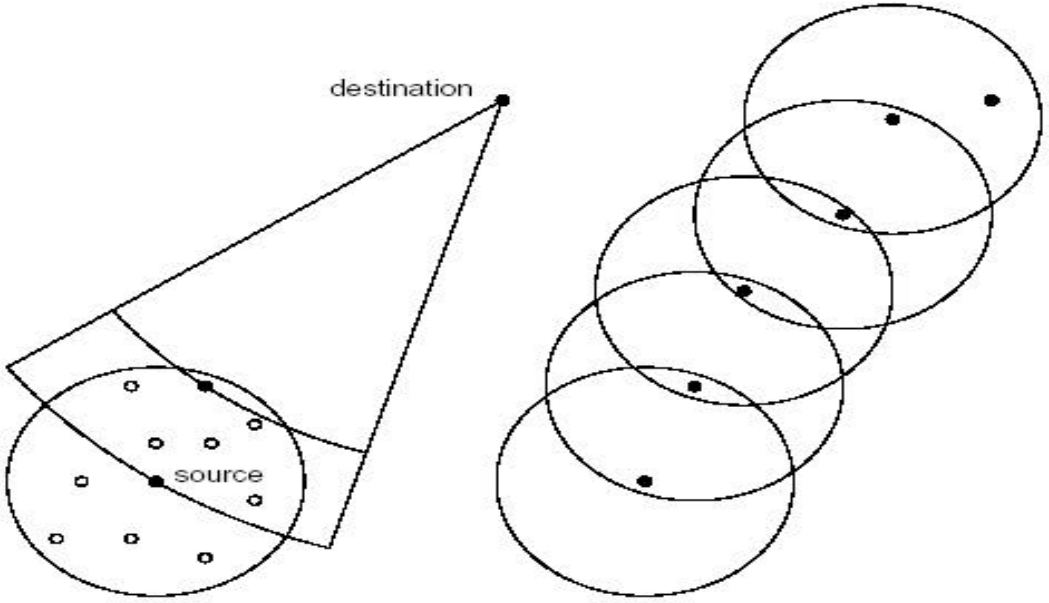
Keeping track of on/off nodes

- **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)





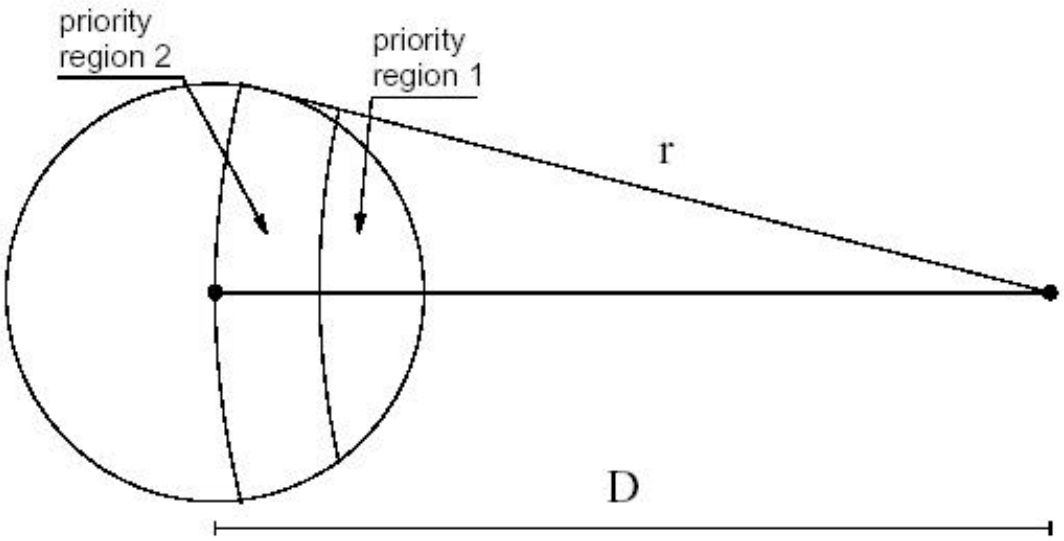
GeRaF: Key Idea



- 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

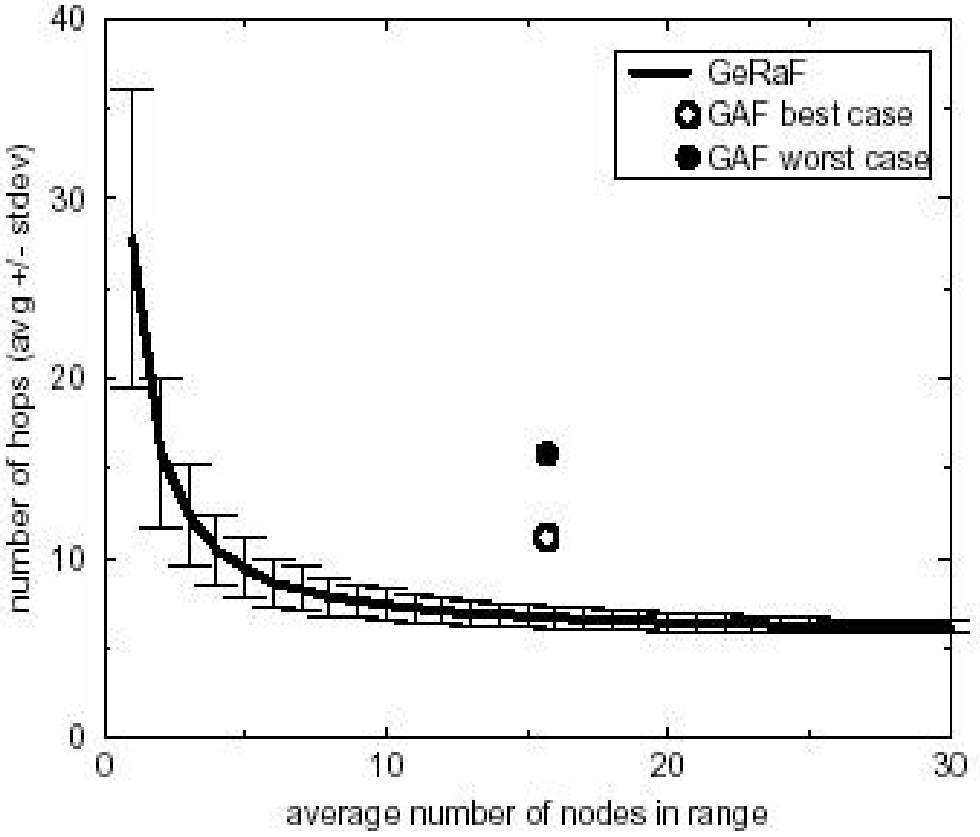
- major problem: how to pick the best relay?
- solution: partition the area and pick relays from slice closest to the destination
- nodes can determine in which region they are
- nodes in highest priority region contend first



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



distance $D = 5$

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

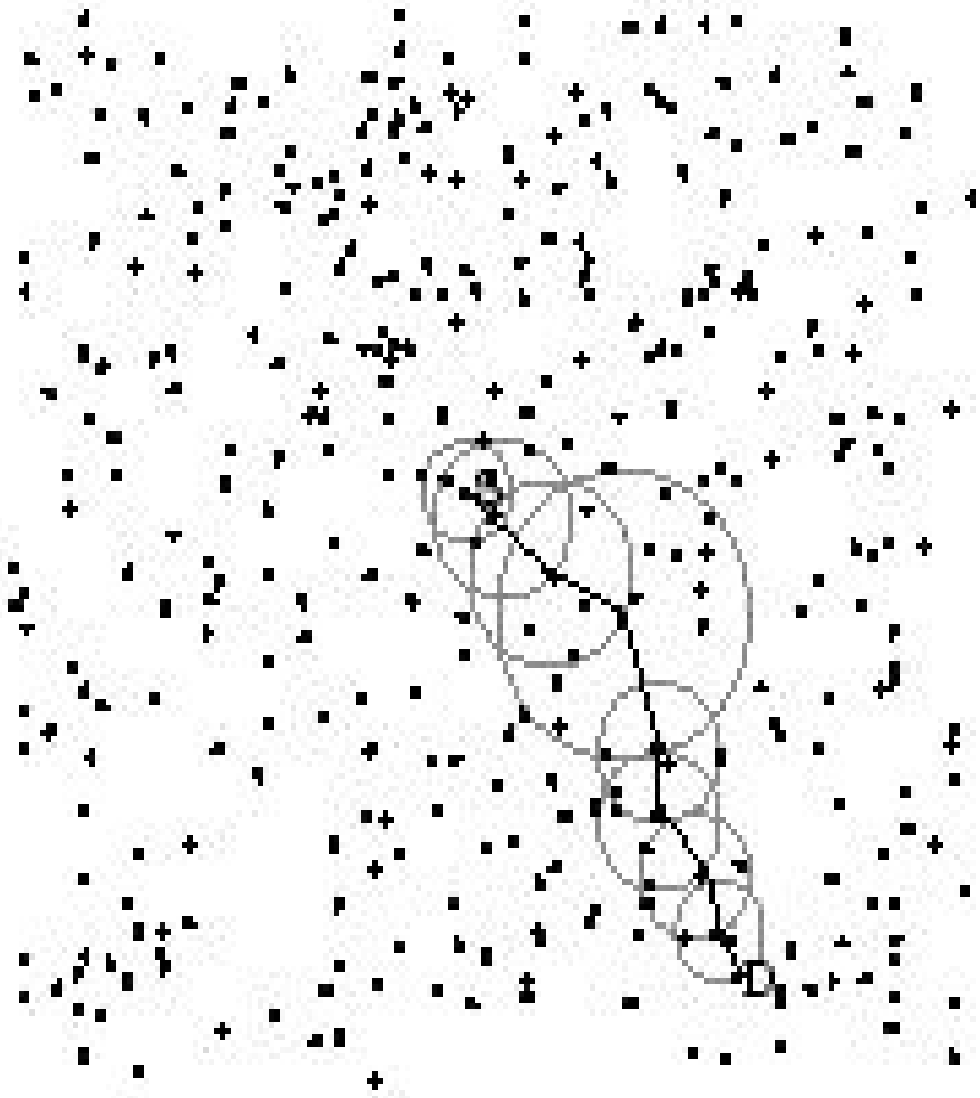
Mobility assisted routing

- 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 know)

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 Enounter 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)