Location-Based Routing

An overview and possible directions for GeoCRON

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Introduction

- Traditional routing
  - Unique address: IP, MAC, Peer ID, etc.
  - Source routing: next hop address, neighbor index
  - Local routing: distance-vector, link state, label-switching

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- Why location information?
  - Geocast: message all (or some) nodes in target region
  - Latency: request from closer server, route locally when possible
  - Congestion: confine route requests to smaller regions (MANETs)
  - Energy: closer nodes need less radio power to reach
  - Sensors: regional event detection, spatial querying
  - Planning: paths (robots), surveillance cameras (focus on area target will appear next)
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    - our primary interest!

Roadmap

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Location Service

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- Distribute load
  - In Jinyang Li et al. (2000), node updates *location servers* (LS) throughout network
  - Divide network into hierarchical grid
  - LS's in 3 external grids at each level
  - Lookup distance $<$ square LS co-resides in

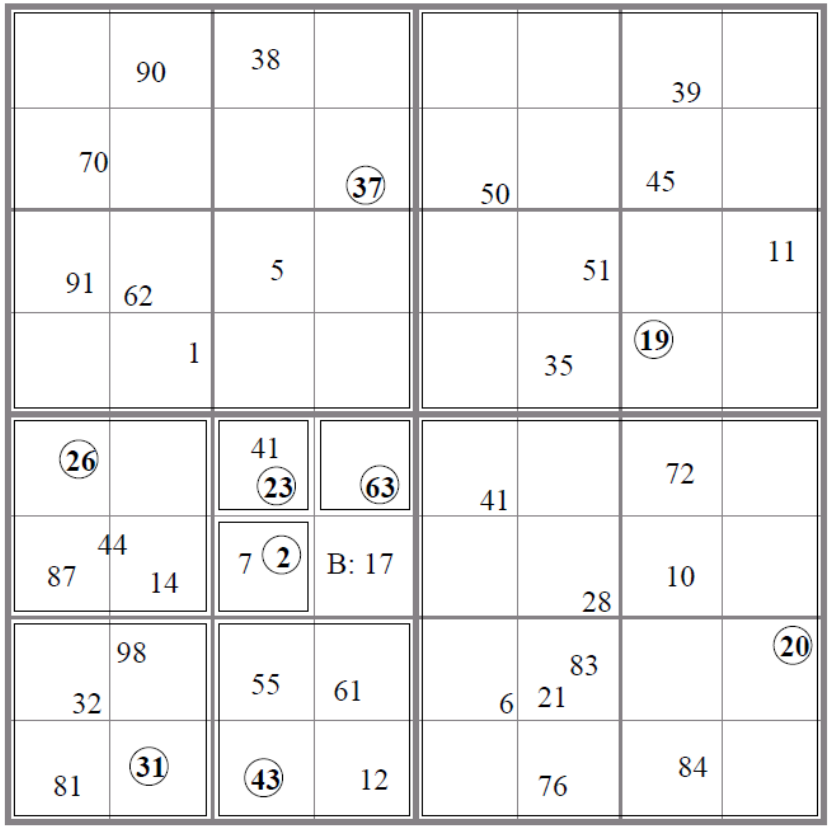

Figure: Hierarchical grid with 4 order-i squares in order-i+1 square.

Location Service for GeoCRON

- Grid $\Leftrightarrow$ CSN's *geocells*
- Location servers $\rightarrow$ sensor's overlay contacts
- Natural geographic diversity $\rightarrow$ more robust!
- Location servers hold address, NOT just location!
- Region ID $\leftarrow$ quad tree path
  - *ex: B* at 203 (count like Cartesian plane)
- Region similarity $\rightarrow$ prefix match region ID

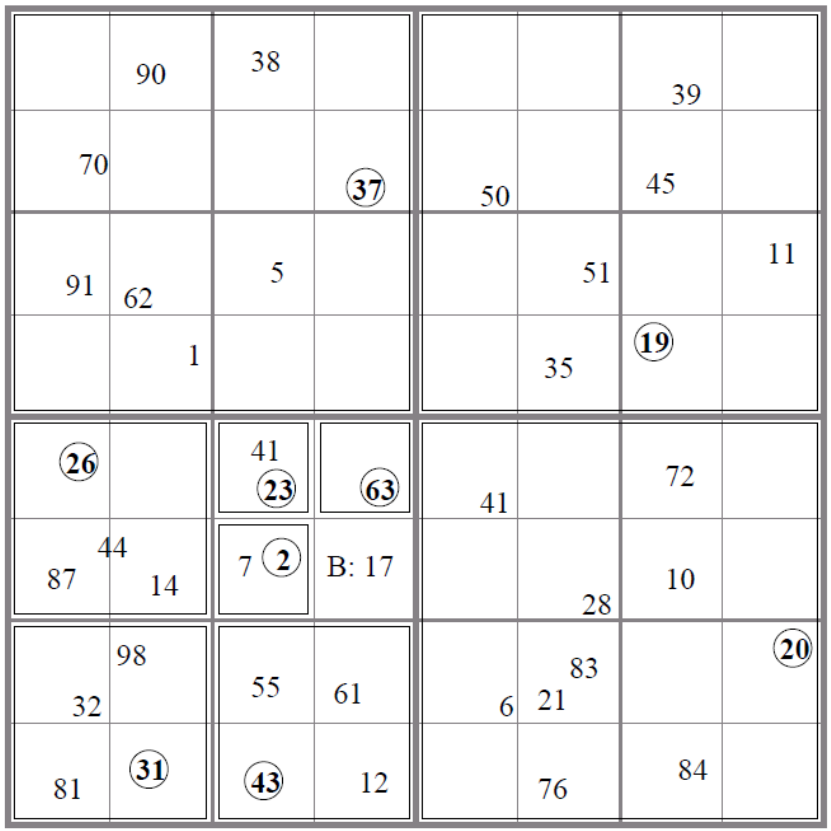

Figure: Hierarchical grid closely resembles CSN's *geocells*

Roadmap

Source Routing

Roadmap

Greedy Forwarding

- Forward to next closest hop to destination
- What if no such neighbor?
  - Reached local minimum
  - *Voids* in network
  - Solution: temporarily forward to farther hop
  - Used by Ko et al. (1998); Young-bae Ko et al. (1999) with parameter δ
  - Forward if next hop distance $\leq$ previous distance $+ \delta$

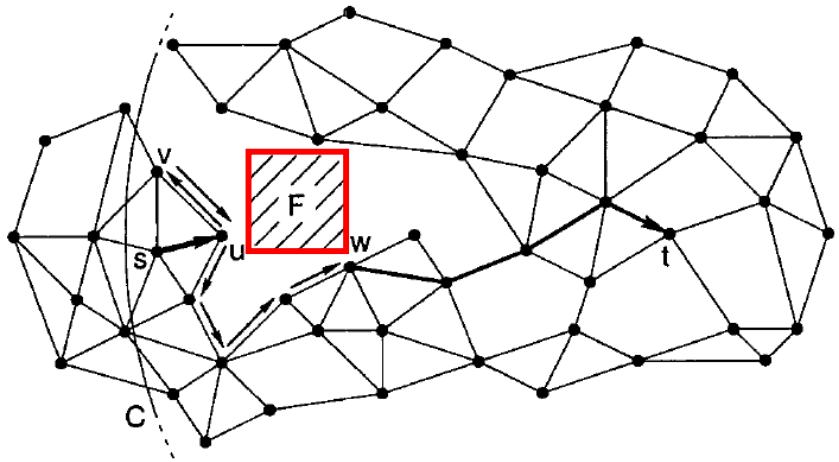

Figure: A void in a network (roughly centered at F, outlined in red) may disrupt greedy forwarding

Greedy Forwarding in confined region

- In Young-bae Ko et al. (1999), source defines a *multicast region* and *forwarding zone*
  - Message delivered to all nodes in multicast region
  - Defined as a rectangle, coordinates inside message
  - Includes source, destination, plus error
  - Message flooded within forwarding zone until target reached

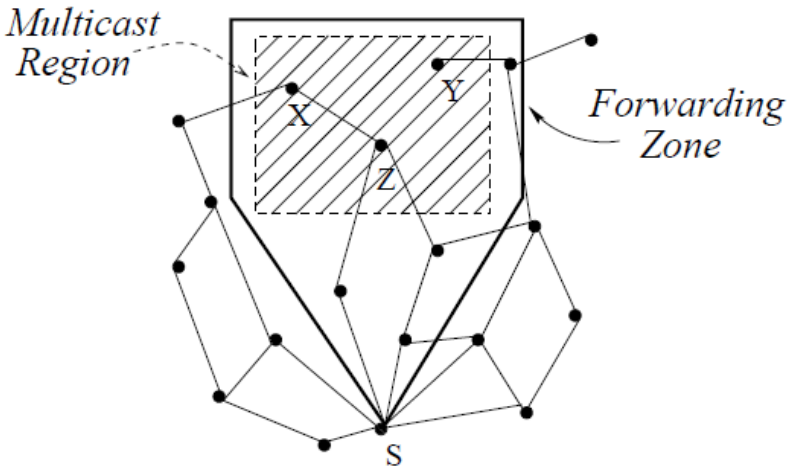

Figure: Depiction of multicast region and forwarding zone

Greedy Forwarding further enhancements

- Adapt forwarding region at each hop Young-bae Ko et al. (1999)
  - Intermediate (closer) nodes know topology better
  - Change region shape

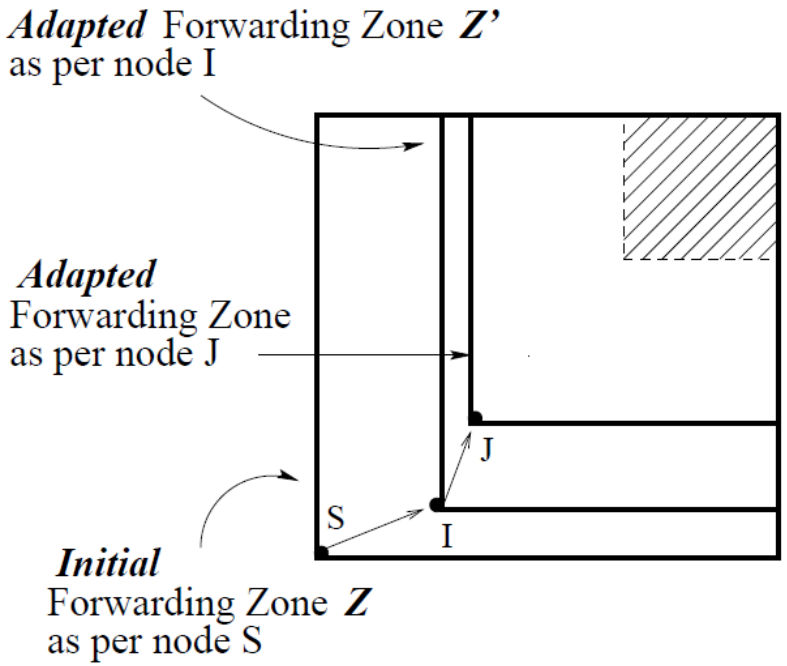

Figure: Depiction of adaptive multicast region and forwarding zone

Roadmap

Trajectory Routing

- Introduced in Niculescu and Nath (2003, 2004), implemented in Yuksel et al. (2006)
- Message follows a curve
- Hybrid greedy/source routing
- Forward to neighbor furthest along curve
- Routes around voids, obstacles, etc.
- GeoCRON: identify failed regions $\rightarrow$ route around

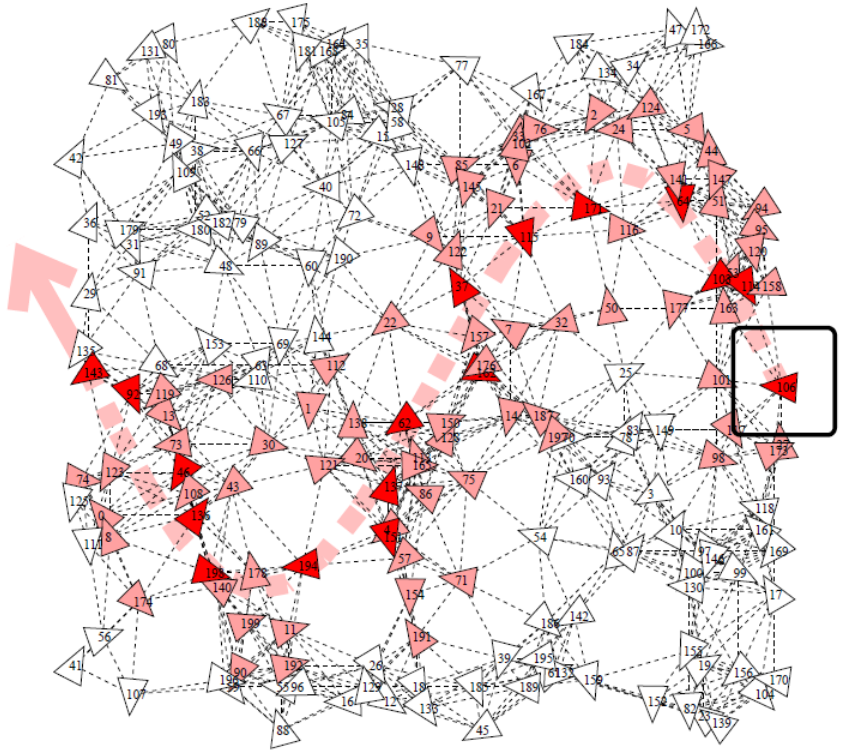

Figure: Forwarding along a trajectory

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Geometric Routing

- Network topology $\rightarrow$ graph
  - Vertices = nodes
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- Graph geometry → forwarding
- *Compass routing* proposed Kranakis et al. (1999)
  - *Right-hand rule*
  - Also called *face routing*
  - Also used in Kuhn et al. (2003); Kim et al. (2005)

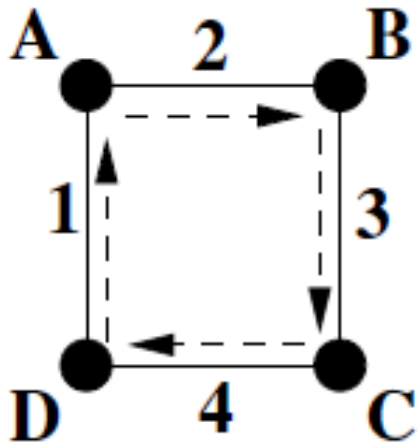

Figure: The right-hand rule: forward packet along next counter-clockwise edge. Analogous to following the right hand wall in a maze.

Geometric Routing in GeoCRON

- Overlay network $\rightarrow$ planar graph
- Faces large enough to avoid routing back to failed regions
- Intermediary makes routing decision, NOT source

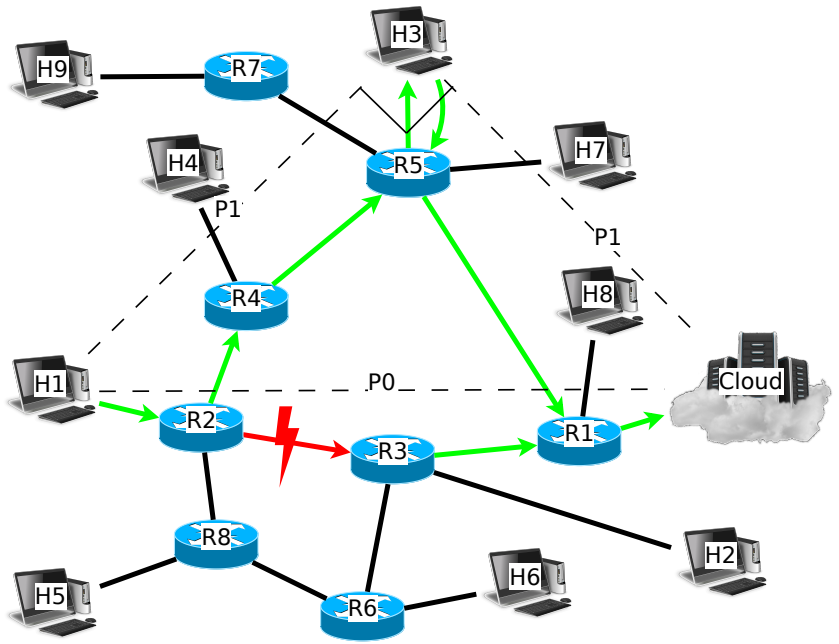

Figure: Apply right-hand rule to overlay paths. Similar to Orthogonal Path Heuristic.

Roadmap

- GRID Liao et al. (2001) divides network into squares
  - Gateway chosen for each square
  - Zone-based version of AODV to route
  - Route requests confined to geographic region
- In Joa-Ng and Lu (1999), an inter-zone clustering protocol periodically run
  - Updated with inter-zone links
  - Destination's exact location within zone unknown $\rightarrow$ packet gets close enough

Clustering - LABAR

- LABAR Zaruba et al. (2003)
  - GPS-enabled nodes → backbone G-nodes
  - Nodes near G-nodes belong to a *zone*
  - G-nodes give sender vector towards intermediary zones

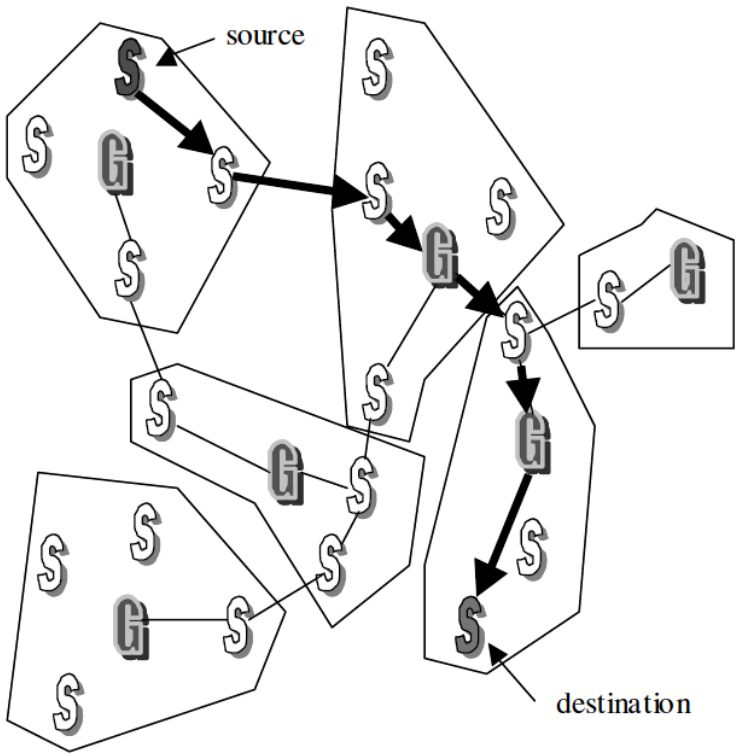

Figure: Routing in LABAR

Roadmap

Hybrid

- In Kuhn et al. (2003); Huang et al. (2005); Karp and Kung (2000), greedy forwarding until *void* reached
  - *Face routing* within a bounded region
  - Enlarge bounded region if destination unreachable
  - FAR Huang et al. (2005) introduced *mobicast*: mobile geocast
    - Application: mobile regional sensing
    - *Just in time* forwarding: packet arrives right before mobicast region
    - Decreases *lag time* (how long nodes hold data before mobicast region arrives)

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