Virtual Localization for Mesh Network Routing

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Sensor Networks

- Miniature sensors allow field measurements
- Data must still be collected
- Sensor networks allow sensors to communicate back to a central point

Mesh Sensor Networks

- All nodes are equal.
- All routing computation is distributed.
- Battery power is limited, and processing power and network usage are therefore expensive.

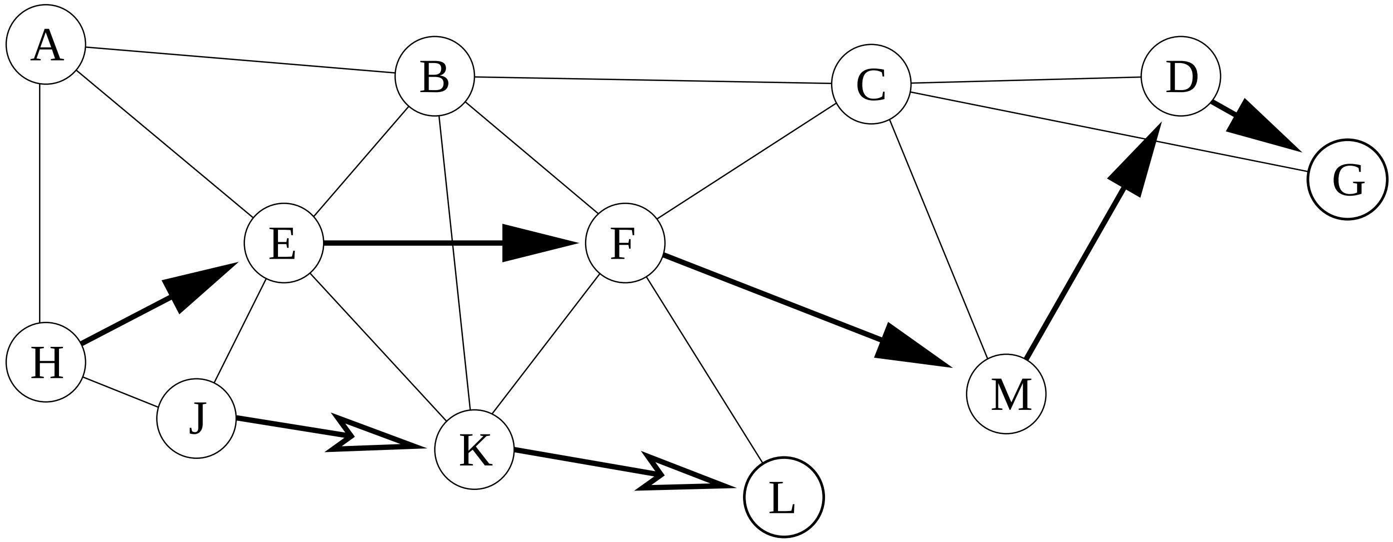
Routing in a Mesh

How can we route packets across the mesh?

- hierarchical partitioning too inflexible
- packet flooding too inefficient
- route flooding
- location based routing

Greedy Forwarding

Simplest algorithm for location based routing: forward packet to whichever neighbour is nearest the destination.



- $\overrightarrow{HEFMDG}$ is longer than $\overrightarrow{HEFCG}$,
  but F forwards to M as M is closer to G than C is.
- $\overrightarrow{JKL}$ is blocked by a 'void'.

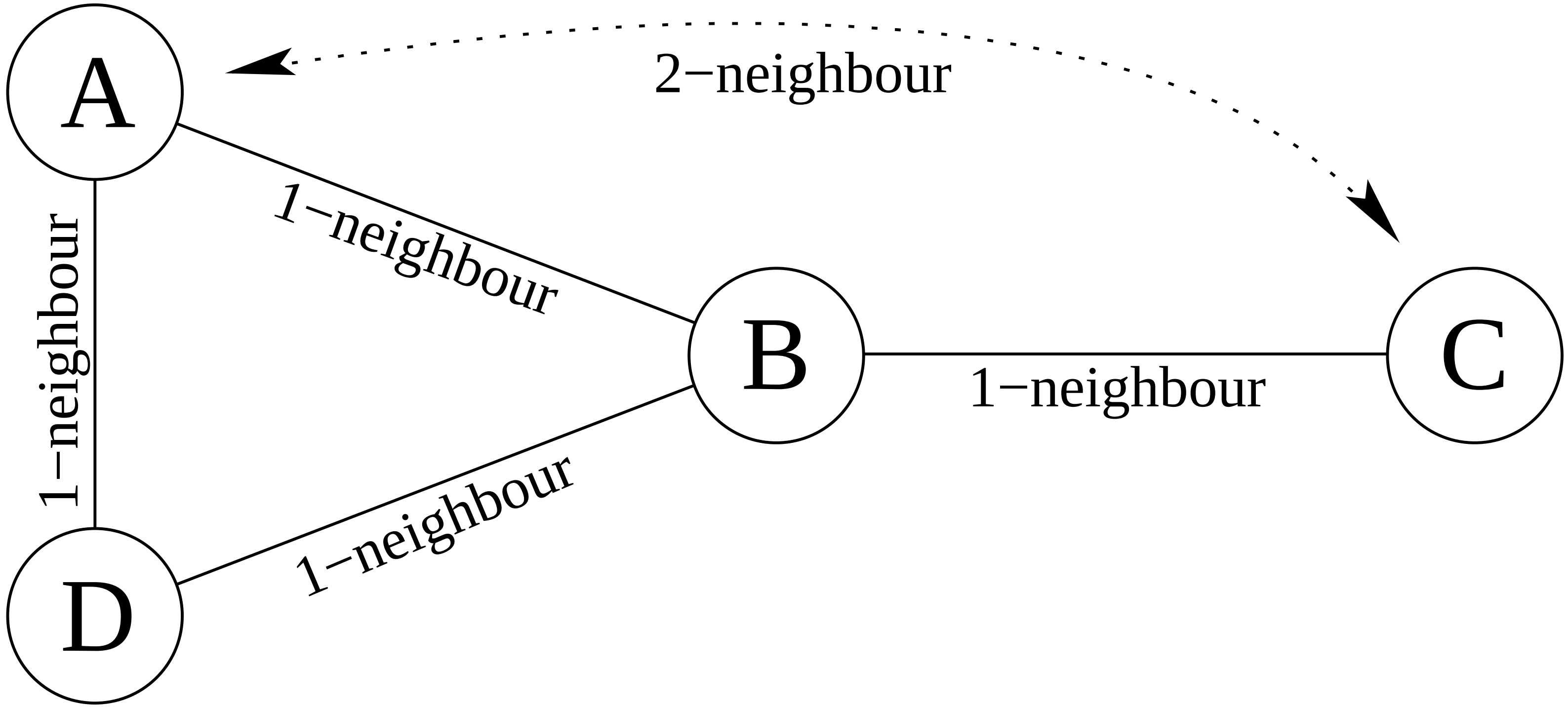
Determining Location

- Naïve solution: GPS
- 'Anchor' nodes (up to 20%)
- Radio distance-finding

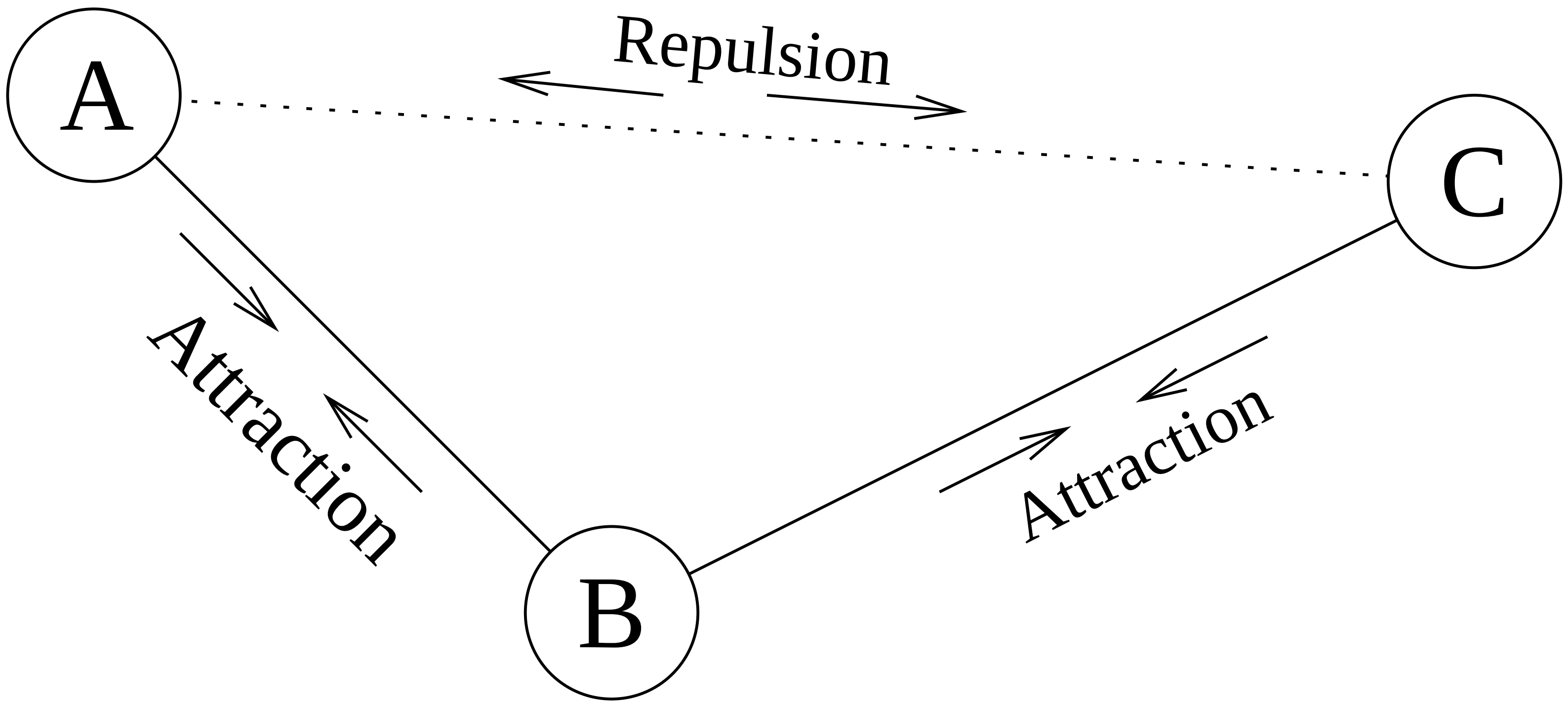
Virtual Location

- Location relative to other nodes
- Axes do not correspond to real directions
- Geometries may not correspond either
- Internally consistent
- Generally only useful for routing purposes

n-neighbours



Spring Models



Forces and Potentials - Equations

- Springlike attraction $F \propto d$ to 1-neighbours

$$U_{ij} = k_{att} \cdot d_{ij}^2 \quad ; \quad k_{att} = 1$$

- Electrostatic-like repulsion $F \propto 1/d^2$ from 2-neighbours

$$U_{ik} = k_{rep} \cdot \frac{1}{d_{ik} + 1} \quad ; \quad k_{rep} = 8 \times 10^6$$

- Node attempts to minimize total potential energy

$$U_i = \sum_{j \in N} U_{ij}$$

Forces and Potentials - 1D