Rumor Routing Algorithm

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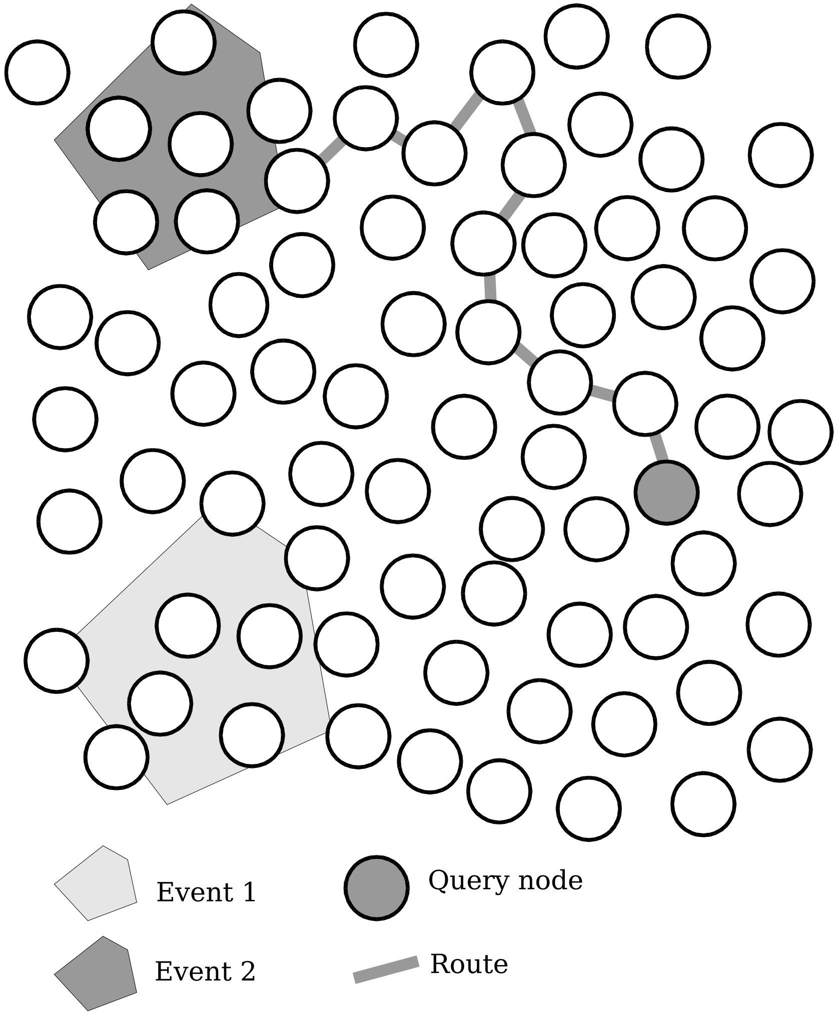
Introduction

- Rumor Routing Algorithm is described in paper:
  - D.Braginsky and D. Estrin. Rumor routing algorithm for sensor networks. In WSNA '02: Proceedings of the 1st ACM international workshop on wireless sensor networks and applications, pages 22-31. ACM Press, 2002.

Routing in Wireless Sensor Networks (WSNs)



- How to reach event nodes from the query node?
- Route consists of short hops
- Event is a localized phenomenon detected by some node(s)
- Query can be:
    1. A request for information
    2. Orders to collect more data
    3. Some unlocalized order, e.g. “Find a node with a camera and enough power to use it, and order it to take a photograph”

Challenges of WSN Routing

- Energy is in short supply
  - Use only short-distance message transmission
  - Minimize number of transmissions
- Wireless ad-hoc network with possibly failing nodes
- Often no common coordinate system available for the nodes

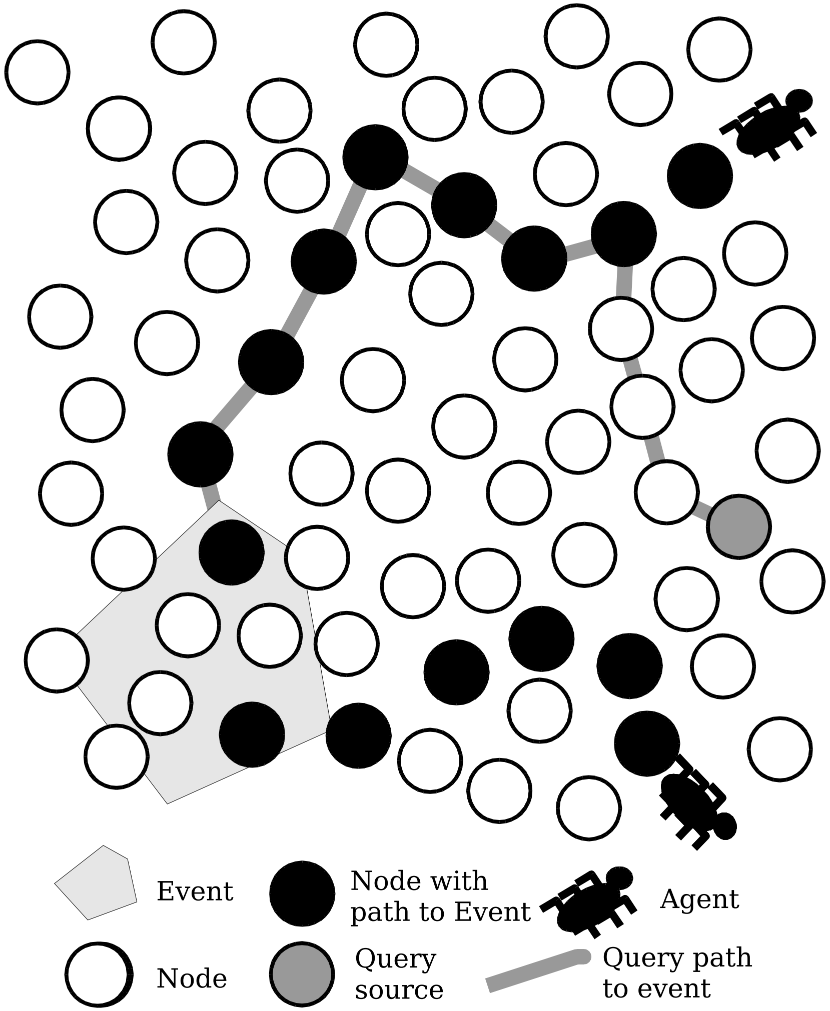
Traditional Routing [1/2]

- Event flooding:
  - When node detectd an event, it broadcasts information about it in its surroundings and other nodes repeat this
  - The nodes store the information, where they received the event from for later querying and/or the event is noticed by some monitoring query node
  - Transmission energy comparable to Event count * Node count
- Query flooding:
  - Query node broadcasts the query through the whole network
  - Transmission energy relative to Query count * Node count

Traditional Routing [2/2]

- Problems with flooding:
  - High energy consumption due to unnecessary transmissions
  - Message loss due to collisions caused by many simultaneous transmissions
- For example probabilistic broadcast has been suggested
- If geographical information is available, greedy shortest path algorithms can be used

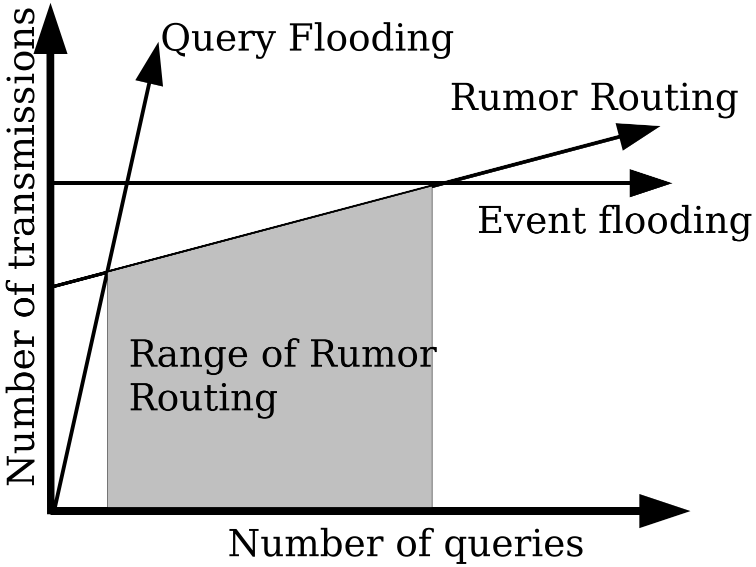
Solution: Rumor Routing



- Main idea:
  - Agent messages precreate paths leading to event nodes as the events happen
  - Later queries are sent on random walk until they find one of the paths, and then route along the path to event nodes

When to Use Rumor Routing?

- Number of queries per event is high enough. If not, better to flood queries.
- Number of queries per event is low enough. If not, better to flood events.
- In best case: ~5..~36 queries per event



- Small amount of data flowing back from event to query node. Otherwise cases better to find the shortest route by query flooding.
- No coordinate system available. Otherwise greedy shortest path algorithms are better.
- Each node has distinct identification number and knowledge of neighboring nodes
- Nodes have similar transmission functionality (no hierarchy)

Algorithm - Basics

- Each node has
  - A neighbor list (generated when the network is initiated)
  - An event table with forwarding information to events it knows of
    - Possibly timestamped for expiration

Agents [1/4]

- When a node detects an event it:

  => stores a path of distance zero to the event in the node

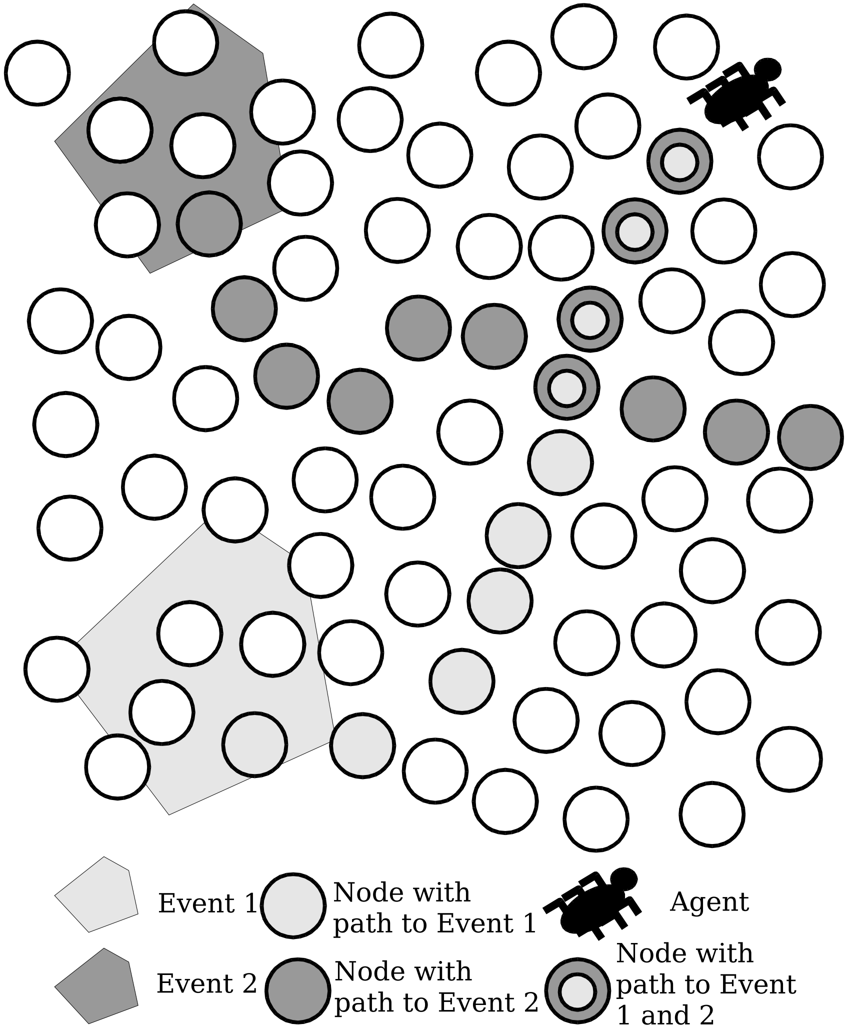
  => creates an agent probabilistically:

  - reason for using probability: usually many nodes notice the same event

- Agent travels for some maximum amount of hops
- Agent contains an event table and combines it with event tables in visited nodes

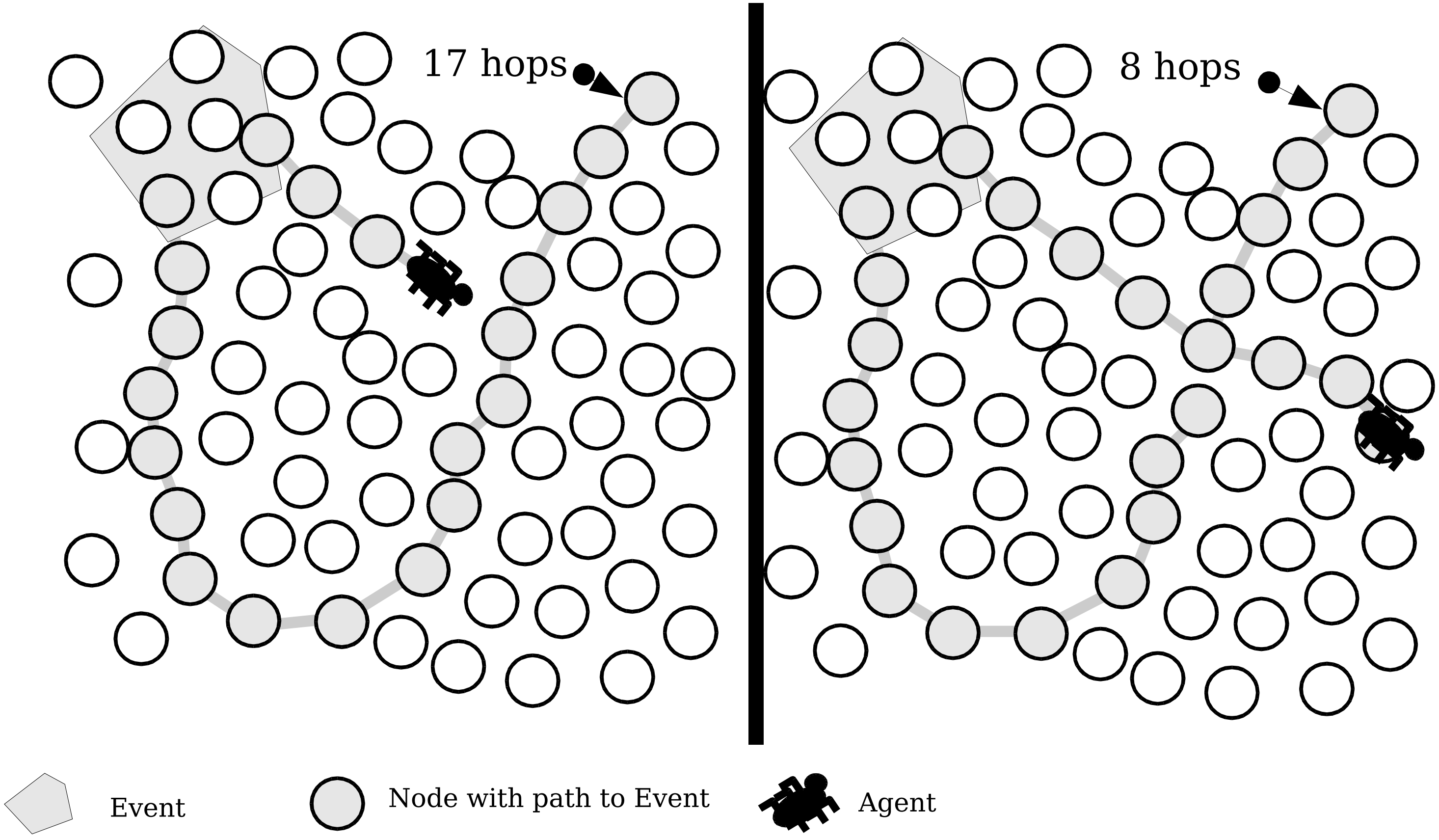
Agents [2/4]

- Agents aggregate paths


Event 1
Node with path to Event 1
Agent
Event 2
Node with path to Event 2
Node with path to Event 1 and 2

Agents [3/4]

- Agents optimize longer paths

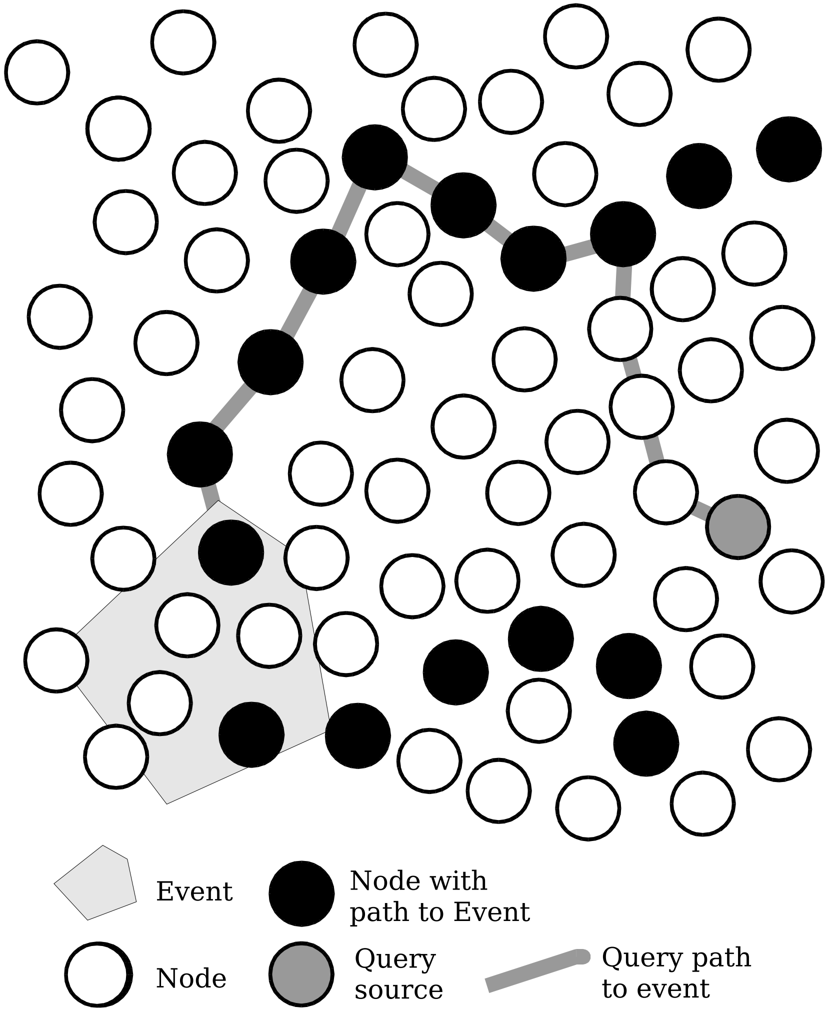


Agents [4/4]

- Agents use a straightening algorithm:
  - Record recently seen nodes and avoid travelling to them if possible
- Neighboring nodes often overhear messages not sent directly to them and can use the information to optimize paths
  - So in fact the paths created by agents are thick trails

Routing Queries

- Query also has some maximum number of hops
- First random walk, then along the path
- If destination was not reached, the query node can either retransmit or flood
- Straightening algorithm used in the random walk
- Possible loops in agent paths can be avoided:
  - Use random ids for queries,
  - store recently seen query ids in nodes and
  - when nodes receive a query on the list, they send it in random direction instead of along the path



Research Setting

- Paper describes simulation results
- 200x200m^2 2-dimensional area with node communication radius of 5 meters
- 3000-5000 randomly scattered nodes
- All events also at 5m-radius circles
- Precreated event distribution (10-100 events) and agent paths
- After that 1000 queries to random events from random query nodes
- Queries flooded after first failure
- Different agent and query hop counts tested

Research Results [1/2]

- With minimal setup costs (small agent hop count and less than 25 agents) only 60% of queries successfully delivered. Even query flooding would have been better.
- With high setup costs (over 400 agents) algorithm had setup costs higher than event flooding, but the query routing success was 99.9%
- Best settings: Small number of agents (31 for 10 events) and high agent maximum hop count (1000) , 98.1% of queries were delivered with average energy of 1/40th of query flood. Setup cost was was then equal to about 8 query floods.
  - Rumor routing better than flooding when queries per event between 5 and 36

Research Results [2/2]

- Algorithm had stable results over several test runs
- But the guaranteed query delivery rate depended heavily on the random distribution of events and queries, i.e. it is difficult to guarantee some energy use for real-life situations
- Fault-tolerant up to 20% node failures, above this strong performance loss

Future Work [1/2]

- Network dynamics and asynchronous events
  - In reality events occur in time and algorithm is likely to favor older events
- Collisions
  - Rumor routing is likely to suffer less from collisions than flooding algorithms
- Non-localized events.
  - How are queries like “find a node with a camera and enough power” handled
- Non-random query pattern
  - Often queries are generated by base-stations or in some networks by nodes close to the actual events

Future Work [2/2]

- Non-random next hop selection in the algorithm
  - If some localization information is available, agents could leave behind information on already visited regions and other agents could later try to cover these
- Use of constrained flooding
  - Instead of random walk, queries could first be flooded at a short distance. Problem is then, how to decide which queries to forward
- Parameter setting exploration
  - Optimal parameters depend heavily on the event and query patterns, perhaps the algorithm could somehow configure itself on the fly

Criticism

- The authors do not describe any method (except brute force) for finding good parameter values
- Test settings and results are not described very thoroughly

Conclusion

- Rumor routing is a good and tunable algorithm for many situations, in which flooding would generate too much traffic and geographic information is not available