Routing protocols for wireless sensor networks

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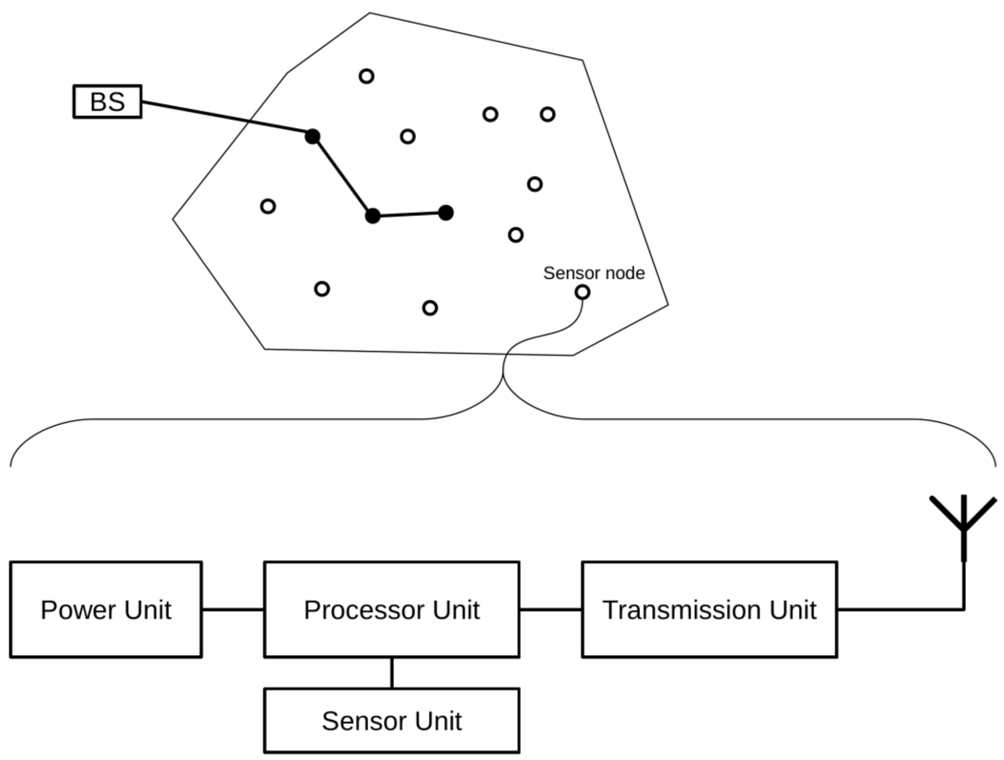
Motivation

- Measurements in regions which are difficult to reach
- No possibility to establish a wired connection
- Not enough energy for a long range transmission
- Find a short route to the data sink



[1] G. Raghunandan and B. Lakshmi, “A comparative analysis of routing techniques for wireless sensor networks,”

Rumor Routing

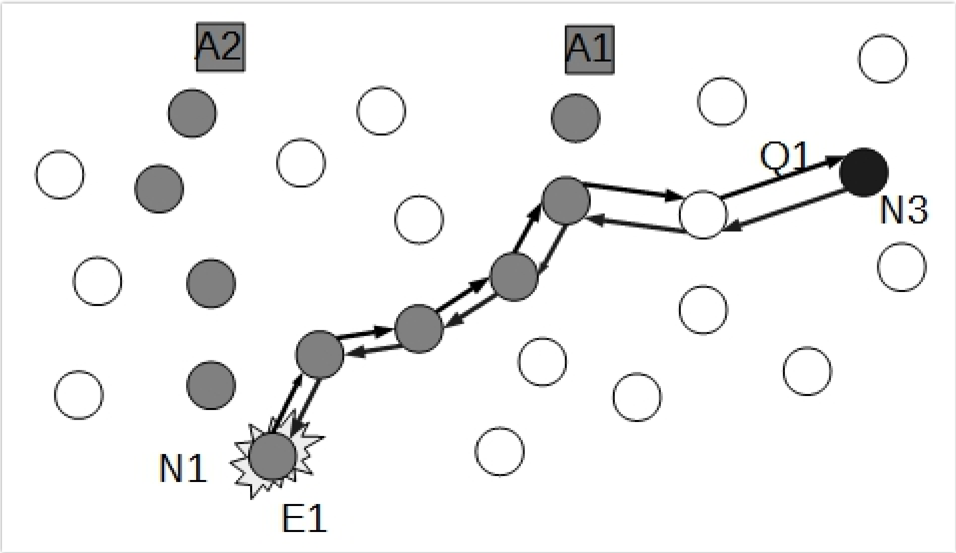
[2] D. Braginsky and D. Estrin, “Rumor routing algorthim for sensor networks,”

Idea

Find a better way to deliver queries to the event node and close the gap between query flooding and event flooding

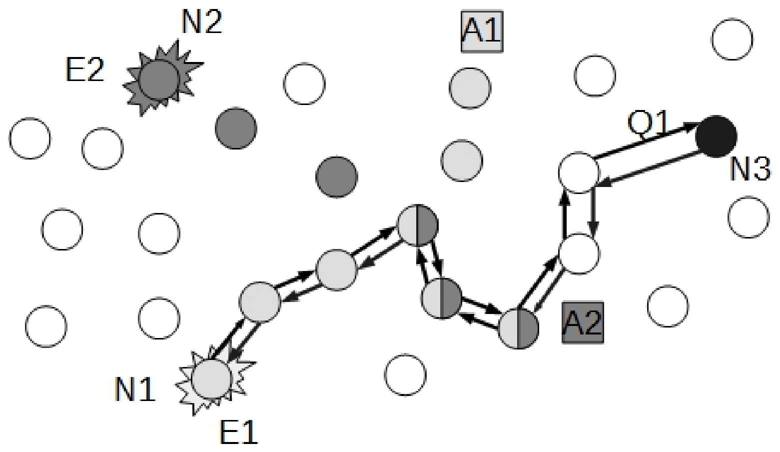
Algorithm

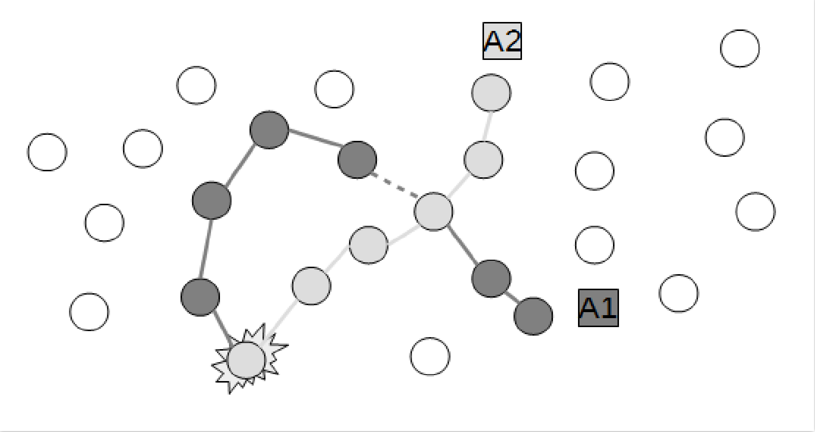
- A node creates a number of agents when a event occurs
- These agents are forwarded in a random manner to the neighbor nodes
- At each node, the agent leaves his ID and the last node
- A sink node creates a query message which is forwarded randomly
- If the query meets a node with the event information it hops along the route to the event node



Additional features

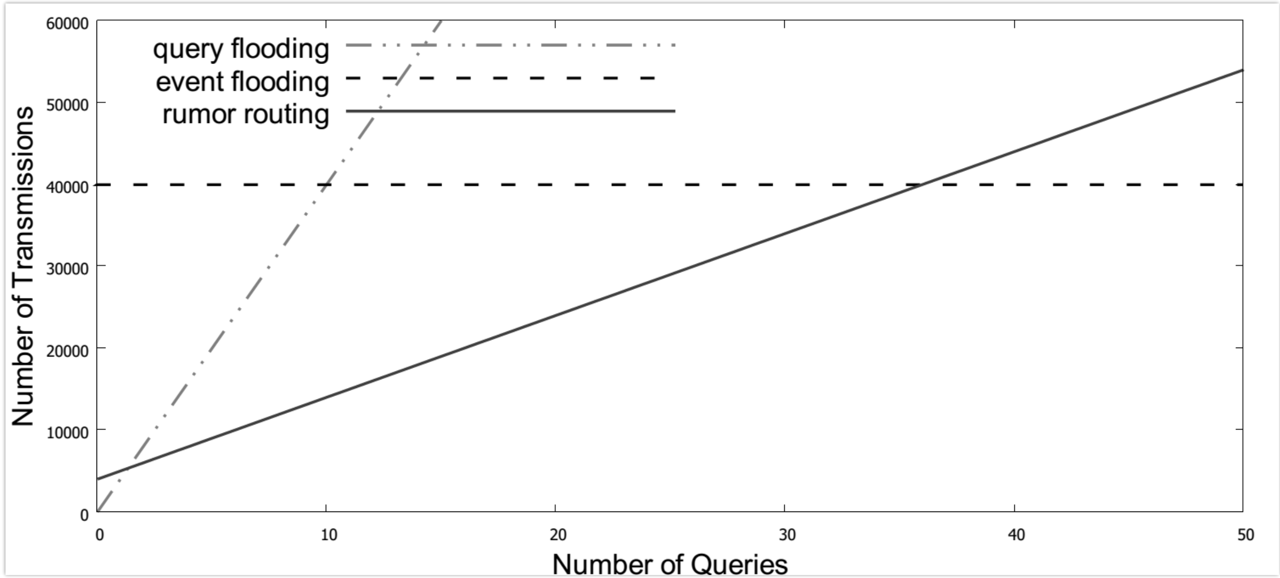
- An agent carries information of another event with it
- An agent which meets a node with Information of itself, it can optimize the route if there is a shorter one
- If a query stays undelivered, the query can be flooded





Analysis

- Number of transmissions wiht query flooding
  - $T = Q \times N$
- Number of transmissions with event flooding
  - $T = E \times N$
- Number of transmissions with rumor routing
  - $T = E \times A \times L_a + Q \times L_q$
- Number of additional transmissions
  - $T = N \times (Q - Q_D)$



ACQUIRE

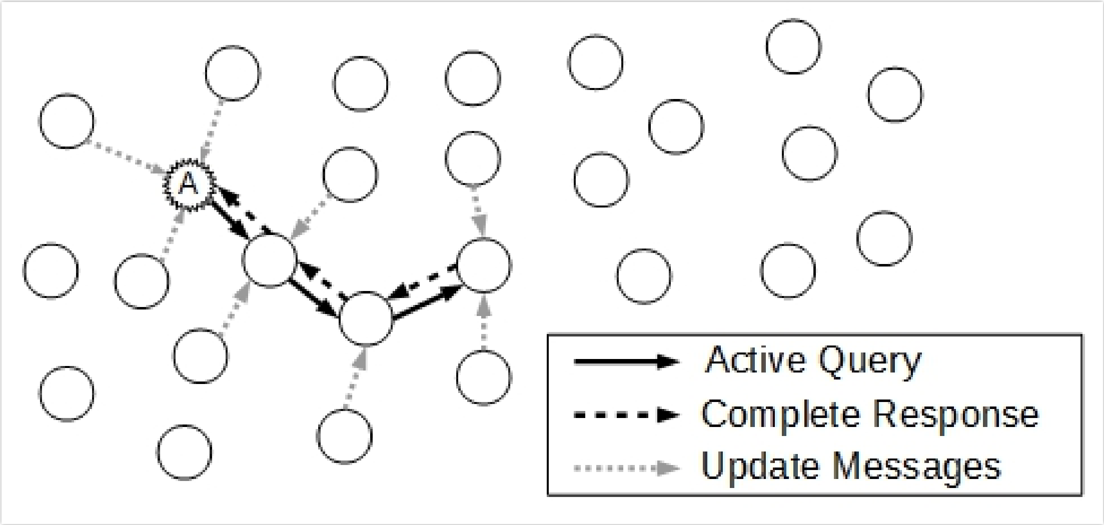
[3] N. Sadagopan, B. Krishnamachari, and A. Helmy, “The acquire mechanism for efficient querying in sensor networks,”

Idea

Find a way to reduce the necessary queries with complex queries which are resolved by the nodes

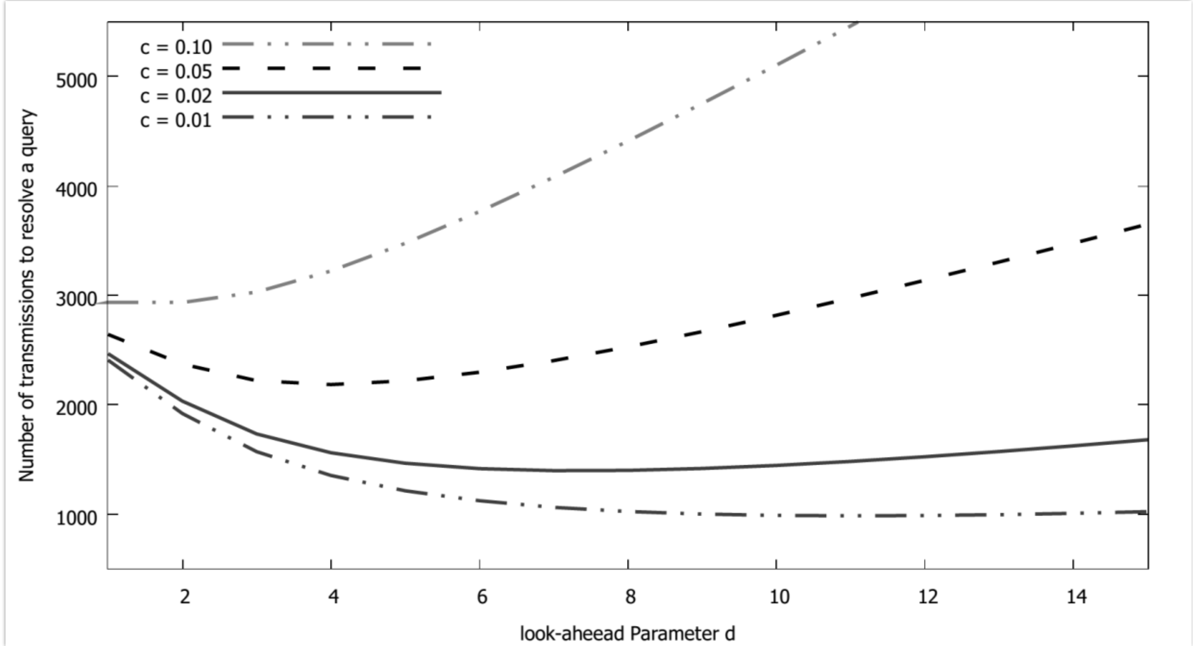
Algorithm

- A sink node creates a complex query
- An active node uses information of the neighbors to resolve the query partially
- Each node sends update messages to its neighbors until a look-up range d
- The active node forwards the query to a random neighbor d hops away
- When the query is completely resolved, it is sent back as a complete response



Analysis

- Transmissions needed to update the information
  - $T_{Update} = F(d-1) + \sum_{i=1}^{d} i \times N(i)$
- Transmission needed to resolve one query
  - $T_Q = (c \times T_{Update} + 2d) \times S_M$



SOFROP

Self organizing and fair routing protocol

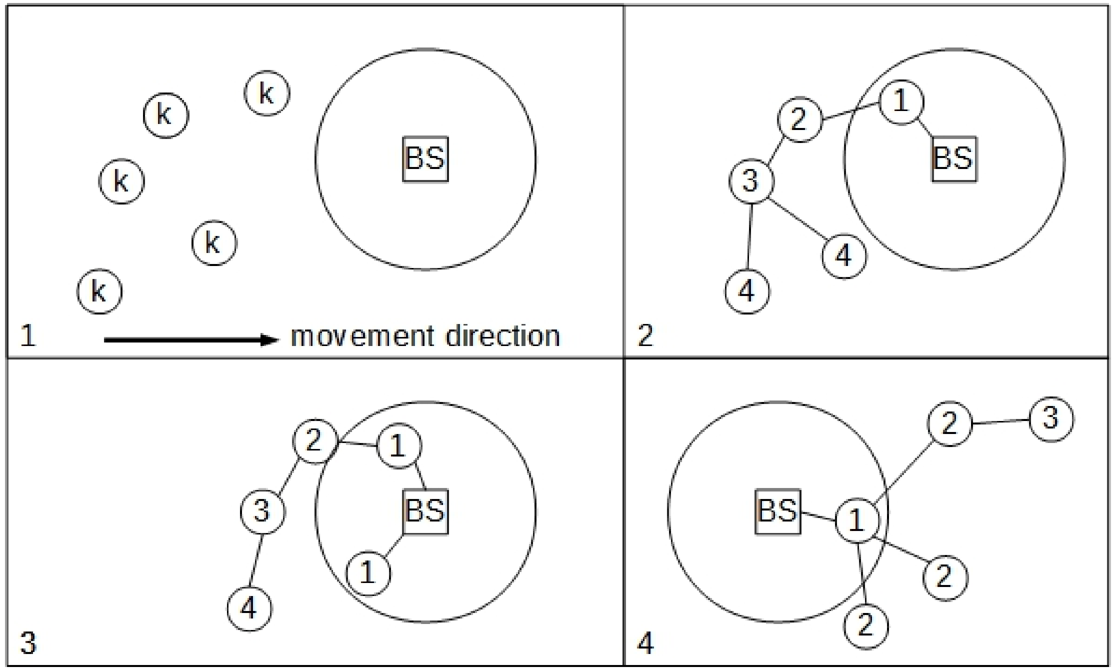
[4] M. Akba, M. R. Brust, and D. Turgut, "Sofrop: Self-organizing and fair routing protocol for wireless networks with mobile sensors and stationary actors,"

Idea

Reduce the transmissions by reorganizing the network topology and sending the packets to one neighbor

Network Organization

- BS sends ACPs with a frequency f
- Each node receiving this stores the ID and the hop count
- Forwarding of the ACP with its own ID and an incremented hop count
- Receiving a ACP with a higher hop count as stored, incrementing its own hop count
- After an ACP timeout resetting the hop count to the max value k
- Data is only transmitted when node is connected to the network



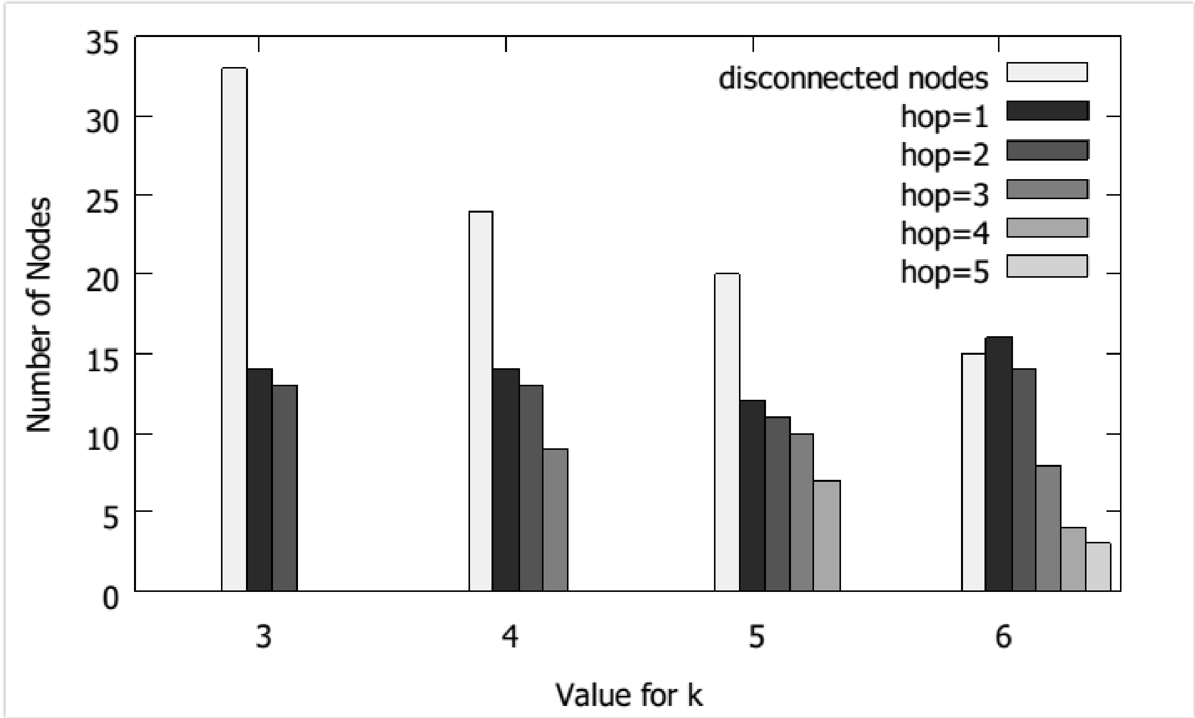
Data Transmission

- Node forwards each packet while $C_r \geq 0$
  - $C_r = C_o - \sum_{i=0}^{n} \alpha_p$
- If $C_r < 0$ packets with a packet rate $\alpha_p \leq \alpha_f$ are forwarded (α_f=fair rate)
  - $\alpha_f = \frac{C_o}{N_i}$
- Packets with higher packet rates have a probability P_d to be dropped
  - Calculated with packet rate α_p, shared capacity C_s, number of shared interest N_s

Effect of k

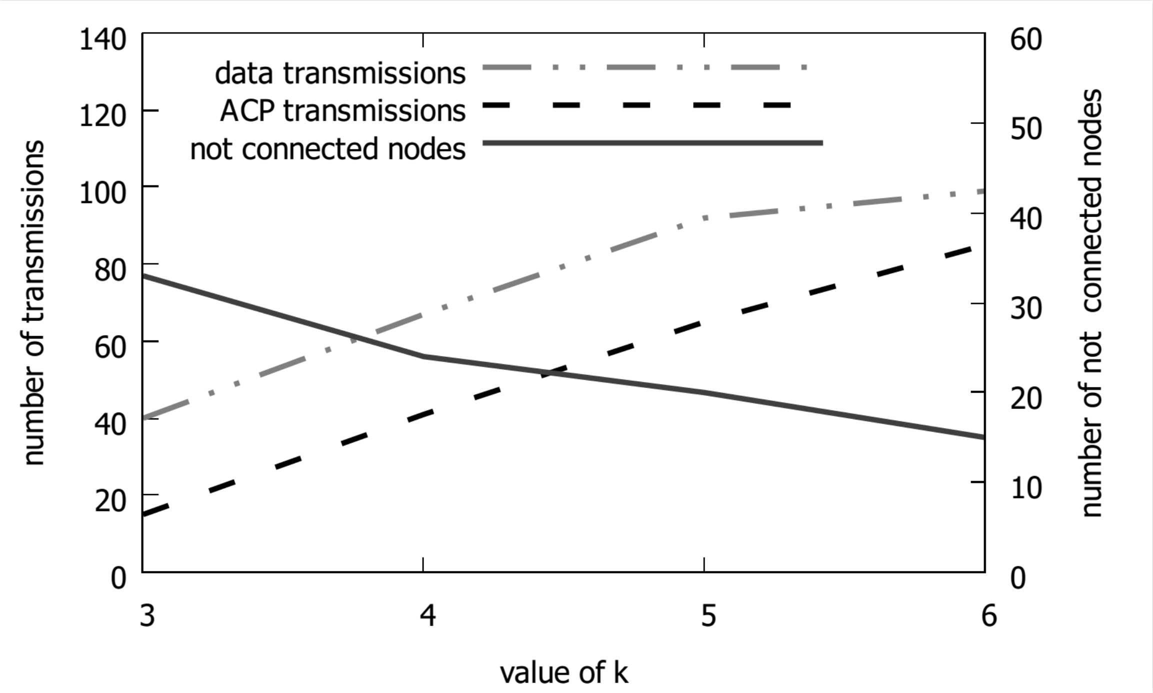
- Experiment with 60 nodes and a real environment

- The value k limitates the highest tree depth to k-1
- This value is mainly responsible for node coverage
- Higher value for k results in
  - more connected nodes
  - Higher risk of getting bottlenecks



Analysis

- Transmissions needed for the network organization
  - $T_{ACP} = 1 + \sum_{i=1}^{k-2} i \times N(i)$
- Transmissions needed for the data transmission
  - $T_{data} = \sum_{i=1}^{k-1} i \times N(i)$



SPEED

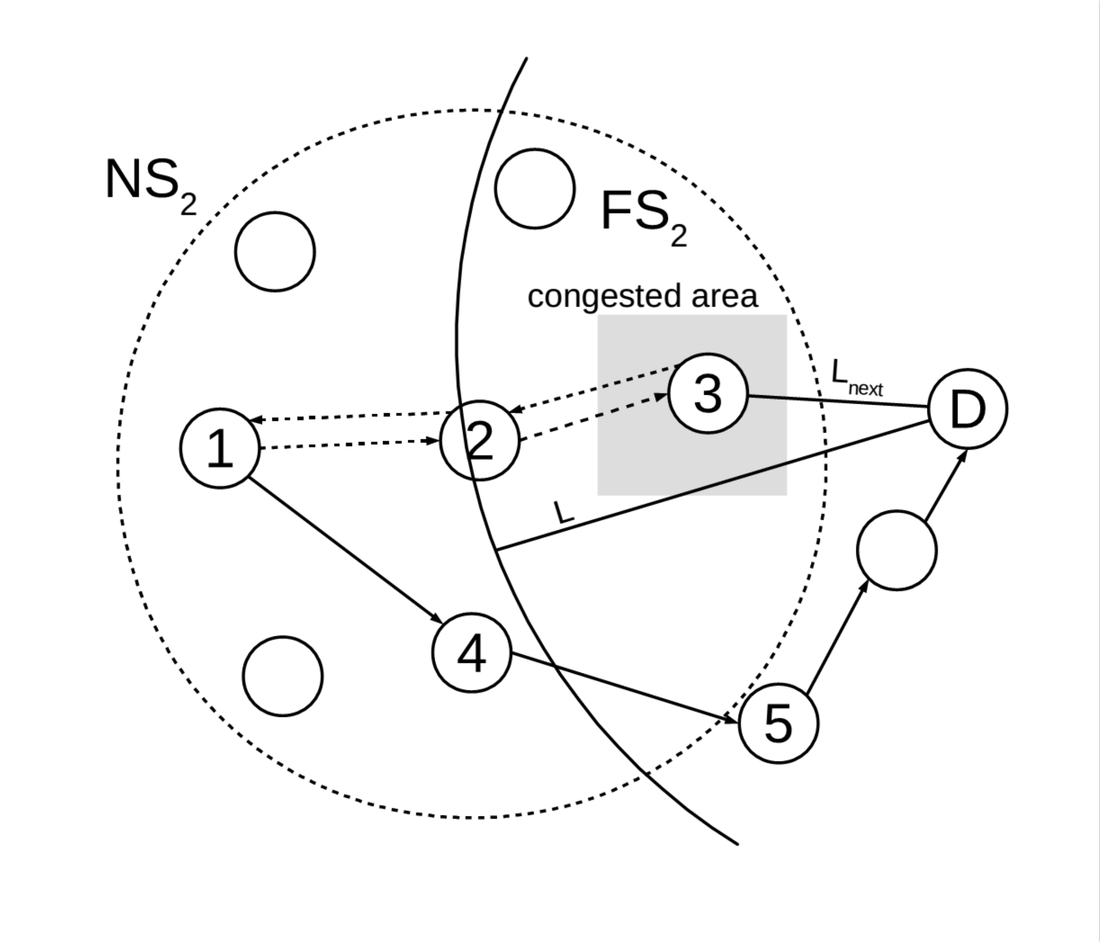
[5] T. He, J. Stankovic, C. Lu, T. Abdelzaher et al., “Speed: A stateless protocol for real-time communication in sensor networks,”

Idea

Better network behavior by using backpressure beacons to avoid congested areas and find a better route

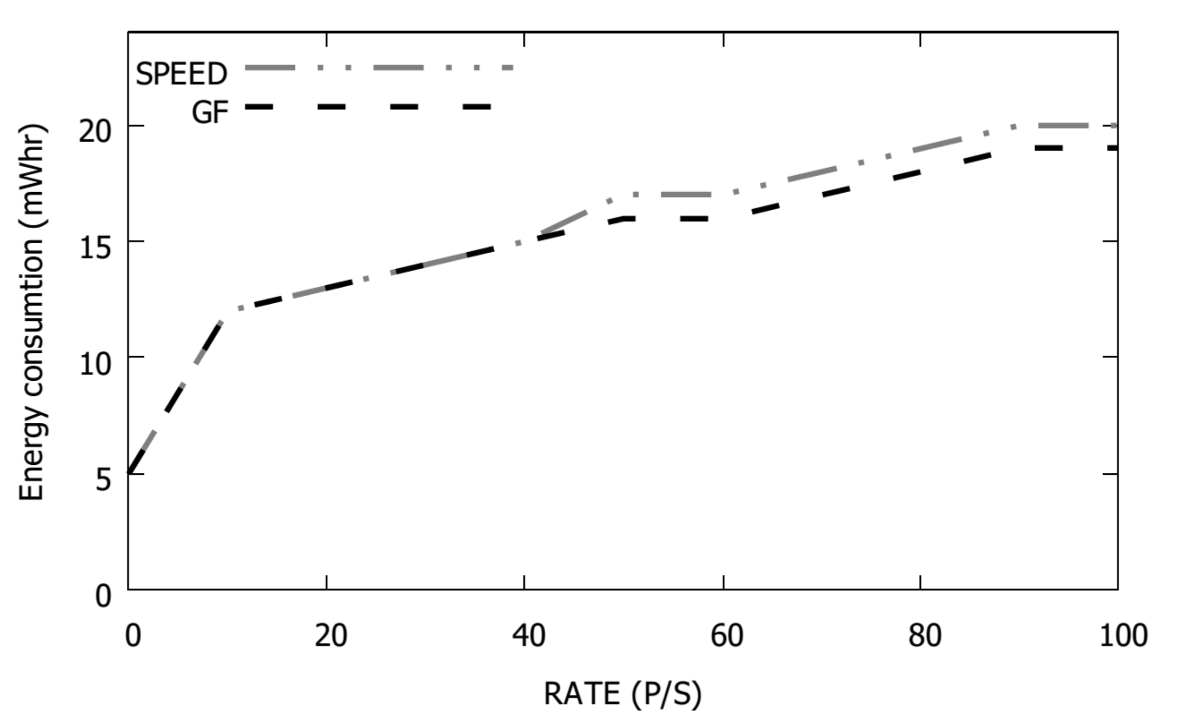
Algorithm

- 3 kinds of beacons
  - Periodically with the location information
  - On demand beacons for delay estimation beacon and backpressure beacon
- Packets are forwarded to a node within the FS_i and a speed $s_j^i > s_{setpoint}$
  - $s_j^i = \frac{L - L_{next}}{HopDelay_j^i}$
- FS_i is divided into two groups
  - Nodes which can maintain the desired speed
  - Nodes with a single hop relay speed greater the desired speed
- Signaling of congested areas with delay estimation and backpressure beacons



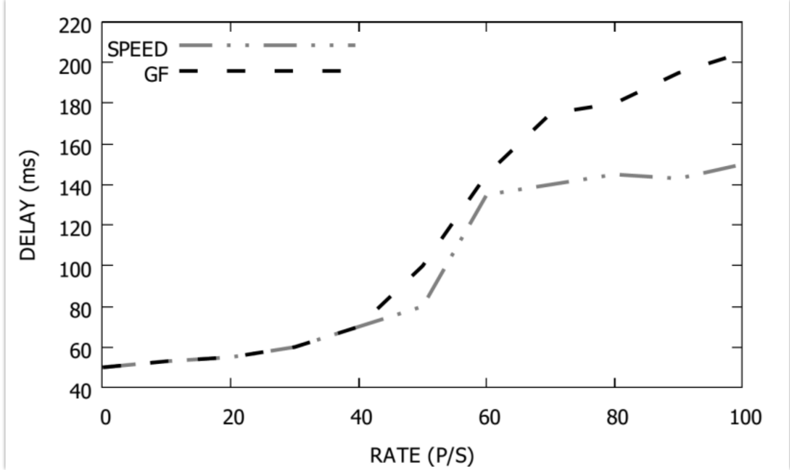
Analysis

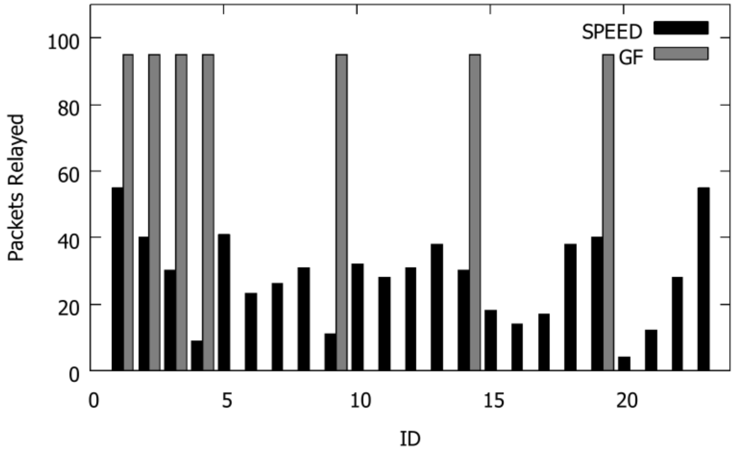
- Compared with the Greedy Forwarding
  - Forwards the packet to the node which makes the best progress
- Malicious package transmission is applied
- Speed has a higher energy consumption above a malicious package rate greater than 40 packet per secons



Analysis

- It has a small delay even on higher malicious packet rates
- It distributes the packets to more nodes
  - Longer lifetime for each node





Summary

Protocol	Classification	Data aggregation	Overhead	Data delivery model	Scalability	QoS	Query based
RR	Flat	Yes	Low	Demand driven	Ltd	No	Yes
ACQUIRE	Flat	Yes	Low	Complex query	Ltd	No	Yes
SOFROP	Hierarchical	No	High	Continuously	Ltd	No	No
SPEED	Location	Ltd	Low	Geographic	Good	Yes	Yes

- Rumor Routing and ACQUIRE depending on the data dynamics and the number of queries/events
- SOFROP best choice for a network with a high mobility
- SPEED if delay and energy distribution are recommended criterias

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Thank you

Any questions?

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