Title
Evaluation of GPSR in the Diffusion Filter Framework

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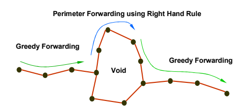
Introduction: Directed Diffusion, Filter Framework & GPSR

Directed Diffusion & Filter Framework

- **Directed diffusion** [Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Networks, Intanagonwiwat et al.]
  - A data-centric communication mechanism for sensor networks
  - Emphasizes in-network processing
- **Filter Framework** [Diffusion Filters As a Flexible Architecture for Event Notification in Wireless Sensor Networks, Heidemann et al.]
  - Goal: Support multiple routing protocols
    - Current protocols: Twp-phase diffusion, one-phase diffusion, push diffusion, GEAR, source routing and GPSR
  - Provides common attribute-based message format
  - Filters modulize each protocol
    - Interconnected by messages and matching rules
    - Can use in single and multiple address spaces

GPSR – Greedy Perimeter Stateless Routing

- **Described in the paper:** [GPSR: Greedy Perimeter Stateless Routing for Wireless Networks, Karp et al.]
- **Good for geographically addressed sensor networks**
- **Routing decisions are solely based on geographical coordinates**
  - Stateless – no route maintenance, very low overhead
- **Mechanisms**
  - Greedy forwarding
  - Perimeter forwarding
  - Planarization: Transforms network topologies into planar graphs, without losing connectivity



Problem Description: Why GPSR?

Why GPSR in Sensor Networks?

- Uses geographical information to avoid flooding
  - Without using geographical information, flooding is necessary for several ad hoc routing protocols
- Building block of geographic hash table and data-centric storage
- Minimal configuration
  - No need to assign addresses
  - No hierarchical aggregation necessary

Why GPSR in Filter Framework?

- Geographical routing could be useful to existing applications running in filter framework
- Want to compare GPSR, GEAR and diffusion
- GPSR as a filter demonstrates support for multiple routing protocols in filter framework

Results: Simulation Results, Analysis & Software Architecture

Configuration of Simulation

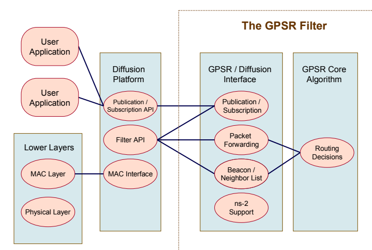
- Topology
  - 100 nodes with radio a range of 250, randomly distributed in a square area, from 400*400 to 2000*2000
    - Average number of neighbors ranging from 121(100) to 4.86
  - Only use connected topologies
- Traffic
  - 10 pairs of source and sink
  - Each source sending at a 10-second interval
- Simulation time: 20 minutes
- Simulation Process: 10 simulations for each area size, using different topologies

A sample of generated topology

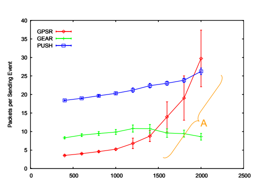
Goals of Performance Evaluation

- Evaluate the performance of GPSR by simulations
- Compare with other routing protocols
- Focus on the relation between performance and network density
- Find favorable conditions for different routing protocols

How GPSR Filter Fit Into The Filter Framework



Simulation Results, Observations & Analysis

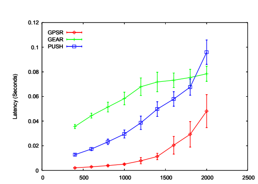


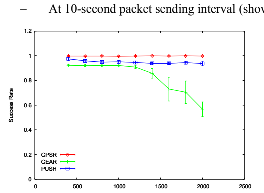
Packets per Sending Event

- GPSR: Low average, but packet cost increases quickly as node density decreases (see A)
  - Denser networks – greedy mode most of the time
  - Sparser networks – perimeter mode more frequently used, results in longer paths
- Push: Average is higher than GPSR
  - Each source floods the network every 60 seconds
  - Simulation done without multicast or in-network processing. Push will work much better with fewer sources, more sinks and in-network processing
- GEAR: Higher for medium density networks and lower for denser or sparser networks
  - For denser networks, large number of neighbors results in increased beacon exchange
  - Drop in traffic for sparser networks reflects failure in delivering packets (see Success Rate)

Latency

- Factors involved
  - GPSR: No route establishment process, each packet routed independently
  - Push and GEAR: Use on demand route establishment process
  - Despite higher initial latency, Push and GEAR usually generate shorter paths
  - Latency for all three protocols increases as networks become sparser, due to longer paths
- Comparing latency based on packet rate
  - Average latency for GPSR is virtually unrelated to packet rate
  - Average latency for Push and GEAR drops for higher packet rates (not shown in the figure), as initial route establishment cost is distributed into more packets
  - At 10-second packet sending interval (shown in the figure), GPSR always has the lowest latency





Success Rate

- Packet collisions cause occasional packet losses
- Push more vulnerable to collisions as it uses flooding
- Significant drop in success rate for GEAR due to bugs in GEAR implementation
  - *As a result, GEAR data is not directly comparable with the other two protocols*

Conclusions

When to use GPSR

- Required conditions for GPSR can be satisfied
  - The coordinates of each node is known
  - One-to-one source and sink relation
- GPSR will deliver better performance if
  - Network is relatively dense
  - Packet rate is relatively low
- Use GPSR if low low initial latency is important

When to use Push

- Push has fewer required conditions
- Push will deliver better performance if
  - One source, multiple destinations, as multicast and in-network processing can be used
  - Packet rate is relatively high
    - Cost of flooding is distributed into more data packets
    - Benefit of shorter paths can show up

Comments about Filter Framework

- Filters easily support different routing protocols like GPSR
- Easy for applications to try different routing protocols