# SPEED: A Stateless Protocol for Real-Time Communication in Sensor Networks

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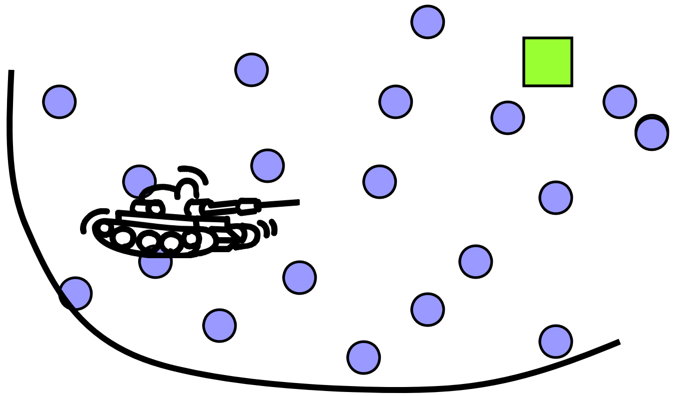
**ICDCS 2003**

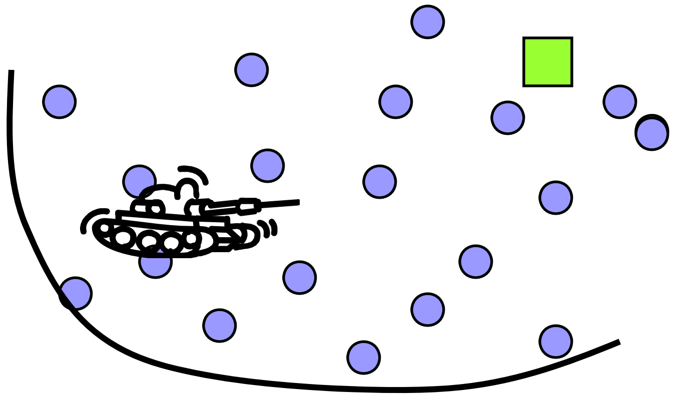
# Motivations and Main Ideas

- Motivations
  - Many sensory data are time-critical
    - soft real-time guarantee of end-to-end deadline
- Ideas
  - AreaMultiCast, AreaAnyCast, Unicast
  - Network-wide constant speed guarantee
    - Feedback control
    - Geographic routing



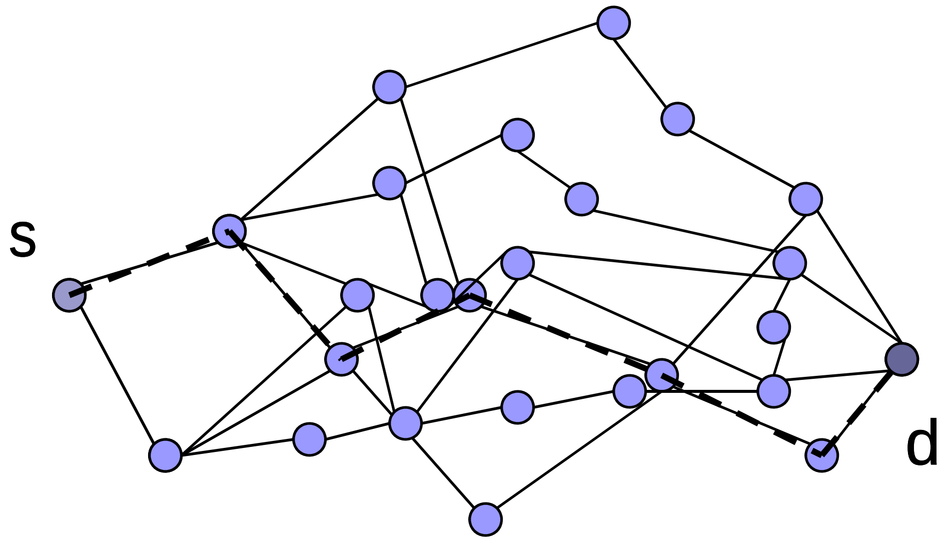
# Area-based routing

- Area-based destination is more meaningful
  - Send sensing request to all sensors in an area (AreaMultiCast)
  - Send sensing request to any sensor in an area (AreaAnyCast)
- So, the packet destination is given as a geographic area (not global node ID)



# Globalized Packet Forwarding

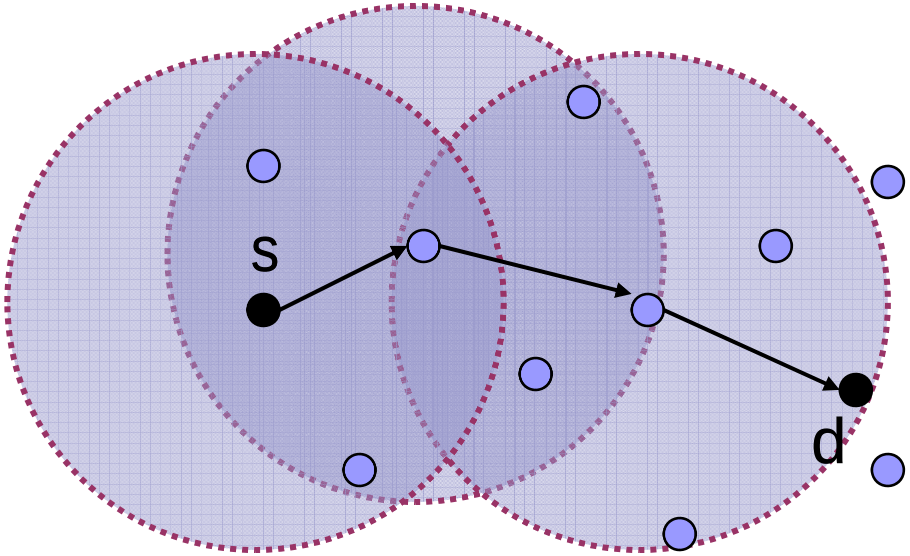
- Build a complete route to the final destination




- **Not Scalable**
- **Large overhead for path maintenance with topology changes**
- **Not aperiodic friendly**

# Localized Packet Forwarding

- Select nodes geographically closer to the final destination



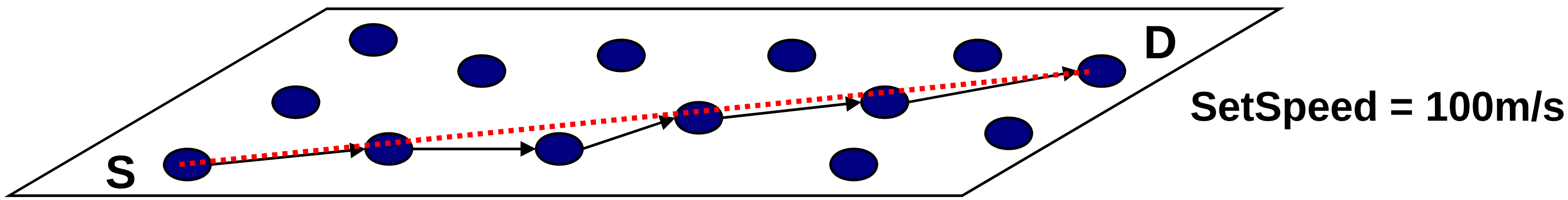

**+ Scalable**

**+ Handle aperiodic and periodic packets**

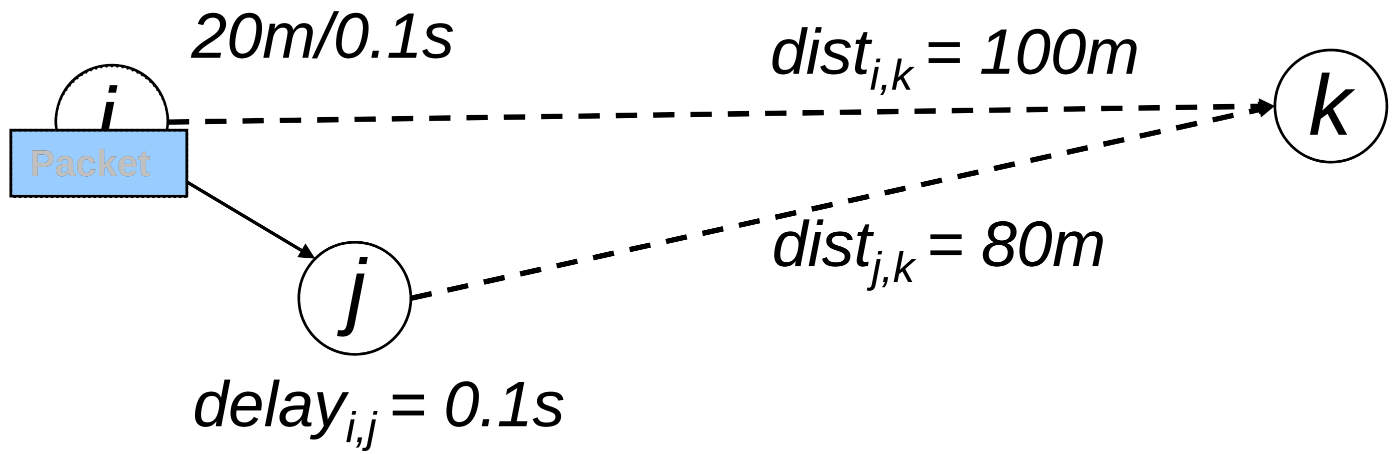
**+ Packet-by-packet adaptation to network dynamics**

# End-to-end deadline guarantee

- Preserve network wide CONSTANT speed say “100m/sec”.
- Once a packet is created from S destined to D, the end-to-end delay can be estimated as “Dist(S,D)/100”.
- If estimated e2e delay is less than e2e deadline, the deadline can be met.



# SPEED calculation

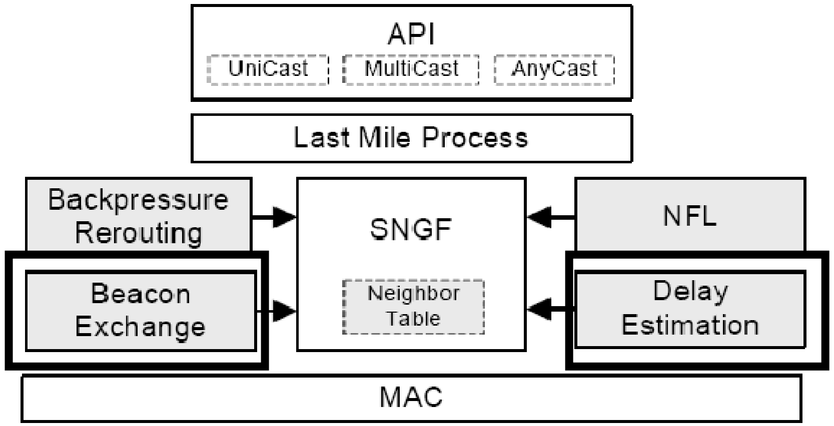



$$Speed_{i,j}^{k} = \frac{dist_{i,k} - dist_{j,k}}{delay_{i,j}} = \frac{100 - 80}{0.1} = 200m/\sec$$

- If every node can find a forwarding node with speed higher than SetSpeed, SetSpeed can be provided network-widely.

# Localized maintaining of neighbor table

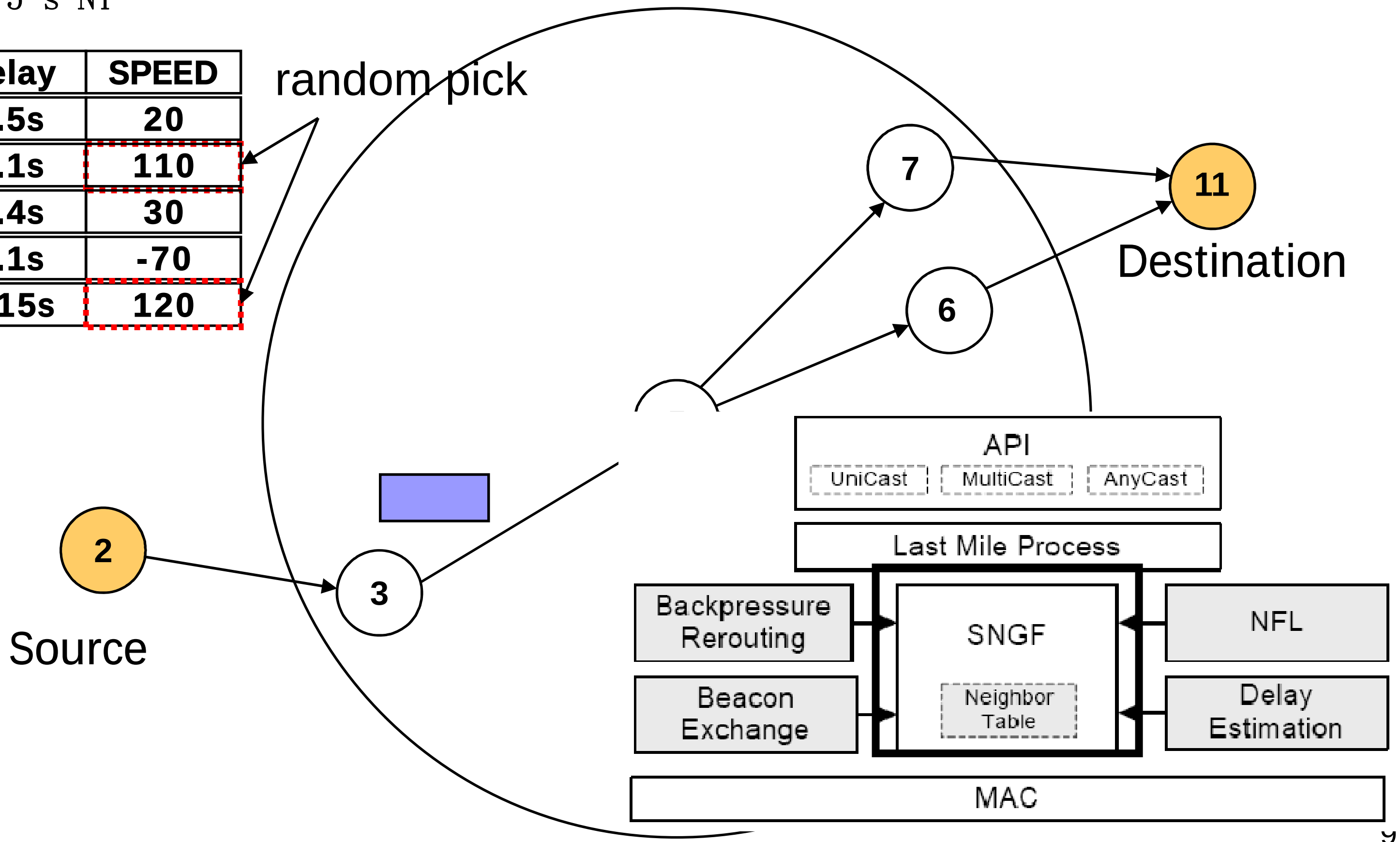
- Periodic beacon exchange
  - so that a node can notice its up to date neighbors
- Delay estimation to every neighbor
  - recent average of delay to each neighbor



# Non-deterministic geographic forwarding

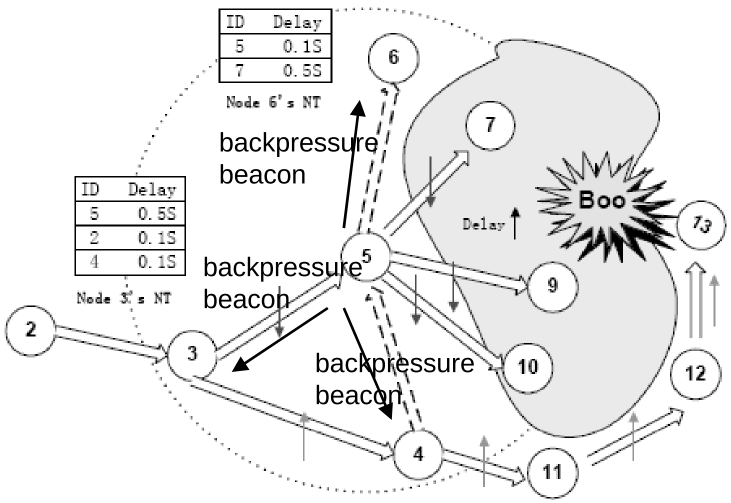
Node 5's NT

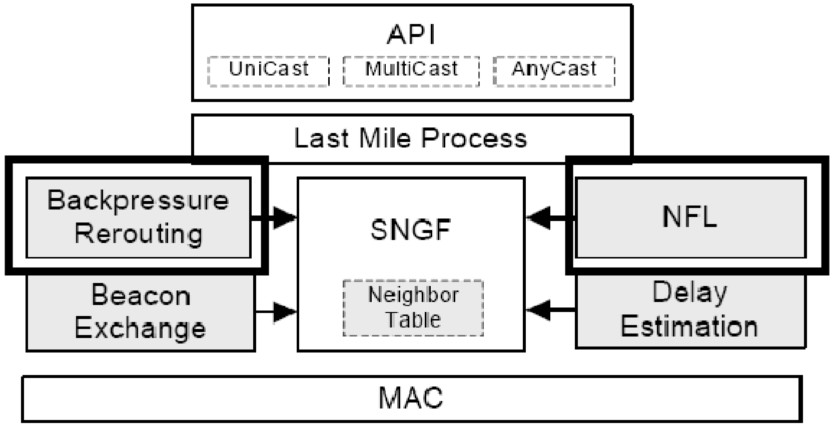
| ID | Delay | SPEED |
|---|---|---|
| 9 | 0.5s | 20 |
| 7 | 0.1s | 110 |
| 10 | 0.4s | 30 |
| 3 | 0.1s | -70 |
| 6 | 0.15s | 120 |



# Neighbor Feedback Loop and Back-Pressure

- What if a node A cannot find any neighbor that can guarantee $Speed_{set}$
  - Neighbor Feedback Loop
    - drop relay ratio u through feedback control (see equations in the paper)
    - this is the probabilistic drop to guarantee that each node can find at least one good neighbor
  - On-demand backpressure beacon
    - to prevent the upstream nodes inject further packets



# Experiments

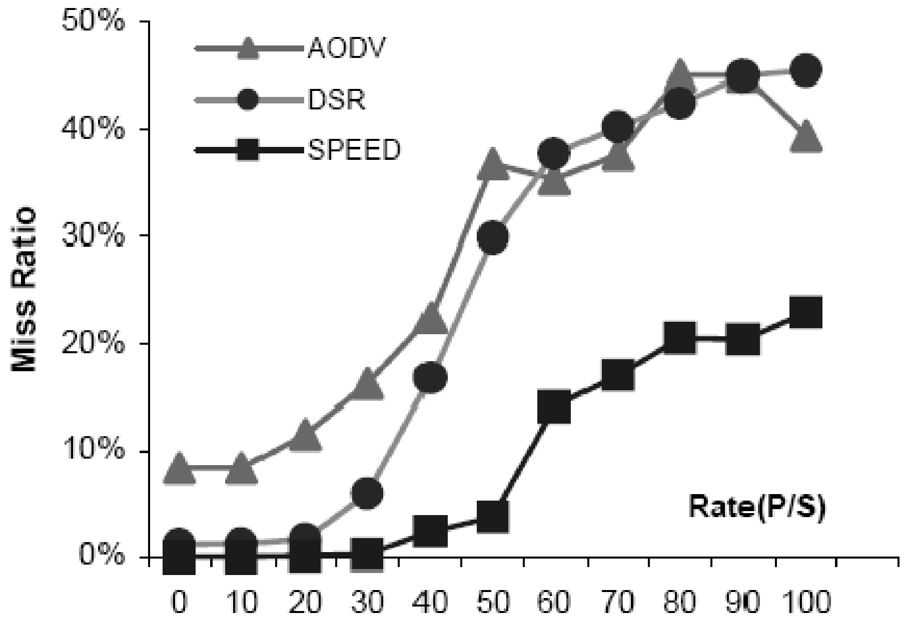



Figure 9. MissRatio Under Different Congestion

# Reference


- Tian He, John A Stankovic, Chenyang Lu, and Tarek Abdelzaher, “SPEED: A Stateless Protocol for Real-Time Communication in Sensor Networks”, Proceedings of the 23rd international conference on Distributed Computing Systems, 2003

# Homework 10

- Simulate the SPEED protocol using NS-2 and reproduce the same data in the paper
- Compare SPEED performance with those of DSDV (not DSR) and AODV as in the paper

# Homework 11 (Optional)

- Simulate the MMSPEED protocol using NS-2 and reproduce the same data in the paper
- Extra credit will be given!