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Matching Data Dissemination Algorithms to Application Requirements

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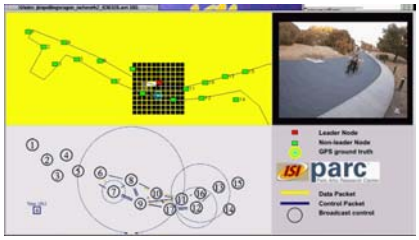
Introduction: Sensor network applications have many different traffic patterns



Sensor Network Applications

- Monitoring
  - James Reserve: habitat monitoring → many-to-one
  - Twentynine palms: vehicle tracking → many-to-many
  - PARC IDSQ: vehicle tracking → one-to-many, one-to-one
- Actuation
  - Traffic Monitoring and Control

- Different traffic patterns



Example: PARC IDSQ: leader sends one-to-many suppression messages and one-to-one state-transfer messages

Problem Description: How can diffusion address application-specific requirements?

Application Requirements

- Sensor network application have different needs
  - Different traffic patterns (one-to-many, many-to-one, many-to-many)
  - Different data rates (fixed and variable, frequent and infrequent)

Robustness Requirements

- Applications must be robust to change:
  - Wireless "links" come and go
  - Nodes fail or move

Question: How can communication be *robust* but also *efficient* for *many different applications?*

Multiple Diffusion Routing Algorithms

- Two-Phase Pull Diffusion [Intanagowiwat et al, 2000]
  - Initial diffusion implementation
  - Periodically floods interests and exploratory data
- One-Phase Pull Diffusion [Heidemann et al, 2003]
  - Only floods interests
- Push Diffusion [Heidemann et al, 2003]
  - Reverses the roles in the publish/subscribe API
  - Floods only exploratory data messages
- GEAR [Yu et al, 2001]
  - Adds support for geographically-scoped queries

Proposed Solution: Match routing algorithms to application requirements

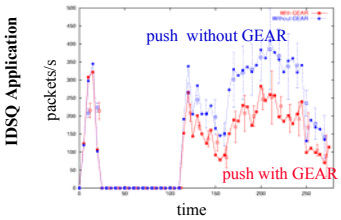
Approach

- Support multiple routing algorithms in *filter framework*
- Describe performance differences for application designers

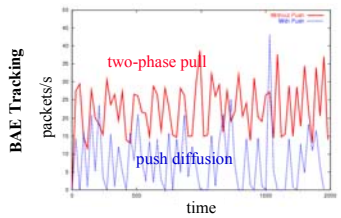
Evaluation Methodology

- Identify test application classes from experience
  - BAE tracking
    - many-to-many→ benefits from push
  - PARC IDSQ
    - one-to-many, one-to-one → benefits from GEAR and push
  - James Reserve Data Collection
    - many-to-one → benefits from one-phase-pull
- Describe performance differences for application designers
  - Use systematic emulation and simulation studies to explore design space:
    - Use different diffusion algorithms
    - Vary number of sources and sinks
    - Vary topologies (clustered vs. unclustered)

Sample Applications

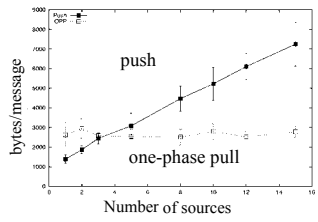


GEAR reduces message count by ~40%
(for 17-node IDSQ with similar target movement; expect another 40% reduction when GEAR supports points. Diffusion here is push.)

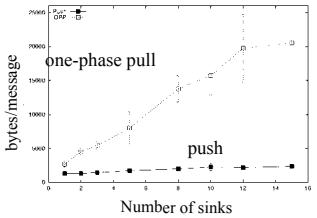


Push reduces message count by ~60%
(for cross-subscribing scenario with few active publishers)

Systematic Evaluation



One-phase pull is best with many sources, few sinks
(for a 60 node network with one sink; sources send data every 2 seconds)



Push works best with many sinks and few sources
(for a 60 node network with one source, sending data every 2 seconds)

Conclusions

- Push works best with many sinks and few active sources
- One-Phase Pull works best with many sources and a few sinks
- The break even point between the two algorithms depends upon specific control message frequency (such as interest send rate and exploratory data rate), as well as application data rates
- For networks with more than a few dozen nodes, the benefits of geographically-scoped queries can outweigh other algorithmic choices.
  - Algorithm selection still matters (e.g. one and two-phase pull diffusion will still incur gradient maintenance overhead by periodic interests even when sources have no data to send

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