CS 428 Information Processing f or Sensor Network

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Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Network

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Building Efficient Wireless Sensor Networks with Low-Level Naming

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Contribution

- “Directed Diffusion”: New paradigm for communication primitive of sensor network
- “Low-level Naming …”: Implementation of directed diffusion using real hardware and verification of the original claims. (in-network processing …)

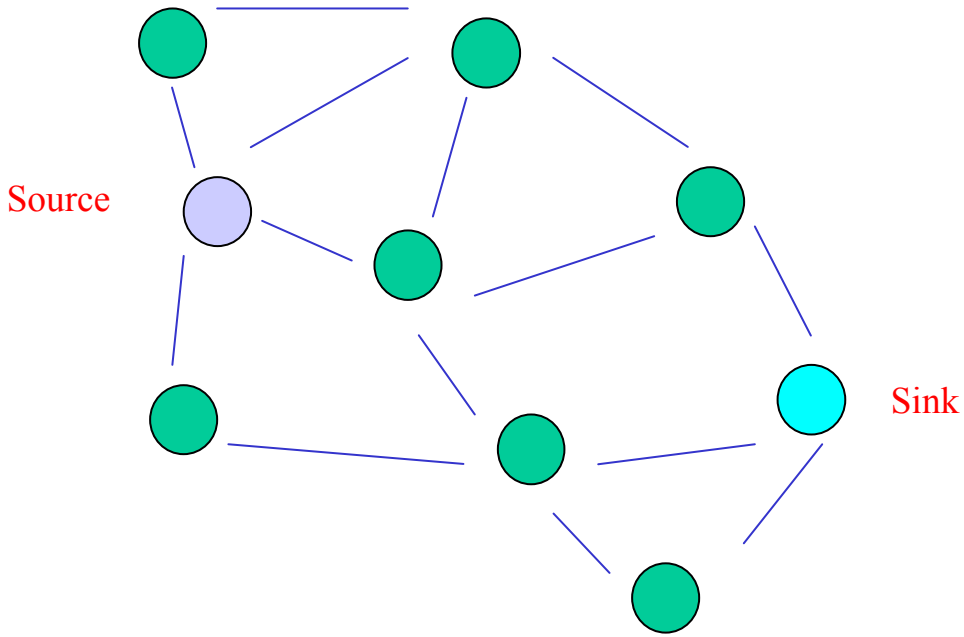
Motivation

	General Network	Sensor Network
Goal	**Share resources**	**Specific Task**
Whom to talk to?	**Node ID**	**Data, Sensing Modalities, Location → Node Attributes**
In-network Processing	**Not Really. All we care is end-to-end comm…**	**Essential for Energy-Efficiency**

→ Need a Data-Centric communication paradigm that allows efficient in-network processing !

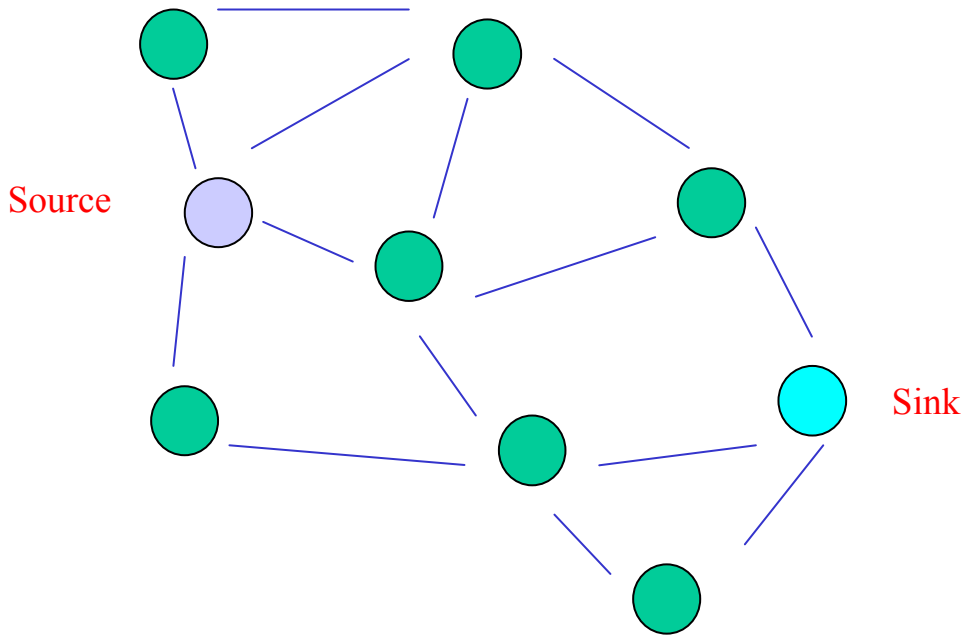
Scenario

- Simple tracking: A user sends to a node (sink) a query/task “Report a position of a four-legged animal in region X”.

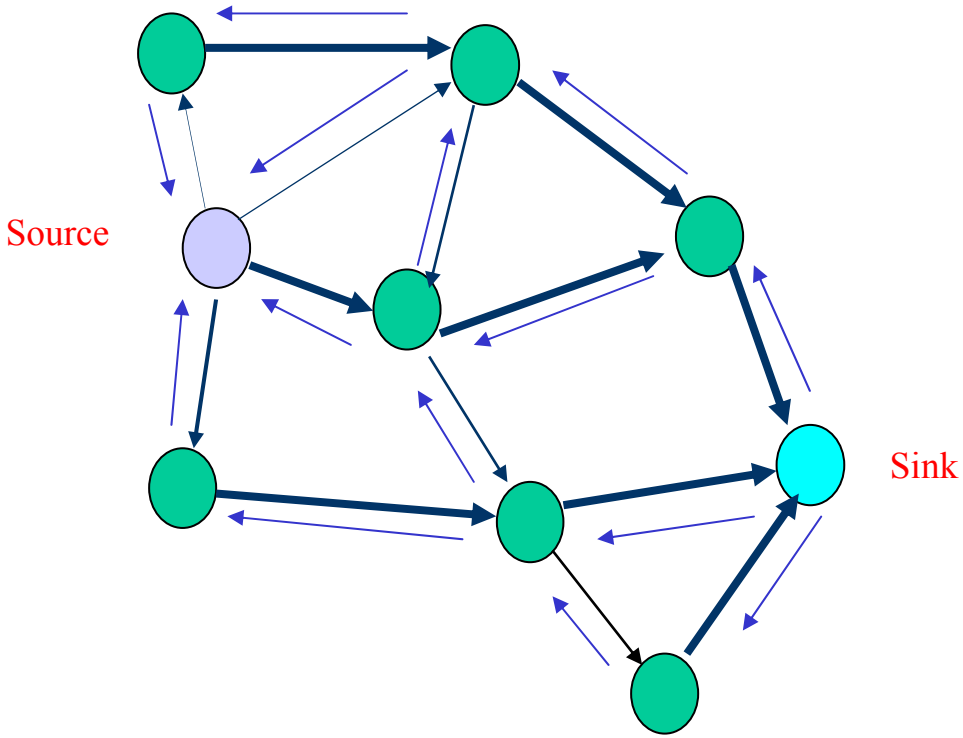


Main Idea

- Sink (user) propagates "*interest*".
  - Interest = (attribute, value) pairs
- Source (data provider) sense/process "*data*".
  - Data = (attribute, value) pairs
- Intermediate nodes: In-network Processing
  - Caching, Aggregation, Transcoding etc.



Main Idea: Example



Local Behavior Choices

1. For propagating interests

   In our example, flood

   More sophisticated behaviors possible: e.g. based on cached information, GPS

2. For setting up gradients

   Highest gradient towards neighbor from whom we first heard interest

   Others possible: towards neighbor with highest energy

3. For data transmission

   Different local rules can result in single path delivery, striped multi-path delivery, single source to multiple sinks and so on.

4. For reinforcement

   reinforce one path, or part thereof, based on observed losses, delay variances etc.

   other variants: inhibit certain paths because resource levels are low

Directed Diffusion Summary

- Application-aware communication primitives
  - expressed in terms of named data *(not in terms of the nodes generating or requesting data)*
- Consumer of data initiates interest in data with certain attributes
- Nodes diffuse the interest towards producers via a sequence of local interactions
- This process sets up gradients in the network which channel the delivery of data
- Reinforcement and negative reinforcement used to converge to efficient distribution
- Intermediate nodes opportunistically fuse interests, aggregate, correlate or cache data

Second Paper

- Actual implementation of directed diffusion on testbed.
- Matching Rules
- Filters
  - Aggregation
  - Nested Query

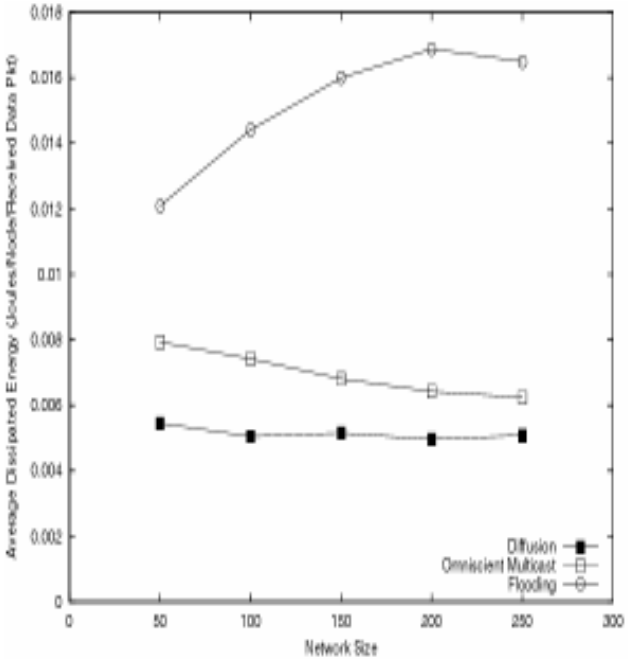
Matching Rule

- Interest(and Data): (attribute-value-operation) tuple
- Operators
  - Actual: IS
  - Formal: EQ, NE, LE, GE, EQ_ANY
- Example of interest: (type EQ four-legged animal-search, interval IS 20ms, duration IS 10 seconds, x GE –100, x LE 200, y GE 100, y LE 100, class IS interest)
- Example of data: (type IS four-legged-animal-search, instance IS elephant, x IS 125, y IS 220, intensity IS 0.6, confidence IS 0.85, timestamp IS 1:20, class IS data)
- Complete match ←→ one-way match in both direction

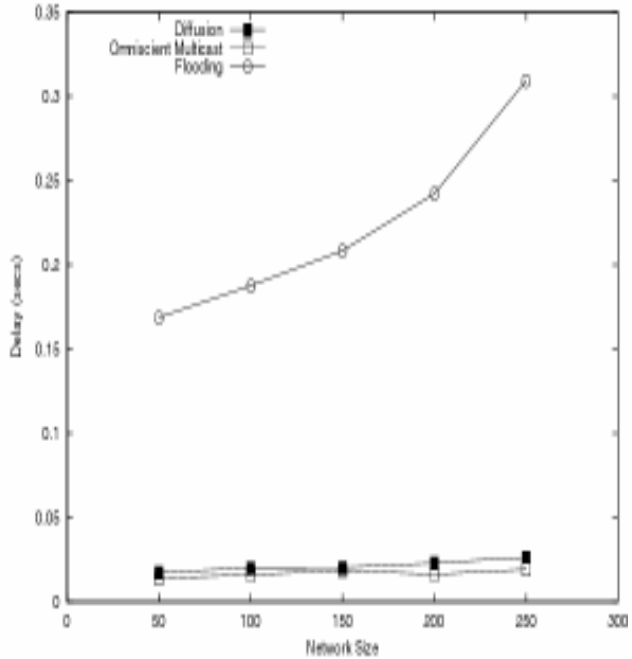
Filter

- A mechanism for allowing application-specific code to run in the network and assist diffusion and processing.
- Examples of Filter Application
  - Aggregation
  - Nested Query

Results I: Simulation

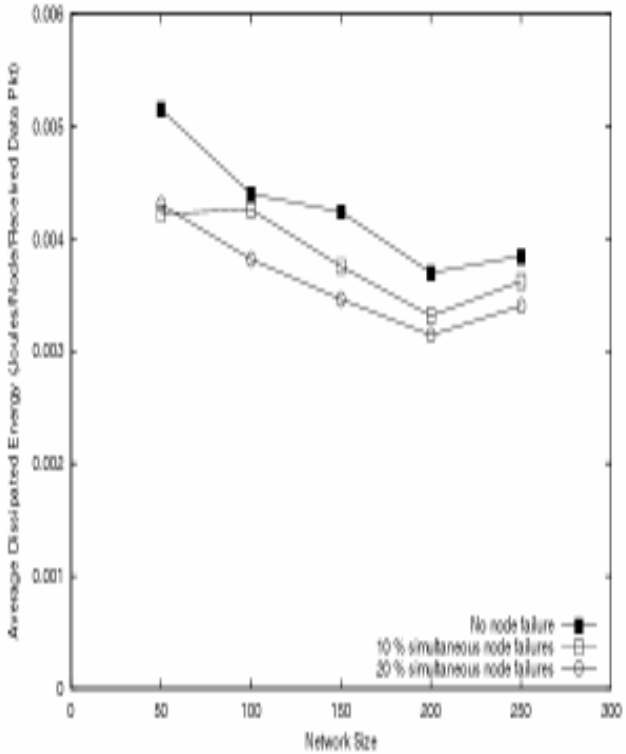


Average dissipated energy

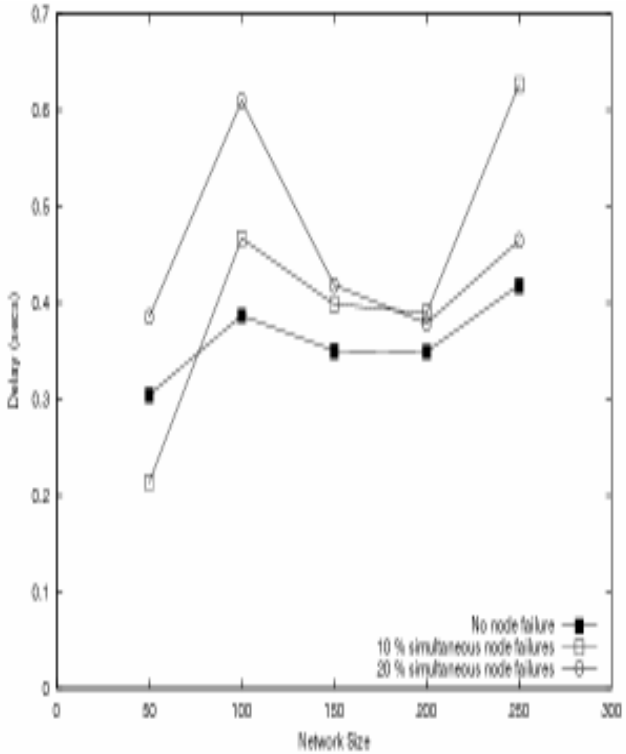


Average delay

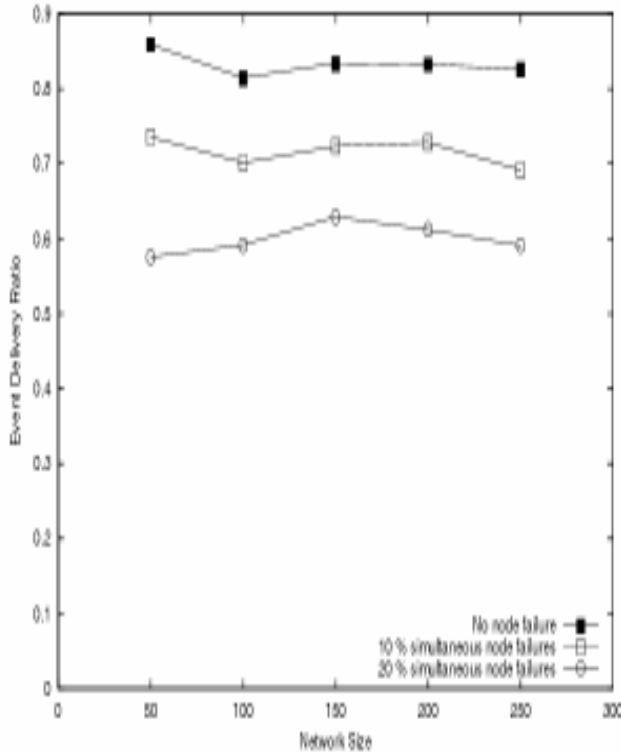
Results II: Simulation



Average dissipated energy

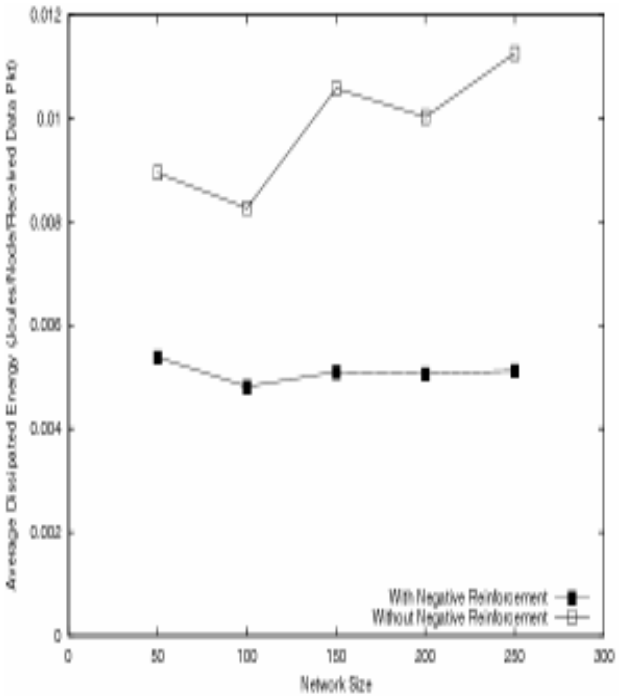


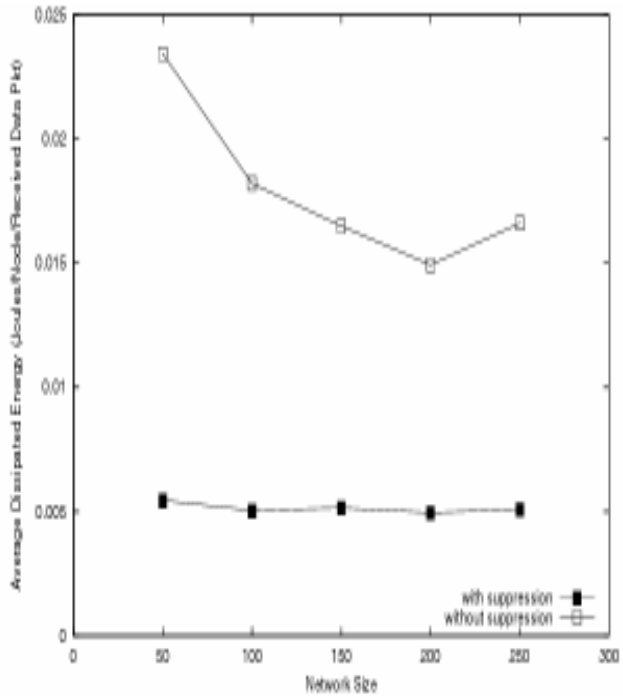
Average delay

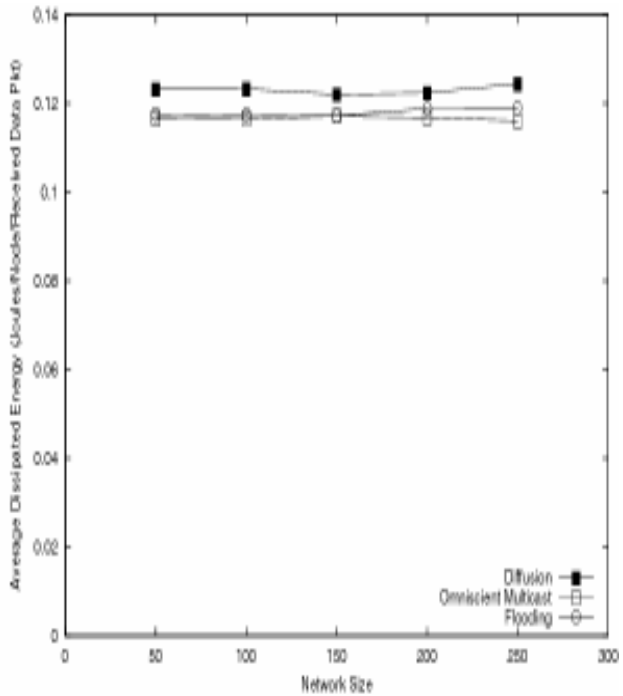


Event delivery ratio

Results III: Simulation





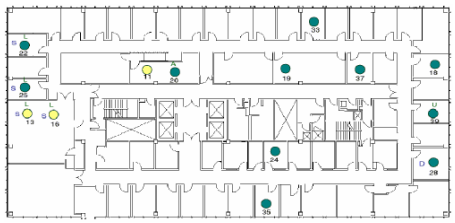


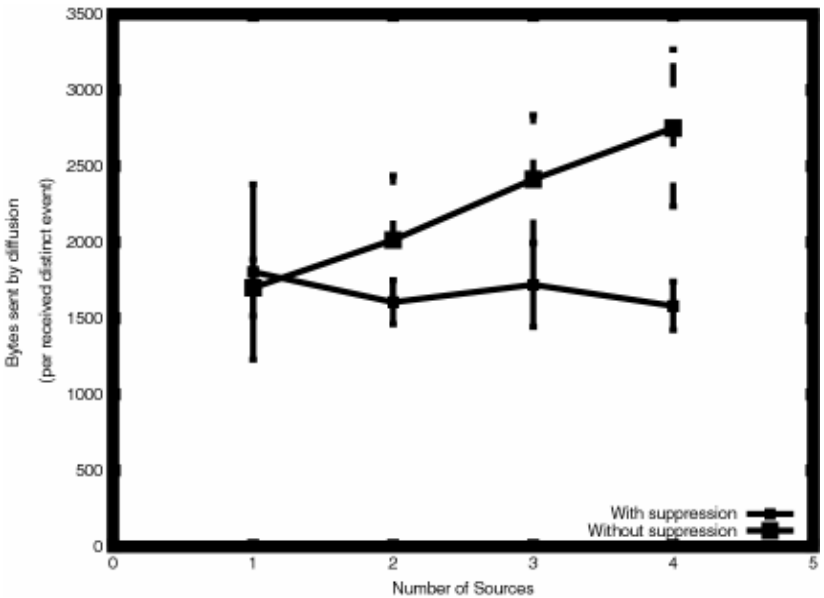
Negative Reinforcement

Duplicate suppression

High idle radio power

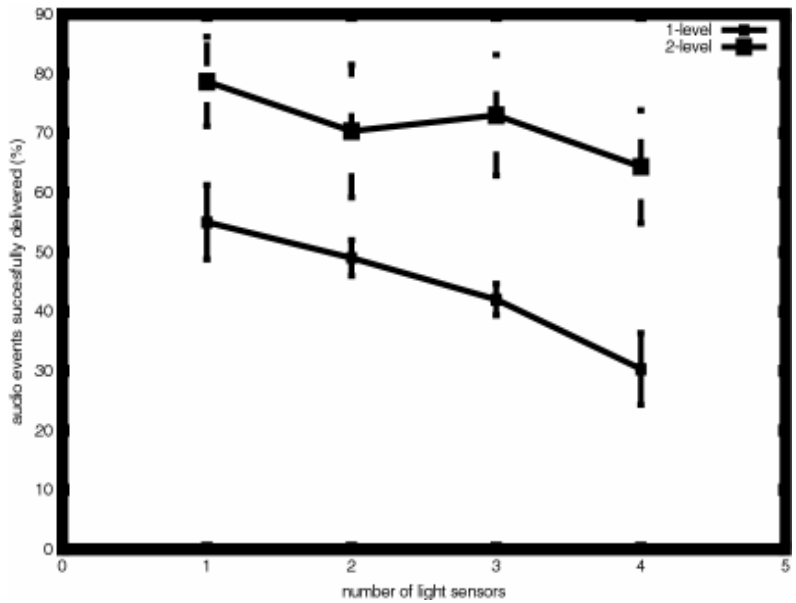
Results IV: Experiment on testbed





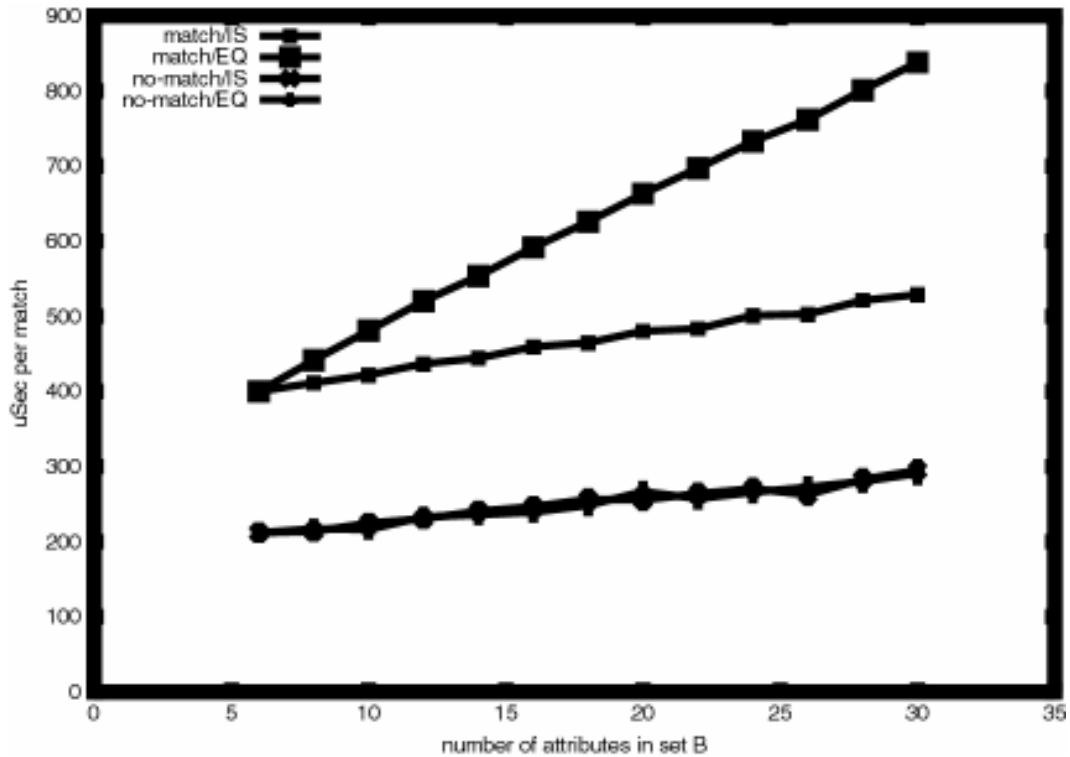
Energy efficiency measure

(Bytes/Event)



Effect of nested query

Results V: Experiment on testbed



Matching Performance as a function of # attributes

Conclusions/Discussions

- Directed Diffusion and its implementation
- New, energy efficient communication primitives in sensor network
- Not obvious how to write application on top of directed diffusion. (Directed diffusion itself is an application.)
- Importance of energy efficient MAC layer protocol