CS649
Sensor Networks
Lecture 18: Routing II

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Outline

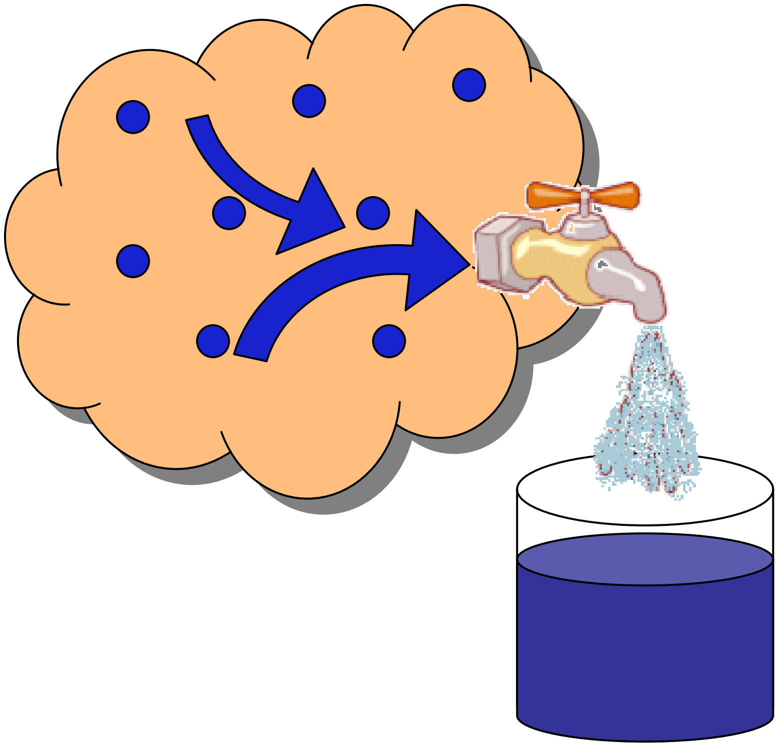
- Types of data collection in WSNs
- Directed Diffusion model
- Evaluation results
- Diffusion variants

Types of Data Collection

- Streaming
- In-Network Processing
- Triggering
- Tasking

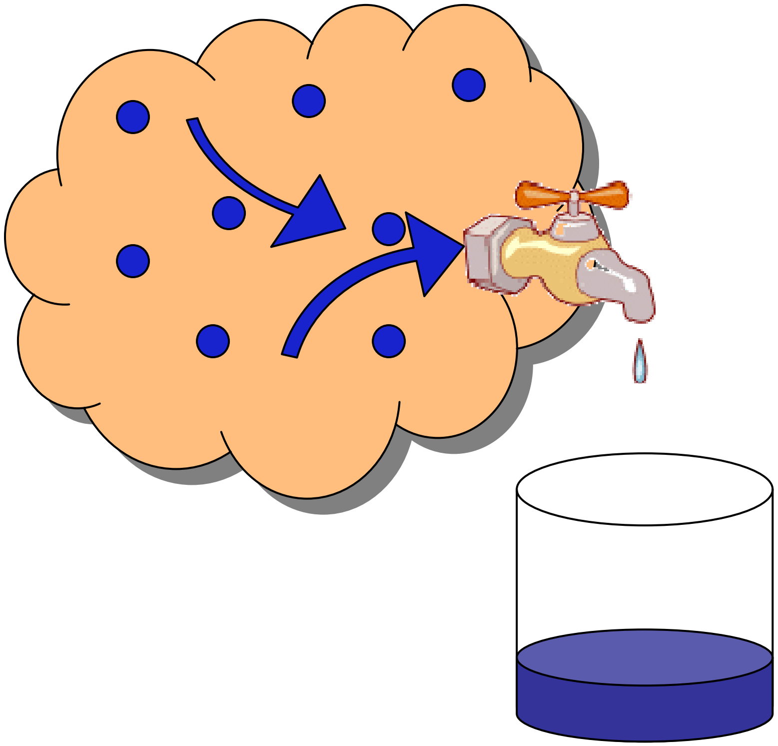
Streaming

- Most typical method in current deployments
  - Great Duck Island deployment
- Correlation, processing, and logic is largely done outside of the network



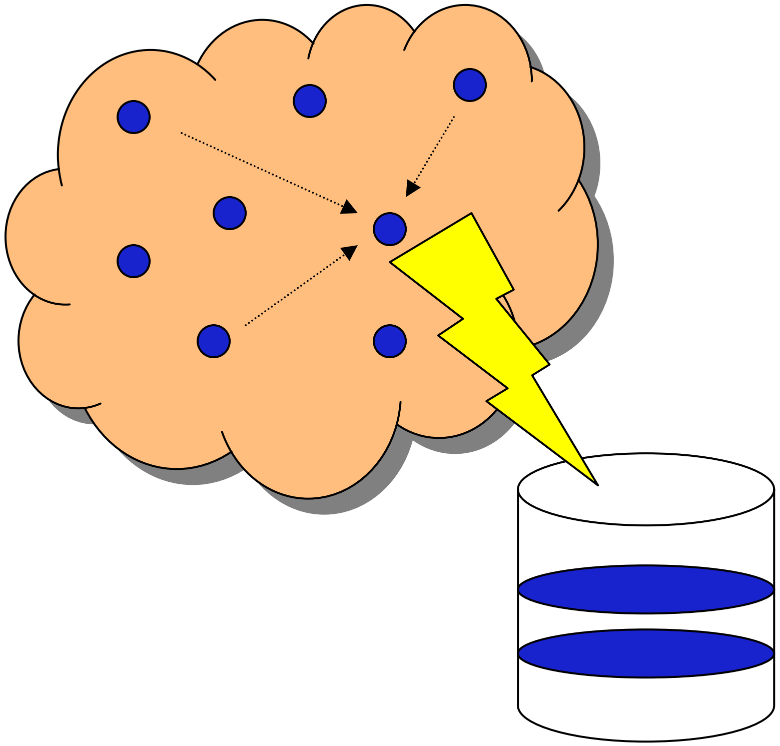
In-Network Processing

- Routing
  - Diffusion Matching
- Storage
  - Data Distribution
  - Lookup
- Aggregation
  - TinyDB
- Compression
- ESS
- Loose Model



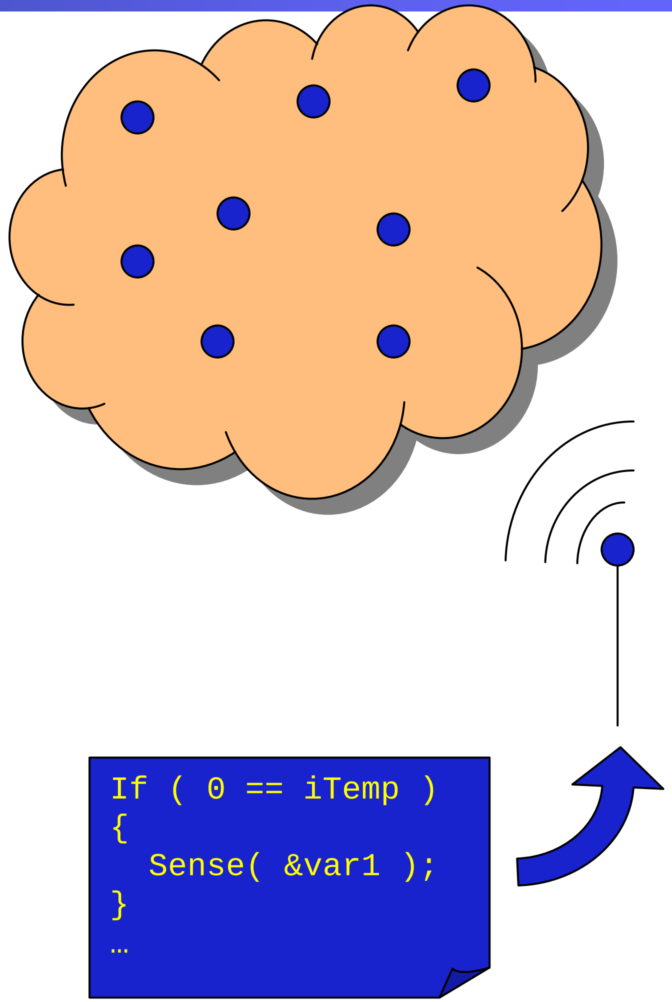
Triggering

- Event Detection
  - Data may be routed for different reasons
  - Relevance of data is defined by distributed model



Tasking

- Network control and configuration
- Query languages
- Programming “scripts”
- Binary-reprogramming



Directed Diffusion

- New routing model
  - Named data
  - Publish and subscribe
  - Diffusion protocols

Publish and Subscribe

- Data sources need not know anything about data sinks
  - Network can scale independent of data consumption
  - Data can be routed dynamically, according to its value
    - Matching

Named Data

- Data names are attributes
  - Key
  - Operation
  - Value
- Routes are known as Gradients
- Attributes (data) is matched along gradients as it flows through the network

Attributes Implementation (1)

- Each attribute implemented as a key-type-value-operator tuple
- Key
  - Indicates the semantics of the attribute
    - Latitude, frequency, etc
- Type
  - Indicates the primitive type that the key will be
  - Available types
    - INT32_TYPE // 32-bit signed integer
    - FLOAT32_TYPE // 32-bit
    - FLOAT64_TYPE // 64-bit
    - STRING_TYPE // UTF-8 format
    - BLOB_TYPE // un-interpreted binary data

Attributes Implementation (2)

- Operator
  - Describes how the attribute will match when two attributes with the same key and type are compared
  - Available operators are: IS, EQ, NE, GE, GT, LE, LT, EQ_ANY
  - IS operator specifies a known, actual value
  - Other operators specify a condition that must be satisfied

- Examples
  - LATITUDE IS 12.3
  - LONGITUDE LE 45.2
  - TEMPERATURE IS 72.7
  - CONFIDENCE GT 0.80

Matching Example (1)

Each formal must match some actual:

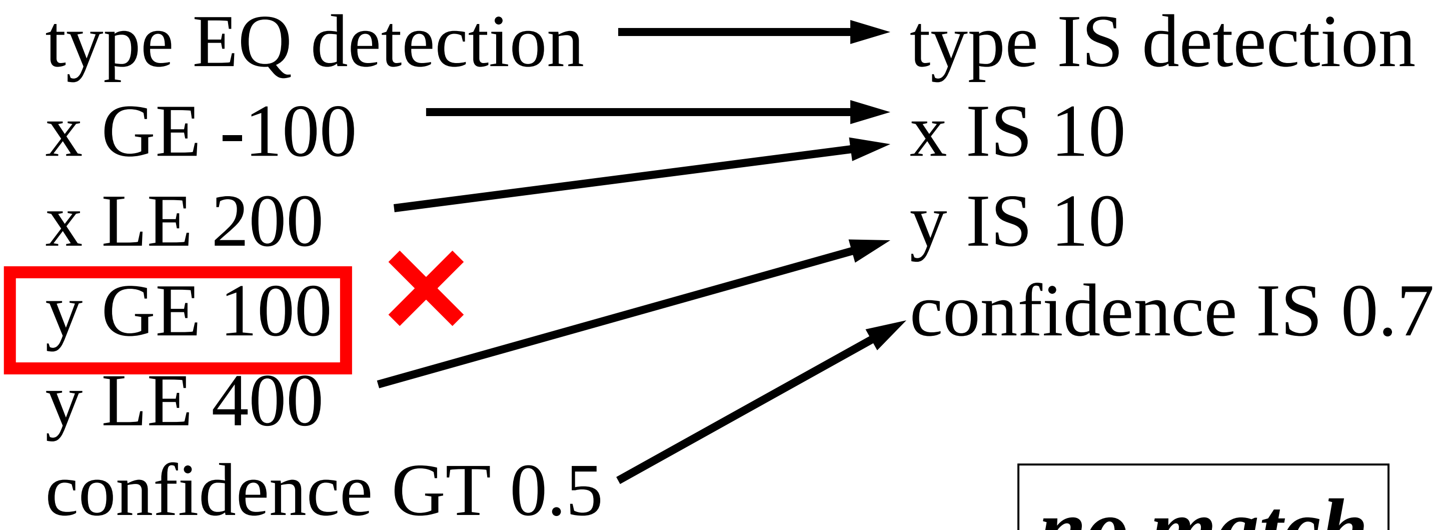
type EQ detection
x GE -100
x LE 200
y GE 100
y LE 400
confidence GT 0.5

type IS detection
x IS 10
y IS 150
confidence IS 0.7

valid match

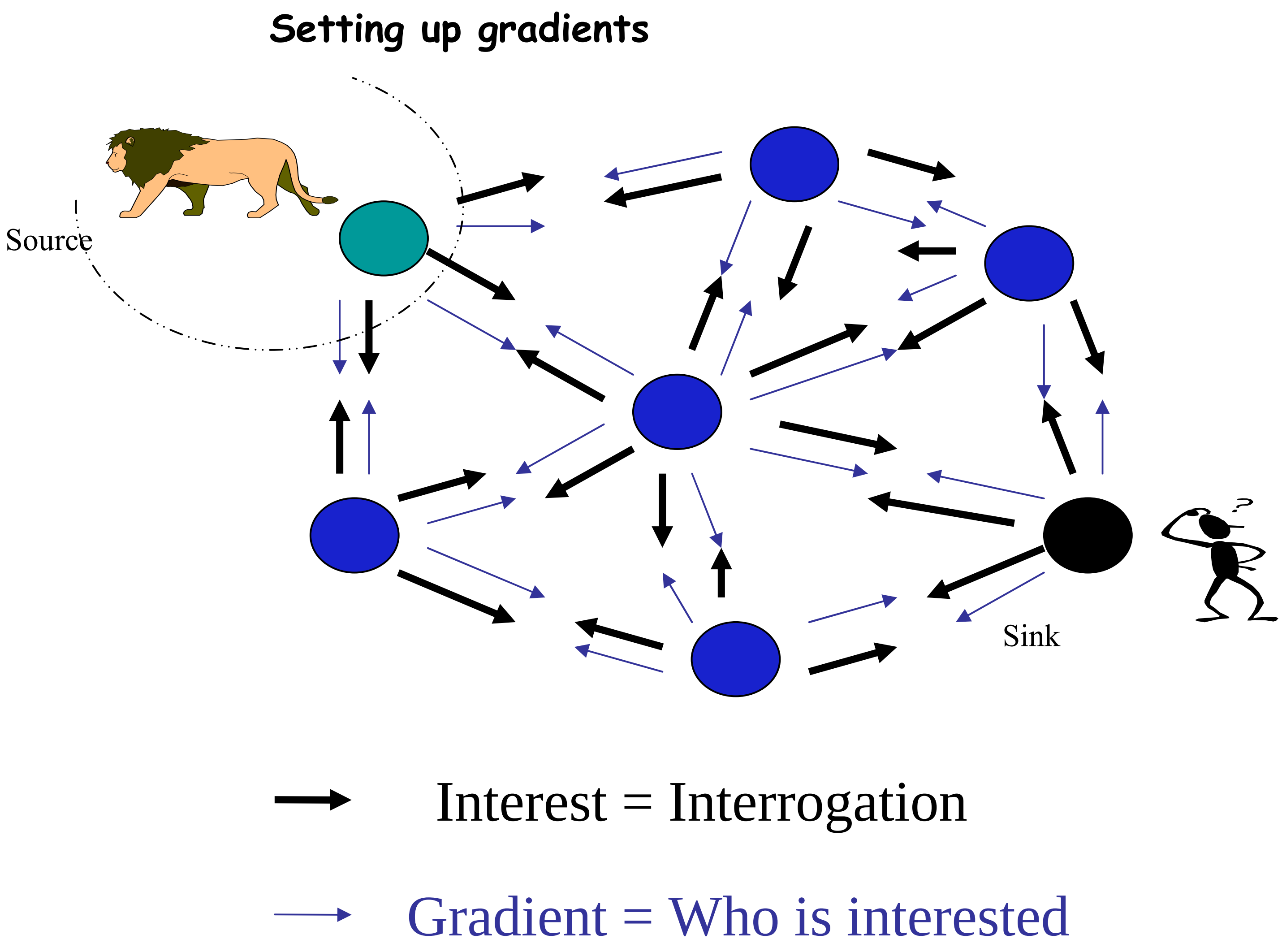
Matching Example (2)

Each formal must match some actual:

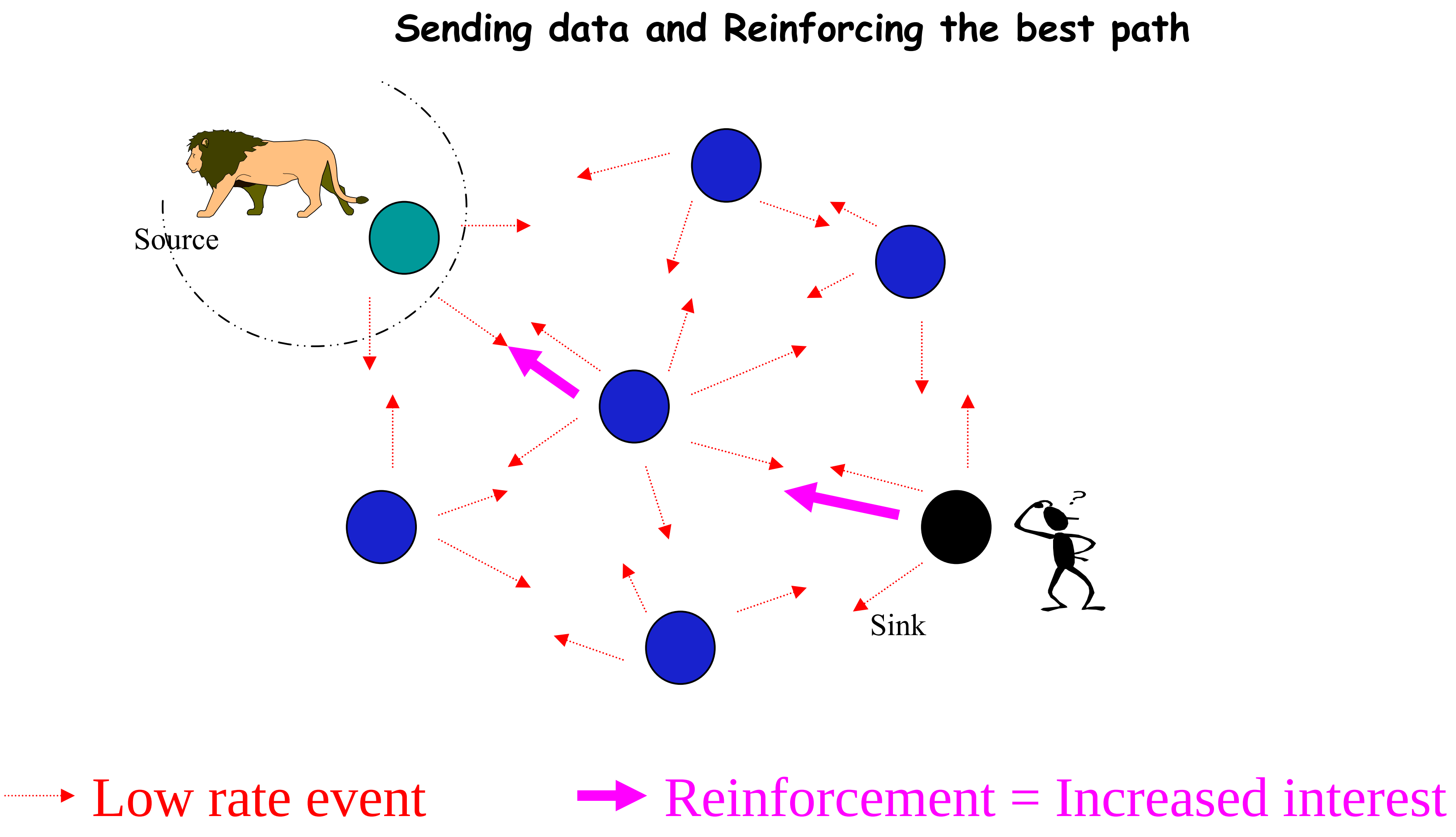


no match

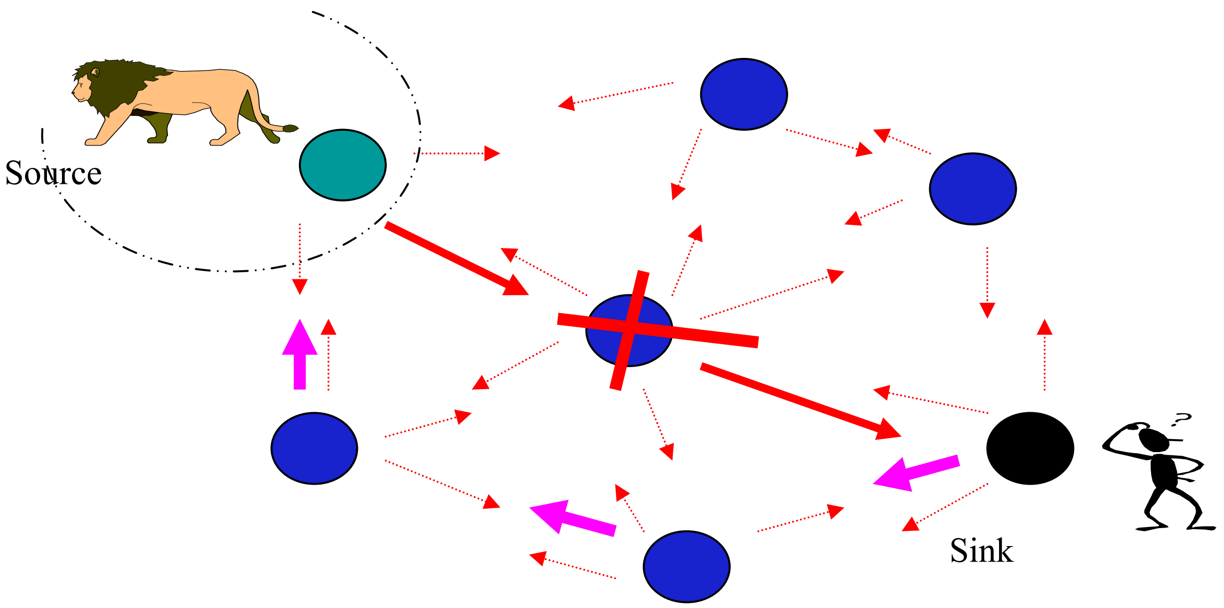
Basic Directed Diffusion



Basic Directed Diffusion



Directed Diffusion and Dynamics



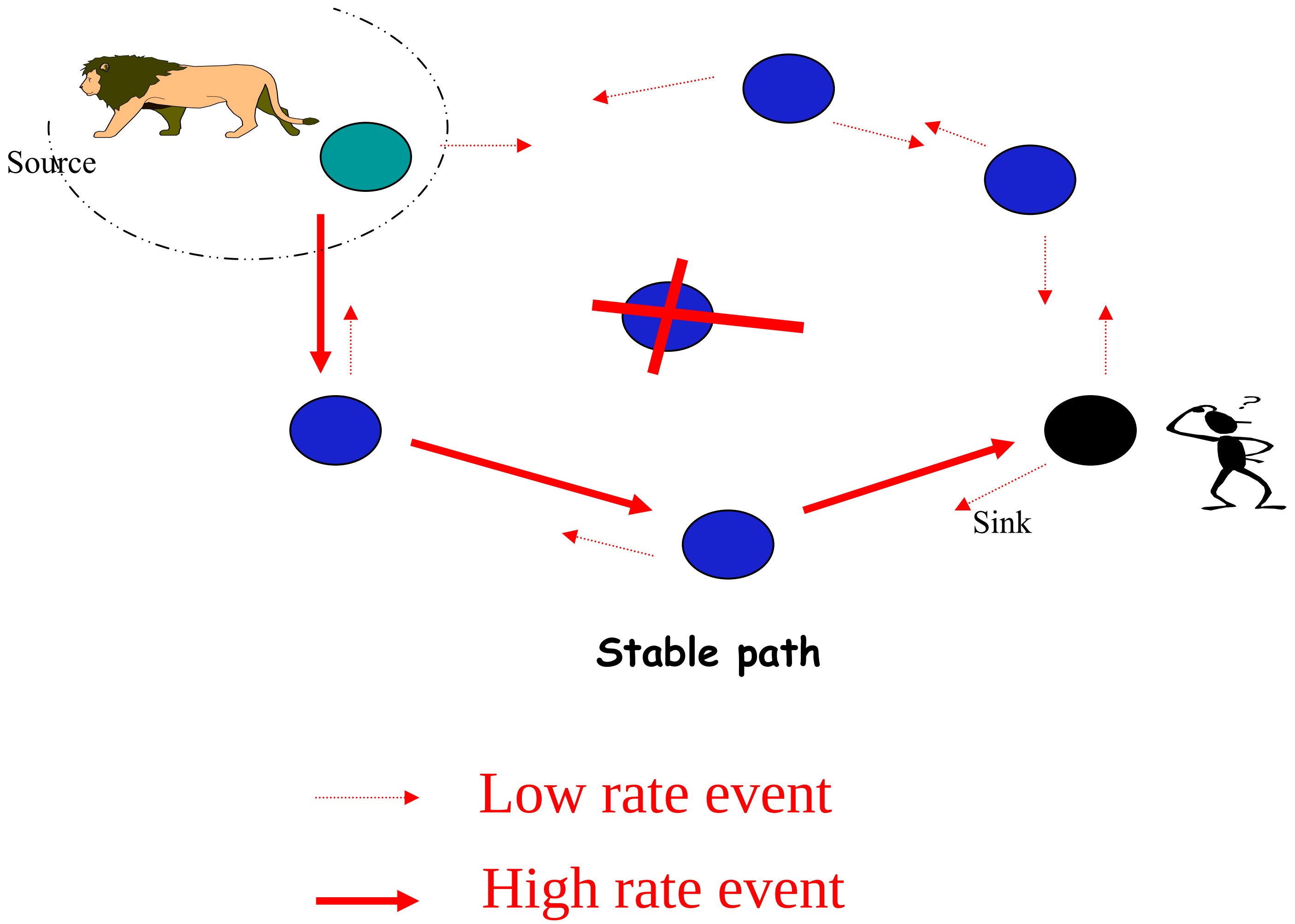
Recovering
from node failure

Low rate event

High rate event

Reinforcement

Directed Diffusion and Dynamics



Initial simulation study of diffusion

- Key metric
  - Average Dissipated Energy per event delivered
    - indicates energy efficiency and network lifetime
- Compare diffusion to
  - flooding
  - centrally computed tree (omniscient multicast)

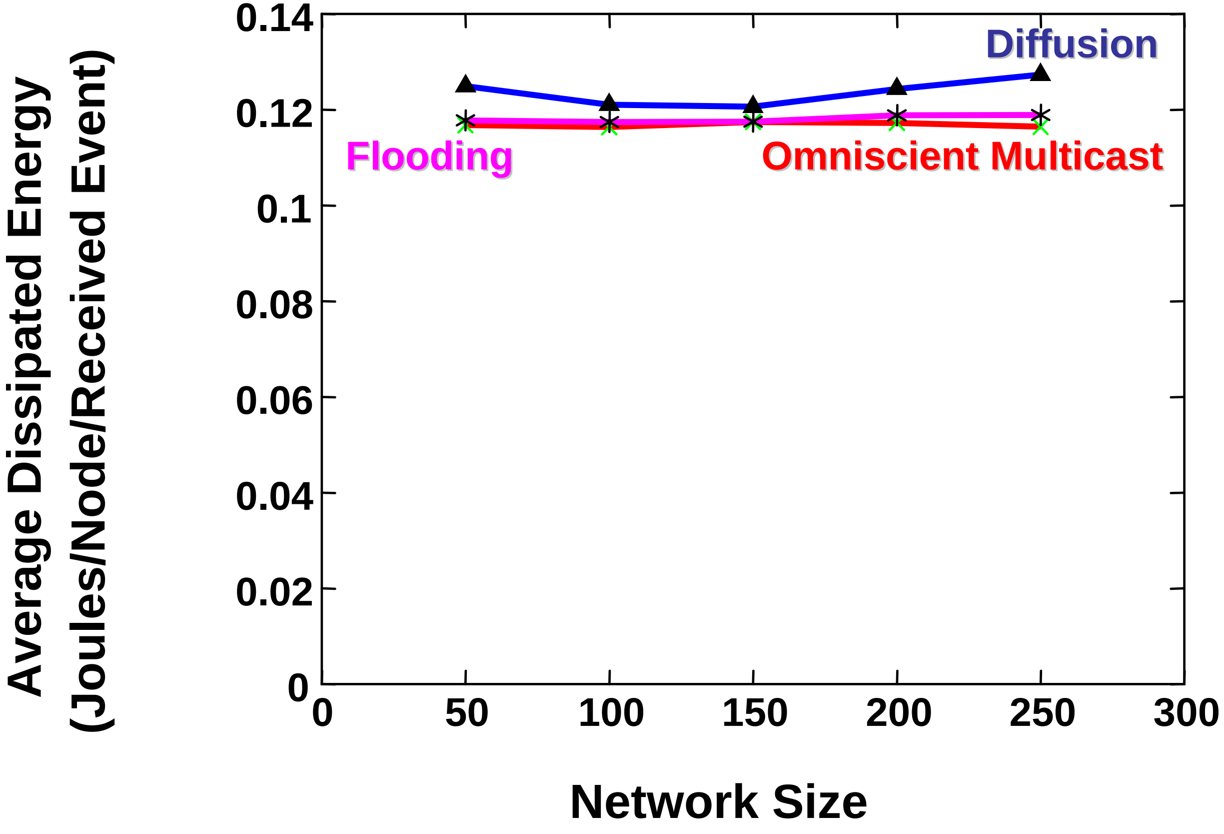
Diffusion Simulation Details

- Simulator: ns-2
- Network Size: 50-250 Nodes
- Transmission Range: 40m
- Constant Density: 1.95x10-3 nodes/m2 (9.8 nodes in radius)
- MAC: Modified Contention-based MAC
- Energy Model: Mimic a realistic sensor radio [Pottie 2000]
  - 660 mW in transmission, 395 mW in reception, and 35 mw in idle

Diffusion Simulation

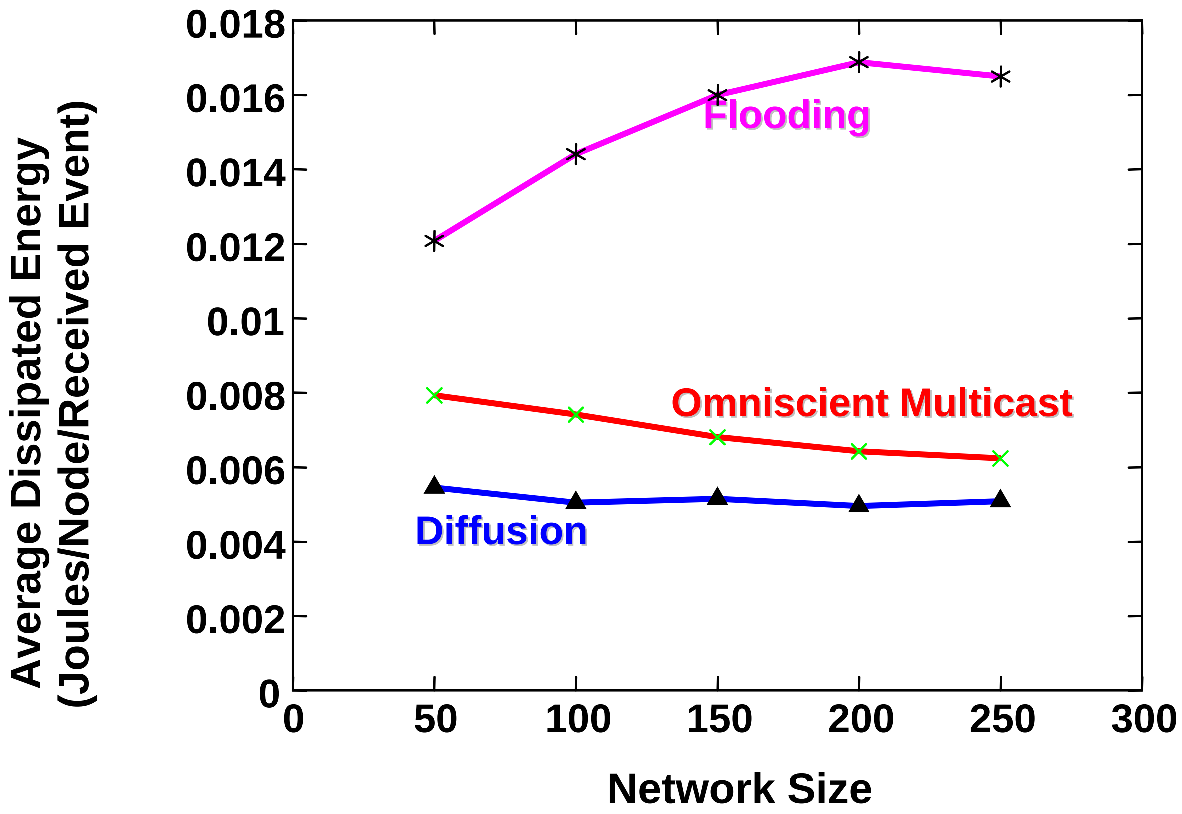
- Surveillance application
  - 5 sources are randomly selected within a 70m x 70m corner in the field
  - 5 sinks are randomly selected across the field
  - High data rate is 2 events/sec
  - Low data rate is 0.02 events/sec
  - Event size: 64 bytes
  - Interest size: 36 bytes
  - All sources send the same location estimate for base experiments

Average Dissipated Energy (Standard 802.11 energy model)



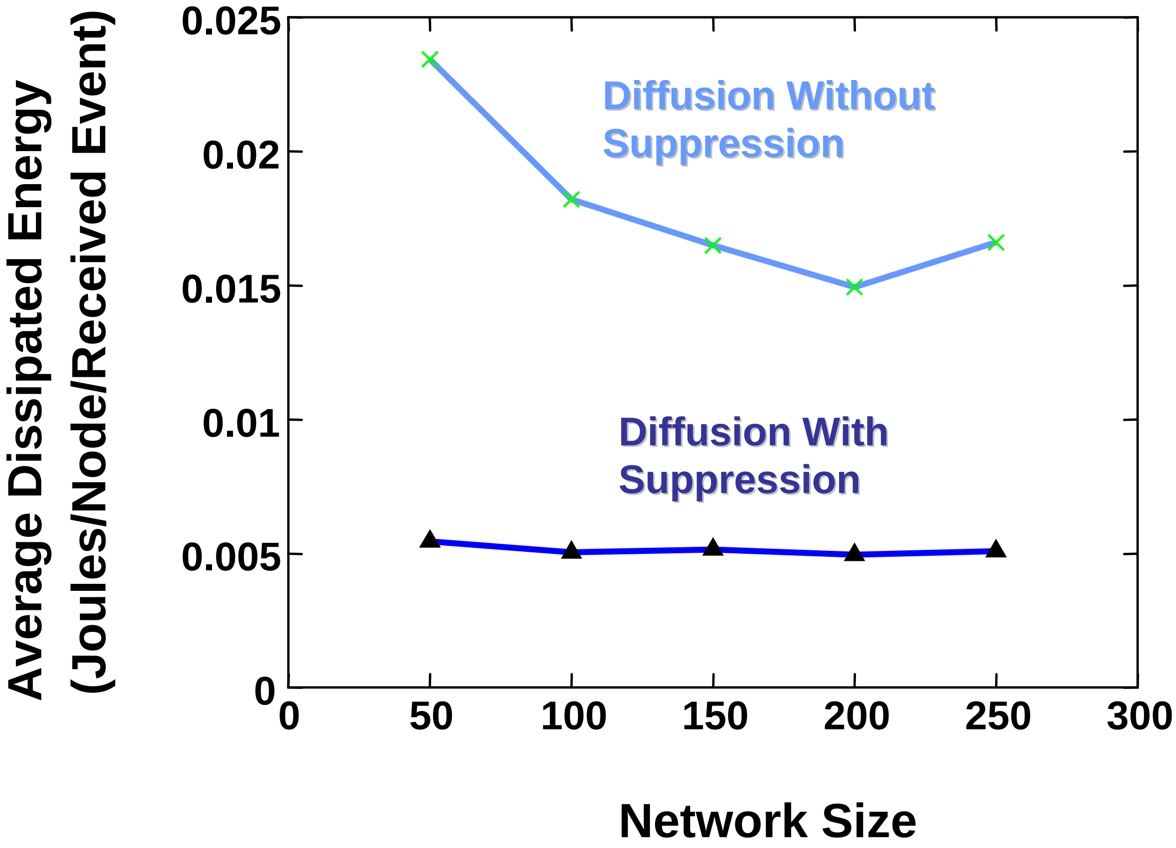
Standard 802.11 is dominated by idle energy

Average Dissipated Energy (Sensor radio energy model)



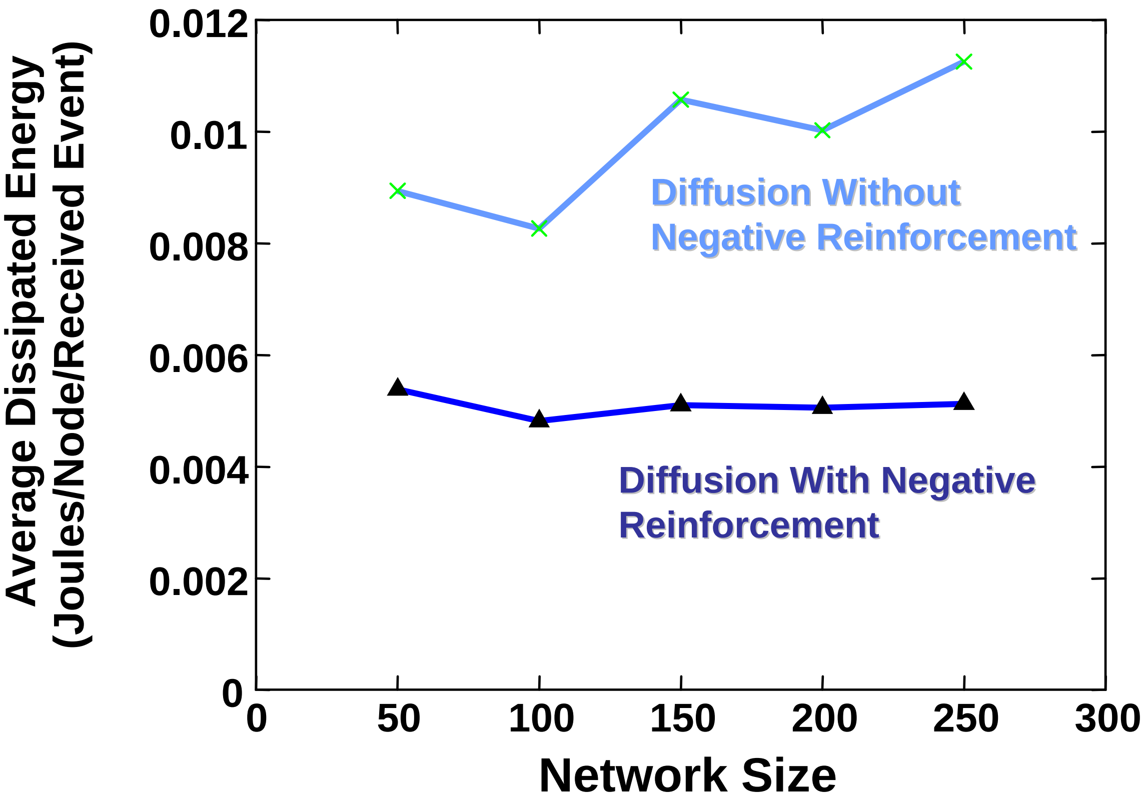
Diffusion can outperform flooding and even omniscient multicast.
WHY ?

Impact of In-network Processing



Application-level suppression allows diffusion to reduce traffic and to surpass omniscient multicast.

Impact of Negative Reinforcement



Reducing high-rate paths in steady state is critical

Diffusion Variants

- Diffusion family of protocols includes variants optimized for specific scenarios
  - No one single protocol is optimal for all cases
- Two-Phase Pull Diffusion
  - Interests have global scope (are sent to the network)
  - Data has local scope (does not leave a node if there is no matching interest)
- PUSH Diffusion
  - Interests have local scope (do not leave the sink node)
  - Data has global scope (is flooded to the network)
  - After rendezvous at a sink node, a positive reinforcement is sent on the reverse path, establishing a reinforced path
  - Local subscriptions not possible (as interest messages do not leave sinks)

One Phase Pull

- Subscriber based system that avoids one of the two phases of flooding in two-phase pull
- Only floods interests
- No exploratory messages