# Mobile and Ubiquitous Computing
## Data-centric routing and storage

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# Overview

❑ Data-centric approach to tasking a sensor network

❑ Directed diffusion

# Data-centric approach

We want to get information from the sensor network about some type of event without knowing
- ❑ the ids of the nodes nor
- ❑ the location of nodes

that generate relevant sensor data.

- ❑ We can express our request as a series of attribute-value pairs, e.g.:
  - type = animal
  - instance = horse
  - interval = 30 min

# Directed diffusion terminology

❑ *Sinks:* nodes requesting information
❑ *Sources:* nodes providing information
❑ *Interests:* records indicating a desire for certain type of information

A typical **interest** record contains an '*interval*' attribute field, which indicates the frequency with which the sink wishes to receive information about objects matching the other record attributes.
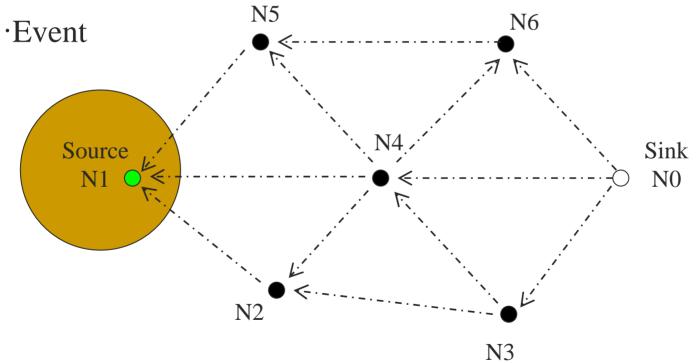
# Directed diffusion goal

❑ Directed diffusion is suitable for addressing attribute-value requests

❑ It finds good paths between sources and sinks.

❑ The cost of finding good paths is amortized over the period of use of the paths (assuming a long-lived request)

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# Directed diffusion

❑ Sinks generate interests that *diffuse* through the sensor network.

·Event

N5

N6

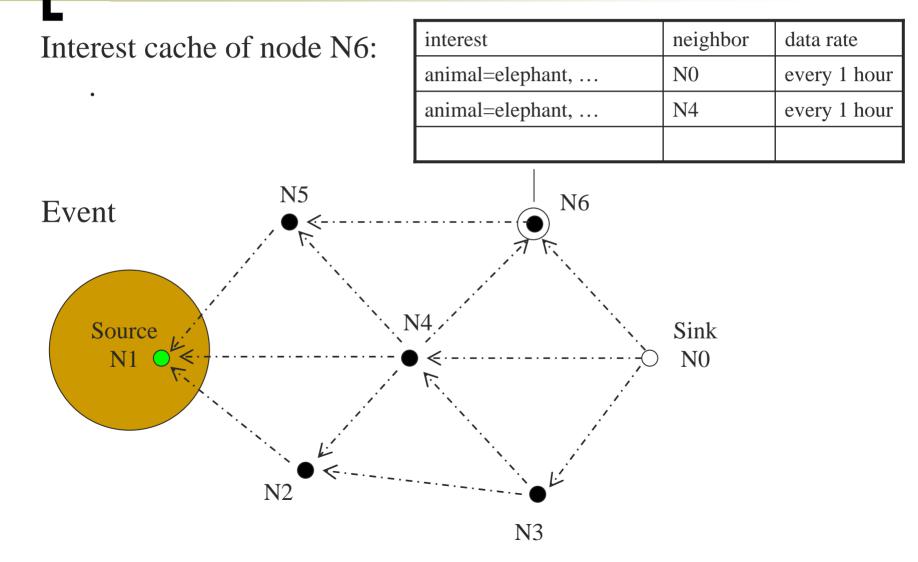Source
N1

N4

Sink
N0

N2

N3

# Directed diffusion

❑ Each node that receives an *interest* message stores:
- ❑ the interest record
- ❑ the neighbor who sent it
- ❑ the data rate in which results are requested } gradient

in a local *interest cache.*

The initial requested data rate is set to a very low value.

# Directed diffusion

Interest cache of node N6:

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| interest | neighbor | data rate |
|---|---|---|
| animal=elephant, … | N0 | every 1 hour |
| animal=elephant, … | N4 | every 1 hour |
| | | |

Event

# Directed diffusion
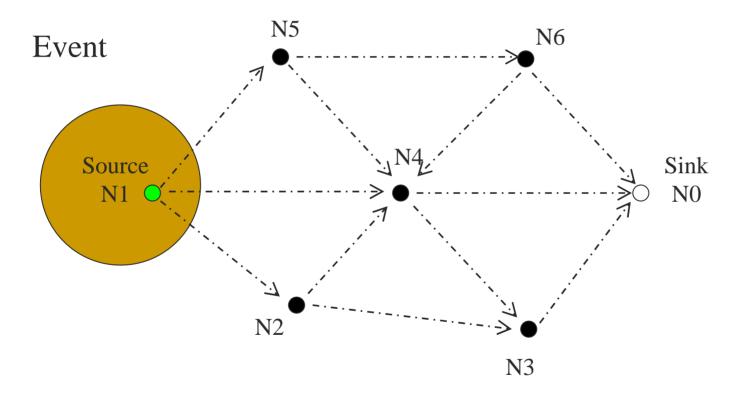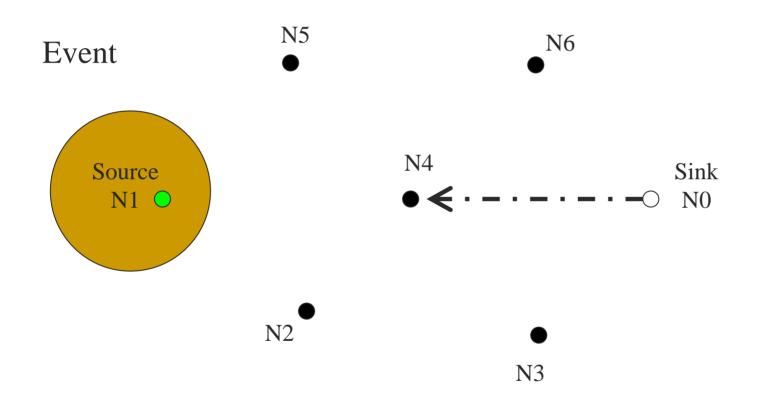
❑ A source computes the highest data rate among all its gradients for a certain interest.

❑ It sends event records to all neighbors for which it has a gradient for a particular event interest.

❑ A node that receives an event record checks its cache to see if it has matching interests.

➢ If not, it drops the message

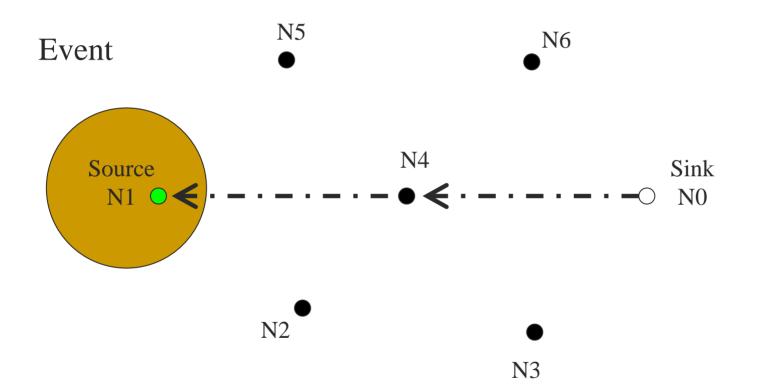➢ Otherwise it processes the message as follows:

*The node caches recently seen event records.* If the event record has not already arrived at the node through another path, the node forwards it to interested neighbors.
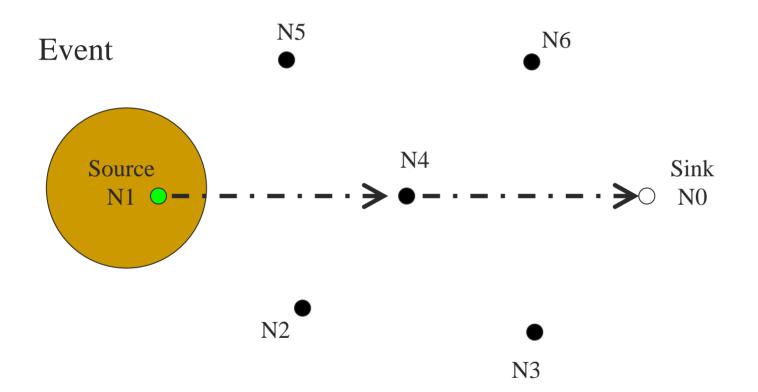
# Directed diffusion

Event

N5

N6

Source
N1

N4

Sink
N0

N2

N3

Event records are propagated back to the sink through **multiple paths** at the initially **low data rate**.

# Directed diffusion

Event

N5

N6

Source
N1

N4

Sink
N0

N2

N3

The sink **reinforces min-delay path**, by sending the same interest to neighbor N4 with higher requested data rate.

# Directed diffusion

Event

N5

N6

Source
N1

N4

Sink
N0

N2

N3

N4 reinforces min-delay path, by sending the same interest to N1 with higher requested data rate.

# Directed diffusion

Event

N5

N6

Source
N1

N4

Sink
N0

N2

N3

The source propagates event records to the sink along the reinforced path with a high frequency.

# Discussion

❑ Directed diffusion is a distributed algorithm – it works only with neighbor-to-neighbor interaction.

❑ The gradient mechanism is used to reinforce routing along the best paths.

❑ Questions to consider when reading the paper on directed diffusion:

   ❑ What is positive and negative reinforcement and how are they used?

   ❑ Observe whether the paper on directed diffusion includes results regarding the energy-efficiency of the algorithm.

# Related reading

**To prepare for discussion:**

• Chalermek Intanagonwiwat, Ramesh Govindan and Deborah Estrin. *"Directed diffusion: A scalable and robust communication paradigm for sensor networks"*. In Proceedings of the Sixth Annual International Conference on Mobile Computing and Networking (MobiCOM '00), August 2000, Boston, Massachussetts.