Introduction to Sensor Networks

Mobile Ad-hoc Systems Seminar
WS 2004/05

13. Jan 2006

Wireless Sensor Networks

Sensor: a small, lightweight device which measures the environment of physical parameters such as temperature, pressure, relative humidity,...

Sensor Networks: are highly distributed networks of wireless sensor nodes, deployed in large numbers to monitor the environment or system.

Issues and Challenges (1)

- Setup and maintenance autonomous
- Sensor networks are infrastructure-less.
- Available energy!

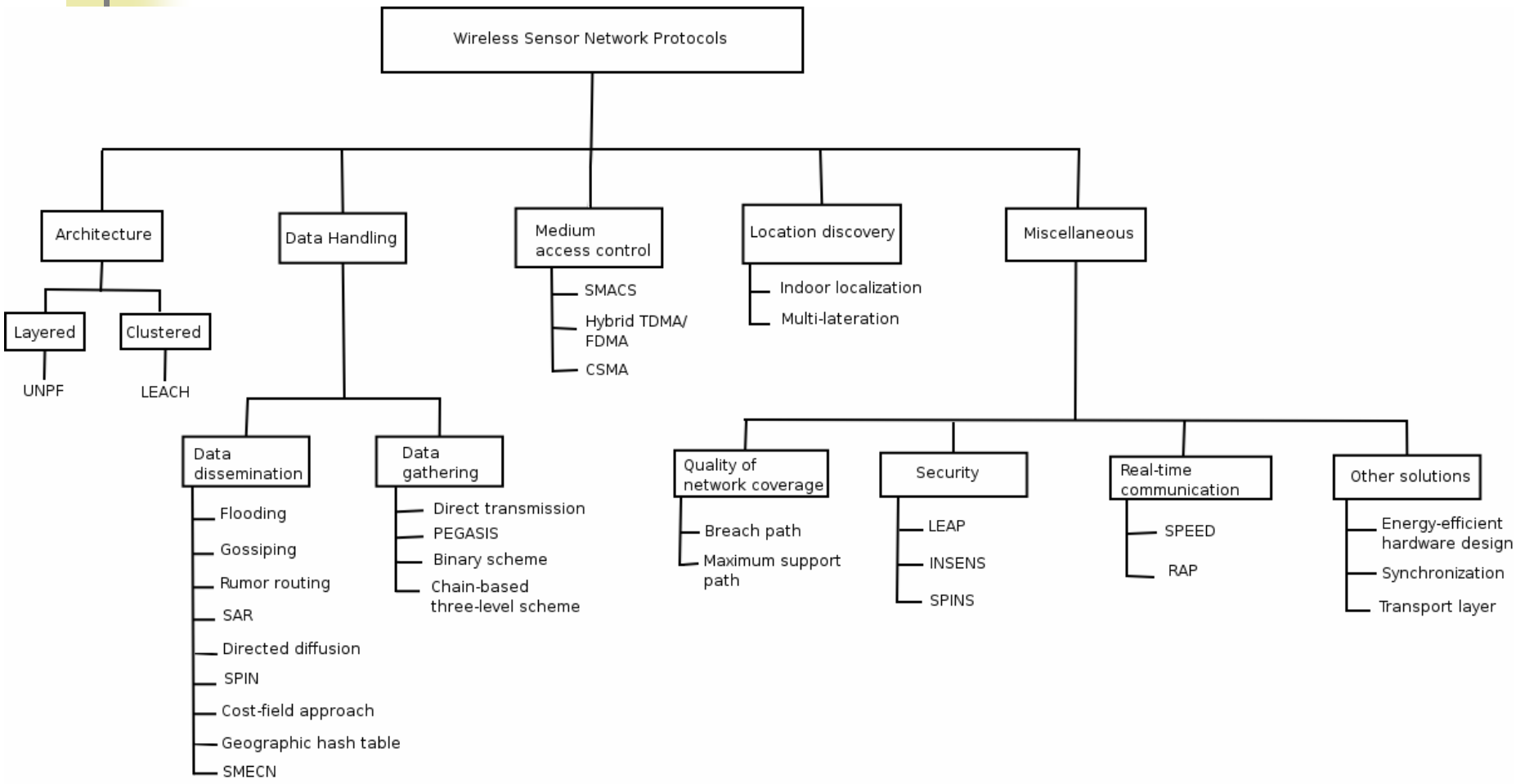
  Network lifetime vs. Accuracy of results and fault tolerance.

Issues and Challenges (2)

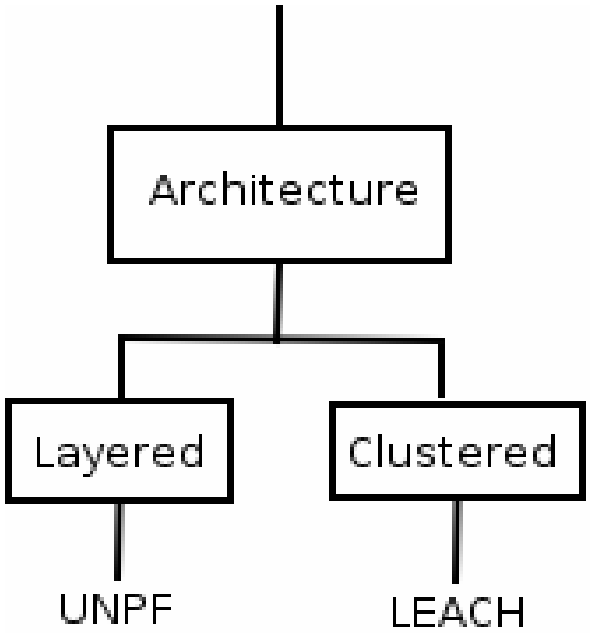
- Include or avoid sensor nodes if their state has changed.

- Communication:
  - Real Time
  - Secure

Classification of sensor network protocols



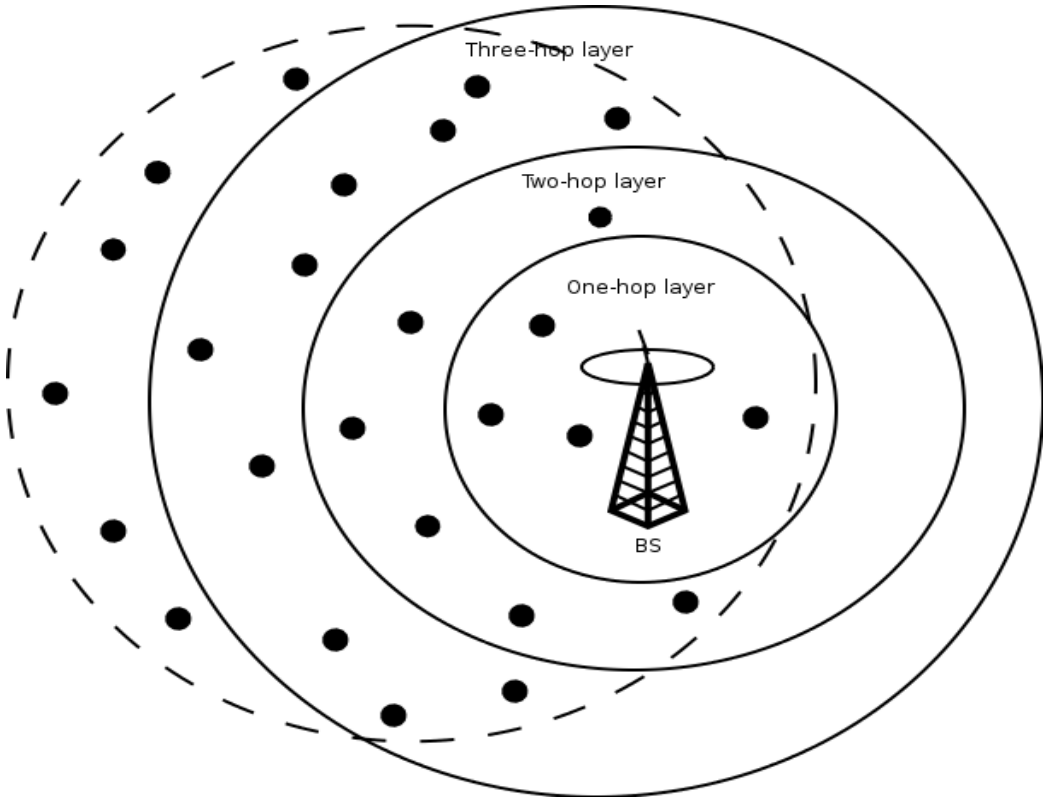
Sensor Network Architecture



Two kinds of Architecture:

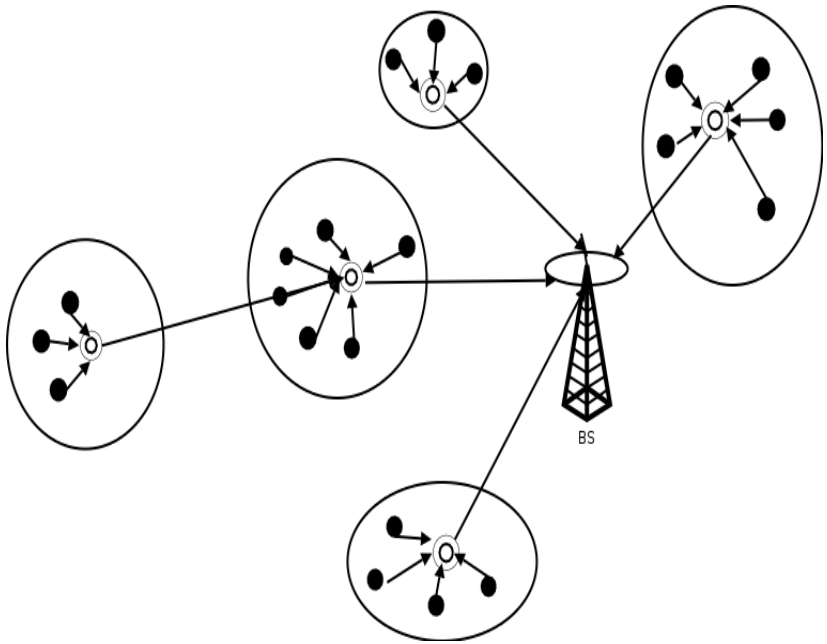
Layered and Clustered

Layered Architecture



- The sensor nodes, which are not near enough to the base station, communicate over nodes of neighboring layers.
- Example UNPF: Unified network protocol framework

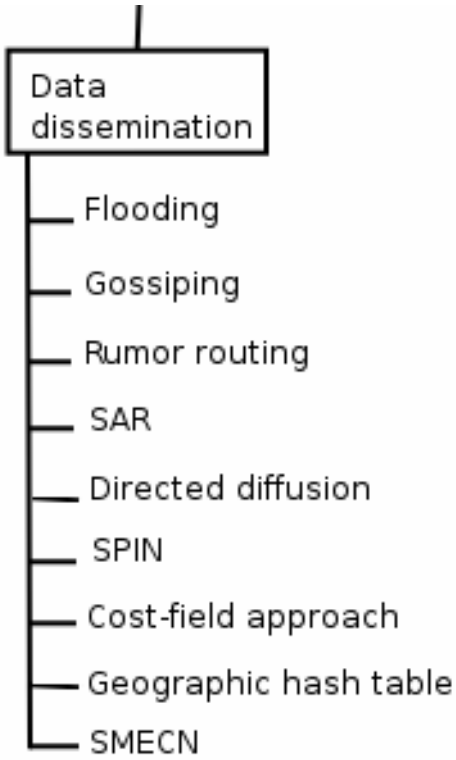
Clustered Architecture



Sensor nodes are organized in clusters

- Each cluster has a cluster-head,
- Cluster formation must be an autonomous process.
- Example: Low-Energy Adaptive Clustering Hierarchy (LEACH)

Data Handling



- Data dissemination is the process by which queries or data are routed in the sensor network

Data dissemination – Data diffusion model (1)

- Consists of a two-step process of *interest propagation* and *data propagation*
- An *interest* is a kind of data or event that a node is interested in, such as temperature, pressure, ...
- For every event a sink is interested in, it broadcasts its interests to its neighbours and periodically refreshes its interest.

Data dissemination – Data diffusion model (3)

- The basic idea of diffusion is made efficient by different algorithms for interest and data routing:

  Flooding, Gossiping, Rumor routing, Sequential assignment routing, Directed diffusion, Sensor protocols for information via negotiation, Cost-Field Approach, Geographic hash table, Small minimum Energy communication Network

Data diffusion model – routing protocols

- **Flooding**

  each node which receives a packet broadcasts it if the maximum hop-count

  of the packet is not reached and the node is not the destination of the packet.

  Advantages: easy to implement and maintenance

  Disadvantages: Implosion (duplicate messages are sent to the same node), Overlap (overlapping regions of sensor coverage), Resource blindness (many redundant transmissions, reduced network lifetime)

Data diffusion model – routing protocols

- **Gossiping**

  modified version of flooding, nodes do not broadcast a packet, but send it to a randomly selected neighbor.

  Advantages: easy to implement and maintenance, lower overhead than flooding

  Disadvantages: need a long time for a message to propagate throughout the network, does not guarantee that all nodes will receive the message!

Data diffusion model – routing protocols

- **Rumor routing**

  Agent-based path creation algorithm

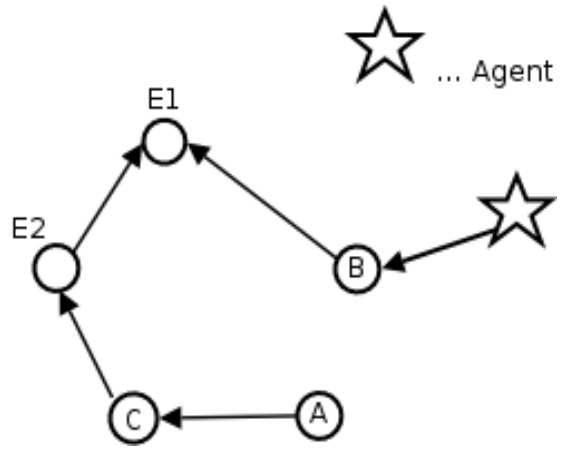


Table of Agent

Event	Distance
E1	2

Table of Node A

Event	Distance	Direction
E1	3	C
E2	2	C

Data diffusion model – routing protocols

- **Sequential Assignment Routing** (SAR)

- Tree based Algorithm
- A node (Sensor) could be part of more than one Tree

Data diffusion model – routing protocols

- **Directed diffusion**

  Useful in scenarios where the sensor nodes themselves generate request/queries for data sensed by other nodes

  Uses *interest gradients* and *data gradients.*

Data diffusion model – routing protocols

- **Sensor Protocols for Information via Negotiation** (SPIN) (1)

  three types of messages:

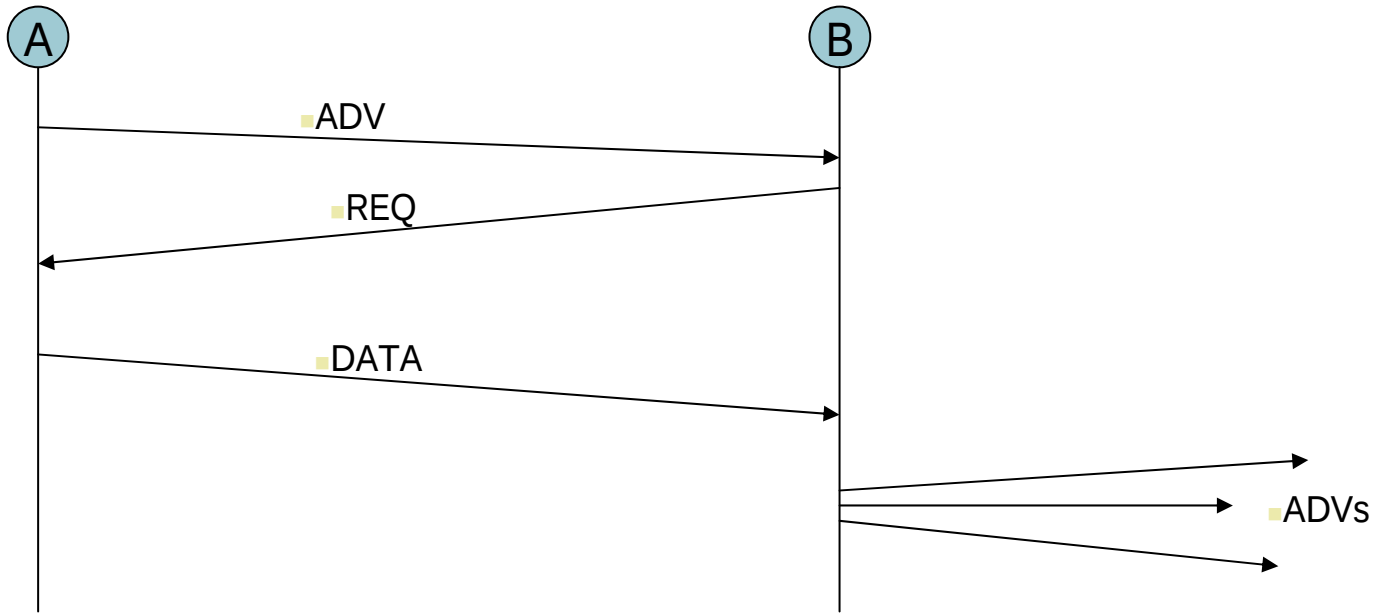
  ADV... advertisement

  REQ... request

  DATA... ...

Data diffusion model – routing protocols

- **Sensor Protocols for Information via Negotiation** (SPIN) (2)



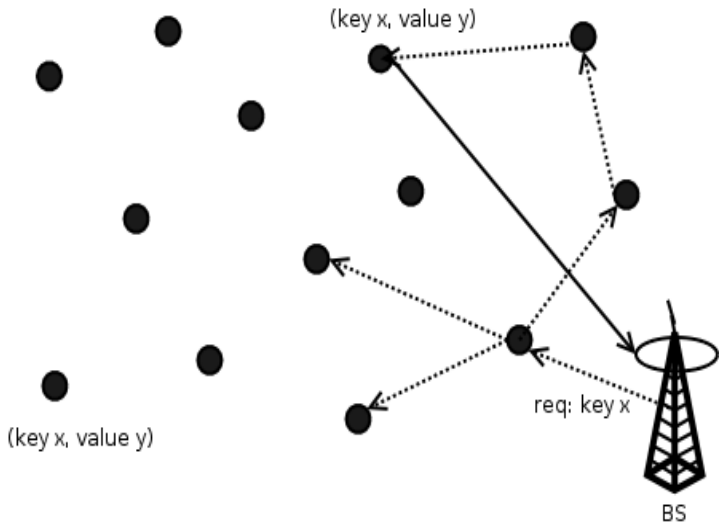
Data diffusion model – routing protocols

- **Cost-Field Approach**
- Considers the problem of setting up paths to a sink
- Two-phase process:

  The first phase set up the cost field at all sensor nodes (based on metrics such as delay,...)

  The second phase uses the cost for data dissemination

Data diffusion model – routing protocols



- **Geographic Hash Table** (GHT)

-Inspired by Internet-scale distributed hash table (DHT)

-stores a pair (key, value)

-The data is stored distributed across all sensors not routed to a central storage.

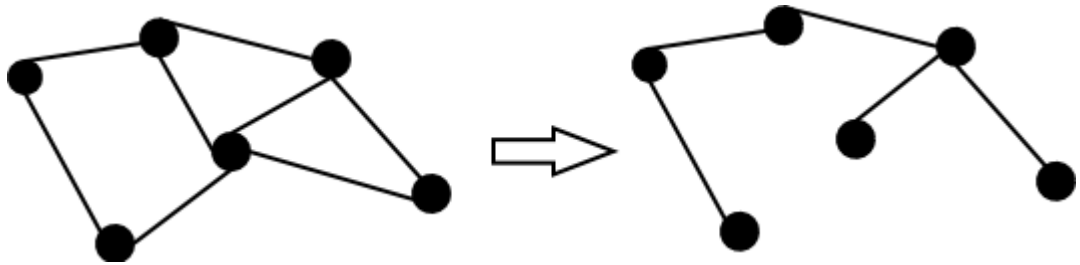
-More effective in large sensor networks where a large number of events are detected but not all are queried.

Data diffusion model – routing protocols

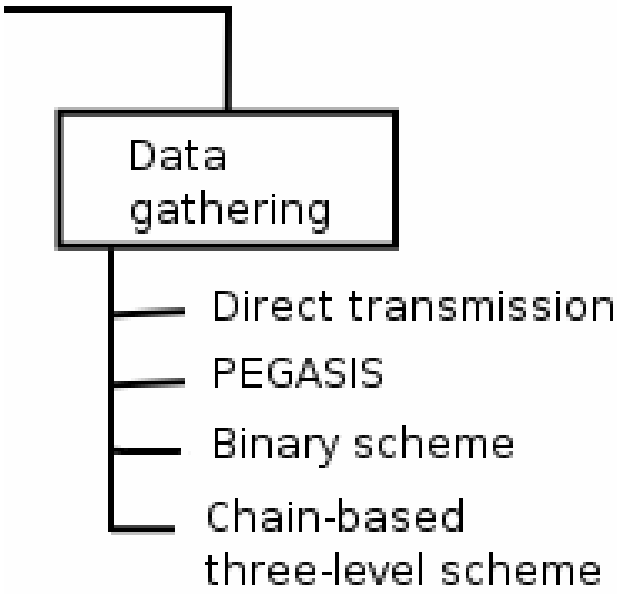
- **Small Minimum Energy Communication Network** (SMECN)

  Builds up a sub network of the given communication network

  Paths which need minimal power consumption



Data gathering model

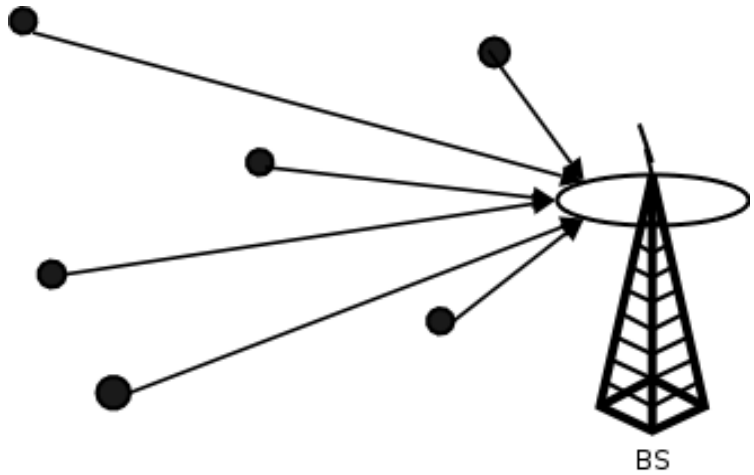


- Data gathering algorithms try to maximize the number of rounds of communication before the nodes die and the network becomes inoperable.
- Conflicting requirements:

  Minimum delay and minimum energy consumption

Data gathering model algorithms

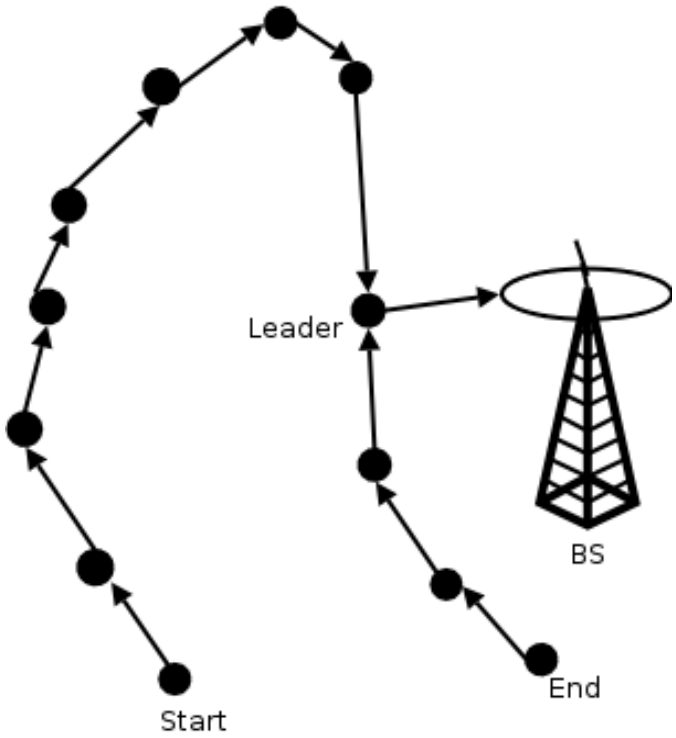
- **Direct Transmission**



Every node sends the collected data directly to the base station.

high energy consumption, and delays

Data gathering model algorithms



- **Power-Efficient Gathering for Sensor Information Systems** (PEGASIS) (1)

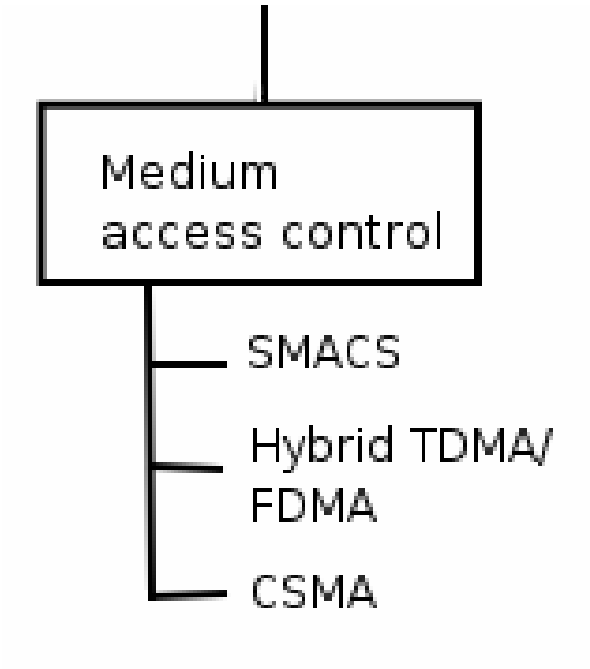
constructs a chain of sensor nodes

performed before any message is transmitted

Data gathering model algorithms

- **Binary Scheme**
- Also chain based algorithm like PEGASIS which classifies nodes into different *levels*.
- Levels: all nodes which receive a message rise to the next level. The number of nodes is halved from a level to the next.
- Chain-Based Three-Level Scheme

MAC Protocols for sensor Networks



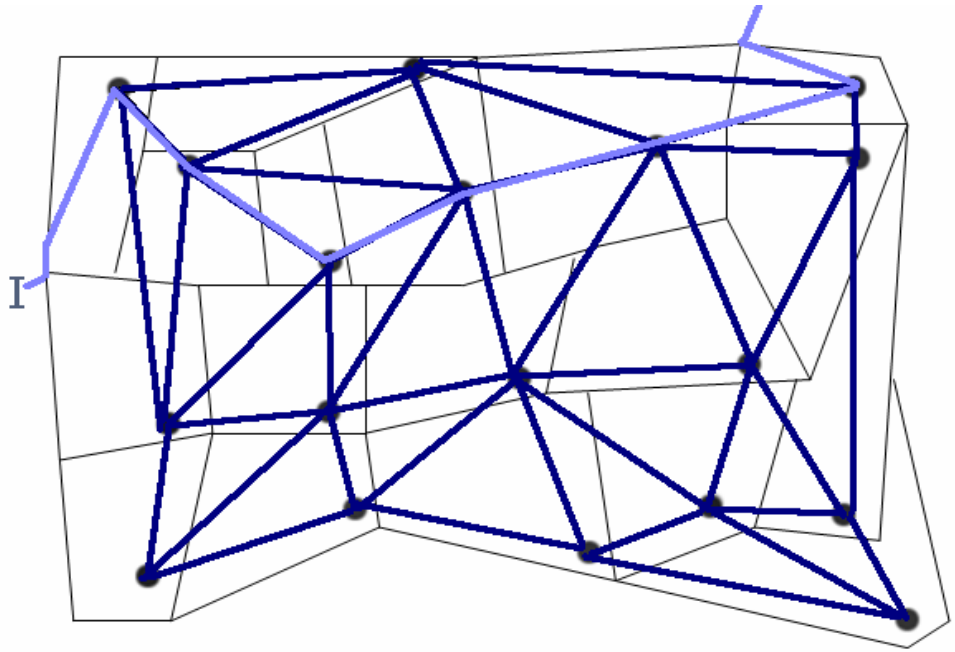
- MAC protocols in sensor networks: **Self-organizing MAC for sensor networks** (SMACS)
- **Carrier Sense Multiple Access** (CSMA)
- Hybrid TDMA /FDMA

  Time Division Multiple Access / Frequency Division Multiple Access

Quality of a Sensor Network

The quality of a sensor network is given by **Coverage** and **Exposure**.

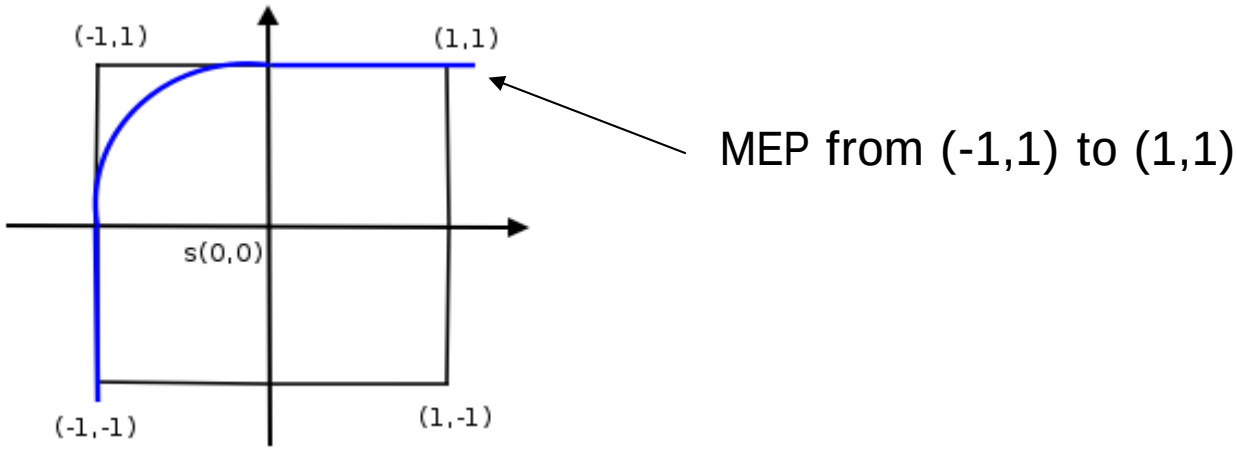
Coverage



Depends on the range, sensitivity and density of the sensing nodes.

Exposure

- The ability of observing a target
- sensor node s at (0,0) in a field
- The minimum exposure path (MEP):



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Thank you for your attention...