# Lecture 5 — October 07, 2003

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The main emphasis of the lecture was on Transport and Routing issues in Sensor Networks.

The lecture was divided into two talks, one by the instructor giving the basic overview of the prevalent issues in the field, followed by a talk given by a student on a specific paper in the routing domain **GRAB** [3] to elucidate the main concepts which of a sensor network routing protocol.

## 5.1 Talk 1: Background and Overview

A sensor network can have the following basic model:

- Sensor Nodes in the environment which perform sensing tasks and report the data gathered back to the user(via a "sink").
- Sensor Nodes are resource constrained : They have limited power, processing power, memory etc
- The network generally comprises of a collection of high transmission error rate, low bandwith wireless links.

The data which flows from the sources(sensors) to the sink is usually loss-tolerant, but the data flowing from sinks to the sources(sensor management data) is loss-sensitive.

In order to meet the very specific and unique requirements for a sensor network, application-specific protocols could be the best approach. There was a small discussion on this topic on cross-layer protocols and whether there is a need to adhere to the "layered" approach for desigining protocols for sensor networks.It was suggested that perhaps combining the MAC and the routing layers and designing a protocol for this "combined" layer might be a better idea in the sensor networks context.

### 5.1.1 Protocol Design: Needs and Present Work

The basic requirements for protocol design for sensor networks are:

1. **Low Energy Usage** Clearly as the sensor nodes have limited energy, the protocols need to be able to minimize as much as energy consumption as possible. This could be done by aggregating data, (therby minimizing communication),perform load balancing such that all nodes do equivalent work, switching off nodes when they aren't doing work and other means.
2. **Robustness** The protocol should be able to adopt to the unpredictable environment without much intervention.
3. **Scalability** The protocol should be scalable; it should rely on local decisions .
4. **Low Latency** The protocol needs to meet application latency and accuracy requirements.
5. **Small Footprint** The protocol should be small and simple to implement and run - sensor nodes have severe energy constraints.

Given the requirements and the specific application, many protocols have been developed in order to satisfy and fulfill them.

### 5.1.2 Routing Protocols

Routing protocols can be based on the following approaches:

- Flooding
- Gradient
- Clustering

Protocols based on the first two approaches are studied.

#### Flooding

The main paper studied which uses the flooding approach is SPIN[2]. The general idea of SPIN is to overcome the limitations of classical flooding by first describing data at a high level(by use of meta-data) and use this data for negotiation. Some of the points raised during the presentation included the usefulness of meta-data. It allows for data aggregation. Also some of the applications which were envisioned included software updates, temperature sensing etc. Some of the problems with SPIN were also discussed, and the question of its convergance rate came up. The convergance rate depends on many factors, including data aggregation. If data is unique; there can't be aggregation, then flooding may converge faster. However with aggregation, and noting that transmission times could be wasted on transmitting duplicates, SPIN may converge faster than flooding. Also some possible future improvements were proposed, which include more efficient dissemination keeping in mind energy constraints.

#### Gradient

Two protocols were discussed under Gradient-based approaches. The first was Directed Diffusion[1]. The main idea in Directed Diffusion is that interests set gradients toward the sink. The sink repeatedly reinforces the best primary path, as well as the interests. Basically the protocol uses the fact that not everyone would be interested in the sensed data, which can be utilized to send the data only to the interested party in a efficient manner. The main points which were discussed during the presentation of this protocol included the ability of this protocol to adopt to mobility - if sink moves then the interests are merely retransmitted again. As the protocol claims to be energy-efficient, a small discussion ensued on how to pose the power utlization problem as an optimization problem. Possible formulations were discussed including ensuring connectivity while increasing lifetime of the network. The problem of reinforcing paths in this protocol was also up for discussion, specifically on the subject of sink-initiated path-reinforcements and how that could lead to inefficient utilization of resources. There is also a potential of wastage of resources by reinforcements initiated bu intermediate nodes. This protocol works better than IP multicast, and after discussion, the notion of data-aggregation was given as the main reason for this behavior.

## 5.2 Talk2: GRAB

The paper GRAB[3] was discussed. The main idea of GRAB, which is to build multiple paths from the source to the sink by creating a cost field. The "cost" is defined as the minimum energy overhead to forward a packet from a node to the sink. The "width" of your cost field can be controlled, and this width gives a measure of the amount of redundancy in the paths. The question of multiple sources was raised - every source builds its own gradient field. The issues which were raised included sink mobility, and adaptive credit assignment.

# Bibliography

[1] Wendi Rabiner Heinzelman, J. Kulik, and H. Balakrishnan. Adaptive protocols for information dissemination in wireless sensor networks. In *Proceedings of the Fifth Annual ACM/IEEE Conferance on Mobile Computing and Networking(MobiCom)*, August 1999.

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[3] Fan Ye, Gary Zhong, Songwu Lu, and Lixia Zhang. Gradient broadcast: A robust data delivery protocol for large scale sensor networks. In *ACM WINET*.