A Survey on Routing Protocols in Sensor Networks

Presented By

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Outline

- Introduction
- Motivation
- Design Criteria & Application
- Network Classifications
- Different Routing Protocols
- Open Research Issues
- Conclusion

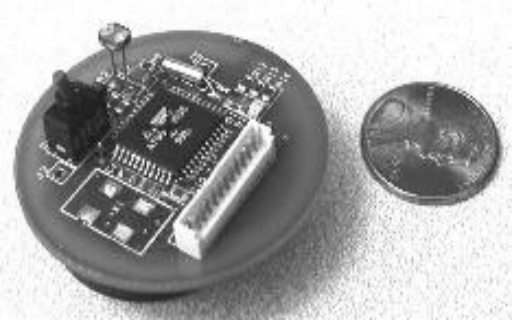
Introduction

Sensor Network

- Wireless network consisting of low cost, densely deployed (may be mobile) sensor nodes
- Distribution is done in an ad hoc fashion
- Close to event to be monitored
- Usually have a limited amount of energy

Sensor Nodes

- Battery Power source, low power wireless communication
- Match Box size form factor and power aware CPU
- Small embedded OS (TinyOS) and program & data memory is few KB
- MEMS sensors (measures light, temp, seismic, acoustics, stress)



Berkeley Motes

Motivation

Goal to have a robust, long live, low latency network

Reason for routing to be challenge and difficult problem

- Sensor nodes:

  Limited energy, low bandwidth radio and limited processing power and storage

- Unreliable Communication channels:

  Harsh environment, battery depletion

- Data Aggregation Opportunity

  Remove duplicate redundant data

- Network Scale
- Network Communication Model
- Routing is application dependent

Design Criteria and Application

Design Criteria

- Low Energy
  - Nodes sleep, traffic spreading, data aggregation
- Robust
  - Dynamic environment changes
- Scalable
  - Using localized & distributed algorithm
- Low Latency
  - Application specific
- Hardware Issues

Application

- Military: surveillance, mine field
- Emergency Rescue & Response: Fire, Health Care, Disaster Relief
- Habitat Monitoring: Wildlife, Weather and Terrain
- Urban Setting: Factory or Office area, Traffic Monitoring

The movie “Twister” is an example of sensor network

Network Model

Ways to classify the sensor networks based on current research [5] :

Sensor Nodes	Users (Sinks)	Phenomena	Interest	Data Dissemination
Stationary	Stationary	Query	Static	Unicast
		Continuous	Unicast	Multicast
Mobile	Mobile	Target Detection	Multicast	Broadcast
			Broadcast	

Routing Protocols

Protocols can be broken down based on following techniques:

1. Flooding
   - SPIN (SPIN-1 and SPIN-2)
2. Gradient
   - Directed Diffusion, GRAB, GEAR
3. Clustering
   - LEACH, TTDD, GEAR, GAF
4. Geographic
   - GPSR, GAF GEAR

SPIN: Sensor Protocol for Information via Negotiation

- It is based on controlled flooding where traditional flooding problems like implosion, overlap, and resource blindness is handled
- The general idea is to use meta data to instead of full data-packet
  - Much shorter than actual data packets transmitted
  - It is a data descriptor with 1-1 mapping between data and meta data
- Three types of messages ADV(advertisement), REQ and DATA
  - Random time is used for REQ packages to prevent overlap
  - There is negotiations using ADV, REQ to reduce problem of flooding
- There are two types of SPIN: SPIN-1 which is does not deal with energy efficiency and SPIN-2 which is energy aware
- Results when comparing to flooding and gossiping
  - SPIN-1 performance compared to time is same as flooding but using 25% of energy
  - SPIN-2 delivers 60% more data per unit energy than flooding
  - Both out performs gossiping and come close to ideal dissemination protocol

SPIN

- In terms of the model presented before
  - Nodes and user can be mobile or stationary and events monitored is continuous or target detection
  - SPIN is a broadcast system for data dissemination, but interest propagation is static
- PRO
  - Usually more efficient than the standard flooding
  - Relative quick convergence in terms of latency
  - Works for mobile sensors and users
  - Robust and scalable (only local interaction and immune to node failure)
  - Fairly simple negotiation (ADV wait for REQ and then send DATA)
- CON
  - Nodes are always active (idle nodes still consumes energy)
  - If you network does not require flooding you probably don’t want it

Directed Diffusion

- Data centric communication (all communication is for named data)
  - Set of attribute value pairs used to identify data (like database query)
  - Next hop along the route is decided by matching the data with established gradients in the network
- Data is cached at intermediate nodes for aggregation and loop prevention
- Use the idea of path reinforcement to identify best route for two nodes
- The local gradient is set up by propagating interest from sink to source
- Nodes can respond to specified interest or task description
- Based on the network classification model presented initially we know
  - Users and Sensors are stationary in this model, event observed can be of query, continuous and target detection
  - Interest is propagated by unicast, multicast broadcast but data is send back by unicast and multicast

Directed Diffusion (Cont..)

- Pro
  - Consumes much less energy by having less traffic compared to flooding and data aggregation
  - In terms of scalability it is based on local interaction only
  - It uses the best path available so it has good latency bound
  - It is robust because of retransmission of interest and low data rate gradients
- Con
  - Gradient setup phase is expensive
  - It is not energy aware as the best paths might be used too often
  - Need to retransmit interest and alternate path maintenance is needed

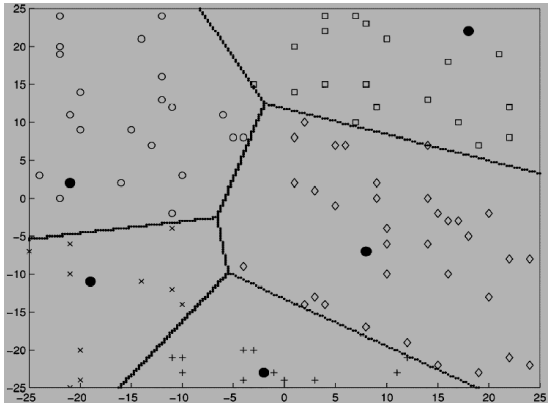
LEACH

- Cluster based approach
- Random cluster head selection each round with rotation to spread load
- Communication done with cluster head via TDMA MAC (a fixed schedule for communicating with non cluster nodes)
- Cluster membership adaptive
- Data aggregation is done at cluster head
- Cluster head communicate directly with sink or user

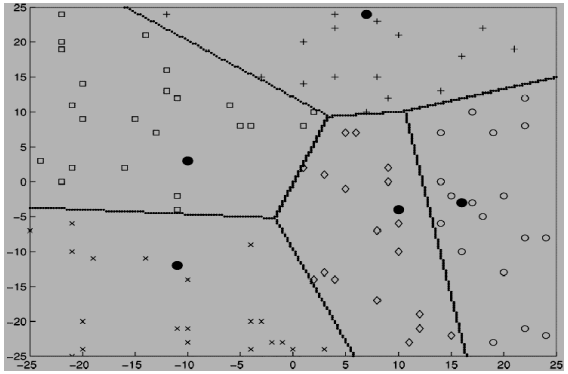
Based on the model the following can be said about LEACH protocol

- The sources and users are stationary and events monitored is continuous
- The interest propagation is predetermined
- Data dissemination mechanism is broadcasting

LEACH(Cont..)



Round X



Round Y

- Pro
  - Optimize energy used by shutting down nodes' radios and load balancing
  - Only two hops needed for reaching sink or user
  - Distributed hierarchical approach makes it scalable
  - It is easy to aggregate data at the cluster head and send to user or sink
- Con
  - Failure of cluster head is a problem
  - Cluster head selection is a difficult problem to optimize
  - Expensive assumption for all nodes to be capable of long range communication

GPSR (Greedy Perimeter Stateless Routing)

- Greedy forwarding strategy used
- Only needs local information for forwarding
- Problem of having to avoid the void does it by creating a planar graph
- Performs better than DSR (dynamic source routing)
- Not energy aware, need to use protocol like SPAN (sits on top of MAC layer) or energy efficient MAC layers to make it energy aware
- Not good at load balancing but good at latency

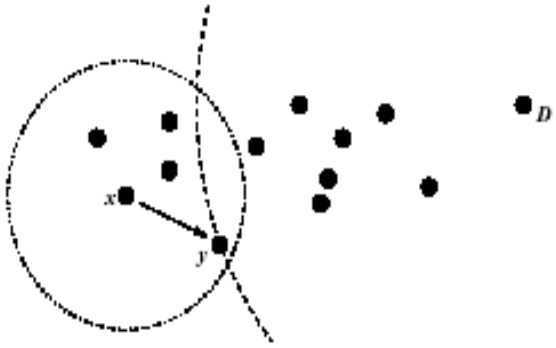


Figure 1: Greedy forwarding example. y is x's closest neighbor to D.

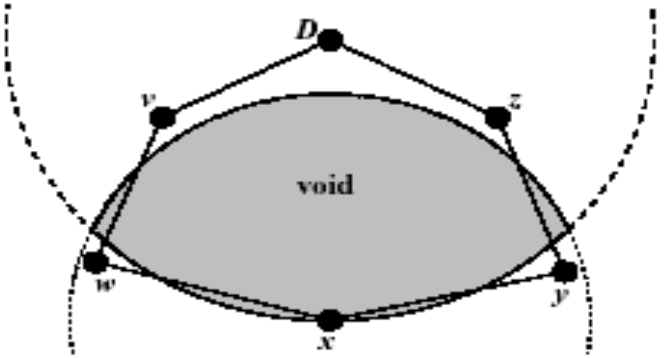


Figure 3: Node x's *void* with respect to destination D.

GAF (Geographic Adaptive Fidelity)

- The general idea is to set up a “virtual grid” based on location information (coordination amongst nodes in same virtual grid)
- Performs at least as well as a normal ad hoc routing protocol (like AODV and DSR) but with substantial conservation of energy
- Currently power consumption is idle time dominated and this protocol address that by turning off nodes based on redundancy
- Network lifetime to increase in proportion to node density
- GAF is application dependent and needs tuning for parameters like estimated node active time, time for discovery, active and sleep
- Packet loss is a problem
- Applicable to stationary and mobile nodes but mobile nodes performance is not as good as stationary

Interesting Areas of Research

- Sensor network still at an early stage in terms of technology
  - Currently there is still nothing in use in the real world
- Needs improved or new routing protocols
  - The protocols present today have their own set of problems
- No work done on contention issues or for high network traffic
  - Currently most researchers claim that although important the present networks thought about does not have high network traffic
- Most protocols deal with energy efficiency
  - There is significant work that can be done with robustness, scalability
- Most results are empirical very little analytical work done
  - General perception is that it is hard to do such work
  - Better ways to categorize the model

Research Issues(Cont…)

- Can use more theoretical work
  - Some overlap with computational geometry problem
  - Results from graph theory are used (particularly spanners)
  - Incorporate game theory for modeling (Think of it as a network connection game)
- Need for better or improved simulation tools
  - Scalability factor limits current tools
  - Most simulations tools are not made with sensor network in mind
  - Recent new tools for modeling are TOSSIM, EMStar
- Research done on it from distributed database perspective

Conclusion

- Routing protocols in sensor networks will have to deal with
  - Scalability (using distributed control and local interactions)
  - Energy efficiency
  - Robustness (maintain connectivity)
  - Load balancing in terms of energy used by nodes
  - Low Latency
  - Minimum computation and memory usage
- Exciting new area with many different kinds of research opportunities
- Any Questions??
- Thanks!!! ☺

References

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