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Routing Protocols for Mobile Sensor Networks

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Abstract

Mobile sensor networks (MSNs) have been widely studied in recent years and are expected to be applied in a variety of applications such as battlefield surveillance, event detections, hostile environment monitoring, and wild animal tracking. In this report, we list out the existing routing protocol for wireless sensor networks. A WSN is composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or predetermined. This allows random deployment in inaccessible terrains or disaster relief operation. In this paper we study different type of routing protocol for sensor network like flooding, SPIN (Sensor Protocols for Information via Negotiation), LEACH (Low Energy Adaptive Clustering Hierarchy) in details and check how they different from the ad hoc network. SPIN and LEACH routing protocol are compared with flooding protocol.

I. Introduction

Recent advances in wireless communications and electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate unfettered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks. A sensor node consists of sensing, computing, communication, actuation, and power components. These components are integrated on a single or multiple boards, and packaged in a few cubic inches.

A WSN[9] is composed of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or predetermined. This allows random deployment in inaccessible terrains or disaster relief operation. On the other hand, this also means that WSN protocols and algorithms must possess self-organization capabilities. Another unique feature of WSN is the cooperative effect of sensor nodes. Sensor nodes are fitted with an onboard processor. Instead of sending the raw data to the nodes responsible for the fusion, they use their

processing abilities to locally carry out simple computations and transmit only the required and partially processed data. In a typical scenario, users can retrieve information of interest from a sensor network by injecting queries and gathering results from the so called base stations (or sink nodes), which behave as an interface between users and the network. In this way, sensor network can be considered as a distributed database. It is also envisioned that sensor networks will ultimately be connected to the Internet, through which global information sharing become feasible.

Figure shows architecture of a sensor network in which sensor nodes are shown as small circles

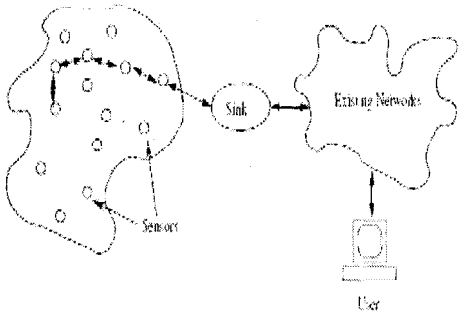

Fig. 1

Component of sensor node[1]*:*

Each node typically consists of the five components: sensor unit, analog digital convector (ADC), central processing unit (CPU), power unit, and communication unit. The sensor unit is responsible for collecting information as the ADC requests, and returning the analog data it sensed. ADC is a translator that tells the CPU what the sensor unit has sensed, and also informs the sensor unit what to do. Communication unit is tasked to receive command or query from, and transmit the data from CPU to the outside world. CPU is the most complex unit. It interprets the command or query to ADC, monitors and controls power if necessary, processes received data, computes the next hop to the sink, etc.

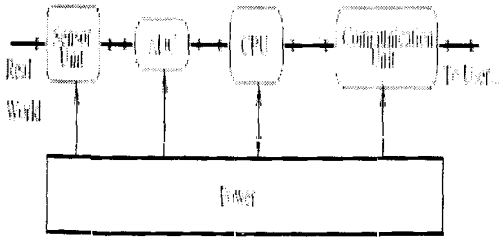

Fig. 2

The difference between sensor networks and ad hoc networks are:

- The number of sensor nodes in a sensor network can be several orders of magnitude higher than the noces in ad hoc networks.
- Sensor nodes are densely deployed.
- Sensor nodes are prone to failures.
- The topology of a sensor network changes very frequently.
- Sensor nodes mainly use a broadcast communication paradigm, whereas most ad hoc networks are based on point-to-point communications.
- Sensor nodes are limited in power, computational capacities, and memory.
- Sensor nodes may not have global identification (ID) because of large amount of overhead and large number of sensors.

II. *Routing Protocols* :

A. Flooding

It is an old technique that can also use in the sensor networks. In flooding[5], each node received a data and then sent them to the neighbors by broadcasting, unless a maximum number of hops for the packet are reached or the destination of the packet is arrived.

It has several disadvantages:

- Implosion: It is a situation where duplicated data are sent to the same node. For example, if node A has N neighbor nodes which are also the neighbors of the node B, node B will receive N copies of the message sent from node A.
- Overlap: If two nodes share the same measuring region, both of them may sense the same data at the same time. As a result, neighbor nodes receive duplicated messages.
- Resource blindness: The flooding protocol does not take into account the available energy resource. An energy resource aware protocol must take into account the amount of energy available to them at all times.

B. SPIN (Sensor Protocols for Information via Negotiation) :

The idea behind SPIN is to name the data using meta-data that highly describes the characteristics of the data, which is the key feature of SPIN [5].

SPIN has three types of messages.

- *ADV:* When a node has data to send, it advertises this message containing meta-data.
- *REQ:* A node sends this message when it wishes to receive some data.
- *DATA:* Data message contains the data with a meta-data header.

Before sending a DATA message, the sensor node broadcasts an ADV message containing a descriptor containing a descriptor (i.e. meta-data) of the DATA. If a neighbor is interested in the data, it sends a REQ message for the DATA, and then DATA is sent to this neighbor node. Respectively, the neighbor node repeats the same process until the data is sent to the sink (or BS). SPIN's meta-data negotiation and resource adaptive solves the classic problems of flooding such as implosion, overlap and resource blindness, achieving a lot of energy efficiency.

Advantages: Topological changes are localized since each node needs to know only its single-hop neighbors.

Disadvantages.

- It is not scalable.
- The nodes around a sink could deplete their energy if the sink is interested in too many events.
- SPIN's data advertisement mechanism can not guarantee the delivery of data. For example, if the nodes that are interested in the data are far away from the source node and the nodes between source and destination are not interested in that data, such data will not be transport to the destination at all.

C. LEACH (Low Energy Adaptive Clustering Hierarchy) :

It is a clustering-based protocol that utilizes randomized rotation of the cluster heads

to evenly distribute the energy load among the sensor nodes in the network. The idea is to form clusters of the sensor nodes based on the received signal strength and use local cluster heads as router to the sink. This will save energy since the transmission will only be done by cluster heads rather than all of the nodes. All the data processing such as propagation and aggregation are local to the cluster. Cluster heads change randomly over time in order to balance the energy dissipation of the nodes. This decision is made by the node choosing a random number between 0 and 1. The node becomes a cluster head for the current round if the number is less than the following threshold:

$$T(n)=\begin{cases}\dfrac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if } n\in G\\ 0 & \text{others}\end{cases}$$

Where p is the desired percentage of cluster heads (*e.g.* 0.05), r is the current round, and organized into rounds, where each of them begins with a set-up phase, and is followed by a steady-state phase. Usually, the latter phase is longer than the former phase. In cluster set-up phase, each non-cluster-head node tells its cluster-head its decision by using CSMA MAC protocol. Then the cluster-heads create TDMA scheduled and broadcast them back to their members in schedule creation phase. In data transmission phase, each node waits for its turn to send data if needed.

LEACH[8] provides many good features to the sensor network, such as clustering architecture, localized coordination and randomized rotation of cluster-heads.

Disadvantages:

- It can not be applied to time critical applications.
- The nodes on the route from a hot spot to the sink might drain their energy quickly, which is known as "hot spot" problem.

III. *Compare and contrast of routing protocols of WSN :*

Based on the analysis of the above protocols, a good routing protocol for WSNs[6] should have some desirable features, such as

- Dynamic clustering architecture: It prevents cluster heads from depleting their power quickly, and hence extends the network's lifetime.
- Data aggregation: If the data classification and fusion can be completed quickly in sensor nodes, it helps in efficient query processing, and decreases network overhead dramatically. Hence saves energy.
- Randomizing path choice : If a routing algorithm can support multiple paths to a destination with low overhead, it could help in balancing the network load and tolerating the failure of nodes.
- Thresholds for sensor nodes to transfer sensed data. Chosen good threshold, it may solve "hot spot" problem and save energy by limiting unnecessary transmissions. It will be helpful to extend the lifetime of the sensor network.
- Thresholds for sensor nodes to relay data. Determining appropriate thresholds of energy and time delay to relay data would help in elongating nodes' lifetime.

Table show the comparison of different routing protocols[6]

Table 1

	Flooding	SPIN	LEACH
Scalability	Limited	Limited	Good
Lifetime	Short	Long	Long
Data diffusion	No	No	Yes
Meta-data	No	Yes	No
Power required	High	Limited	High
Location awareness	No	No	No
Optimal route	No	No	No
Multi-hop	Yes	Yes	No
Classification	Flat	Data-centric	Hierarchical

IV. Conclusions

Sensor Network can be highly mobile, limited power (in terms of computation and memory capacity), and heterogeneous. They can consist of a group of minute sensors, communicating to each other and gathering environmental information. Sensor nodes are densely deployed Sensor nodes may not have global identification (ID) because of large amount of overhead and large number of sensors As a result see it as a potential area for research and consequently a research in this area is justified for its important. In future, we shall evaluate the impacts contributed by each unresolved technical issue towards the deployment of sensor network, identify the most important ones and then formulates strategies to tackle them. As per the literature review of the mentioned papers the good sensor routing protocol have Dynamic clustering architecture, Data aggregation, Randomizing path choice so that the protocol can choose the multiple path and determining appropriate thresholds of energy and time delay to relay data would help in elongating nodes' lifetime. As per the above table the SPIN and LEACH routing protocol have good scalability and lifetime as compared to flooding. So there is vast area to research on routing protocol for sensor network.

V. *Future scope of work .*

Nodes in a wireless sensor network are severely constrained by energy, storage capacity and computing power. To prolong the lifetime of the sensor nodes, designing efficient routing protocols is critical. Most of the existing routing protocols assumes that the node and the sink are both stationary. However, in some situations, the nodes and the sink need to be mobile. New routing algorithms are needed to handle the overhead of mobility and topology changes in such an energy-constrained environment.

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