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Study of Wireless Sensor Networks Using Leach,Teen and Apteen Routing Protocols

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Abstract: ***This paper is about the wireless sensor networks in environmental monitoring applications. As the wireless sensor networks are made up of tiny energy hungry sensor nodes, the number and type of sensor nodes and the design protocols for any WSNs is application specific. The sensor data in this application may be light intensity, temperature, pressure, humidity and their variations. This paper focus on study of wireless sensor network using communication protocols called LEACH, TEEN and APTEEN.***

Keywords: wireless sensor networks, Routing protocol, Reactive protocol, Proactive protocol, Energy Efficiency, battery power

1. Introduction

Wireless Sensor network (WSN) is widely considered as one of the most important technologies for the twenty-first century. In the past decades, it has received tremendous attention from both academia and industry all over the world. A WSN typically consists of a large number of low-cost, low-power, and multifunctional wireless sensor nodes, with sensing, wireless communications and computation capabilities. These sensor nodes communicate over short distance via a wireless medium and collaborate to accomplish a common task, for example, environment monitoring, military surveillance, and industrial process control [4]. In many WSN applications, the deployment of sensor nodes is performed in an ad hoc fashion without careful planning and engineering. Once deployed, the sensor nodes must be able to autonomously organize themselves into a wireless communication network. Wireless Sensor networks have emerged as a promising tool for monitoring (and possibly actuating) the physical world, utilizing self-organizing networks of battery-powered wireless sensors that can sense, process and communicate. The requirements and limitations of sensor networks make their architecture and protocols both challenging and divergent from the needs of traditional Internet architecture. A sensor network [1][4] is a network of many tiny disposable low power devices, called nodes, which are spatially distributed in order to perform an application-oriented global task.

2. Classification of Routing Protocols

A routing protocol specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on networks. Routing algorithms determine the specific choice of route. The topology of the WSNs can be simply star network to an advanced multi hop wireless mesh network. The way how to effectively route the collected data among nodes is very important as well very challenging in WSNs because of many constraints of sensor nodes and several discriminated characteristics of WSN that distinguish them from contemporary communication and wireless ad hoc networks. Routing in WSN is very different from conventional routing in fixed network in various ways: In WSNs there is no infrastructure, it is unfeasible to build global addressing and routing algorithms exactly as for conventional IP-based protocols for the deployment of steep number of energy and processing capacity constrained sensor nodes.

A. Routing protocols can classify based on whether they are reactive or proactive. Depending on how the source finds a route to the destination, routing protocols can be classified into three categories, namely, proactive, reactive, and hybrid protocols. A proactive protocol sets up routing paths and states before there is a demand for routing traffic. Paths are maintained even there is no traffic flow at that time. In reactive routing protocol, routing actions are triggered when there is data to be sent and disseminated to other nodes. Here paths are setup on demand when queries are initiated.

- In proactive protocols, all routes are computed before they are actually needed
- In reactive protocols, routes are computed only when they are needed
- Hybrid protocols are combination of the above two ideas

B. Depending upon the network structure, routing in WSNs can be classified as
(a) Flat based routing (b) Hierarchical based routing and (c) Location based routing.
In flat-based routing, all the nodes in the topology are having same functionality or role.
In hierarchical-based routing, nodes are assigned different roles or functionalities according to the hierarchy.
In location-based routing, routing path for the data is decided according to the Sensor nodes position in the field.

C. Routing protocols are also classified based on whether they are destination-initiated (Dst-initiated) or source-initiated (Source-initiated). A source-initiated protocol sets up the routing paths upon the demand of the source node, and starting from the source node. Here source advertises the data when available and initiates the data delivery. A destination initiated protocol, on the other hand, initiates path setup from a destination node.

D. Depending on the protocol operation, routing protocols can be classified into multipath based, query-based, negotiation-based, QOS based, or coherent based routing.

- In multipath-based routing, multiple paths are used to enhance network performance.
- In negotiation-based routing, high-level data descriptors are used in order to eliminate redundant data transmission through negotiation. Communication
- In QOS-based routing, a balance between energy consumption and data quality is maintained.
- In coherent-base routing, the data is aggregated with minimum processing before forwarding. Here energy efficiency is achieved by path optimality.

2.1 LEACH Protocol

In Proactive Networks, the sensors periodically transmit the value for the sensed attribute. At other times, sensors and transmitters are switched off to save energy. This type of network is most suitable for applications that require periodic examination, namely, monitor machinery for fault detection and diagnosis. LEACH (Low Energy Adaptive Clustering Hierarchy) is a good approximation of a proactive network protocol.

If the interval between transmissions is increased, the total number of transmissions is reduced, conserving sensor energy. But, because of the increased period, critical real-time data may reach the user only after the pre-specified period, thereby making it unsuitable for time-critical applications. If the interval is reduced, the critical data reaches the user with shorter delay. But, this increases the number of data transmissions and the energy consumption, hence reducing the network life. LEACH is a good approximation of a proactive network protocol, with some minor differences. Once the clusters are formed, the CHs broadcast a TDMA schedule giving the order in which the cluster members can transmit the data. Every node in the cluster is assigned a slot in the frame, during which it transmit data to the cluster head. When the last node in the schedule has transmitted its data, the schedule is repeated. The report time is equivalent to the frame time in LEACH

The frame time is not broadcast by the CH but is derived from the TDMA schedule. However, it is not under user control. Also the attributes are predetermined and are not changed after initial installation. This network can be used to monitor machinery for fault detection and diagnosis. It can also be used to collect data about temperature or pressure or moisture change patterns over a particular area. But data collection is done periodically and centralized. Therefore it is most appropriate only for constant monitoring of networks. In most cases, the uses does not always need all that data, therefore periodic data transmission are unnecessary. It consumes more energy at each sensor.

2.2 TEEN Protocol

A reactive network protocol called TEEN is Threshold-sensitive Energy Efficient sensor Network. In Reactive Networks, sensor nodes continuously sense the environment and transmit the value as soon as the sensed parameter exceeds a user specified threshold value. This enables time critical data1 to reach the user almost instantaneously, making such a network most suitable for time critical applications. TEEN (Threshold-sensitive Energy Efficient sensor Network) protocol has been developed specifically for such networks. However, if the thresholds are not reached, the user cannot determine the state of the network, making it inadequate for applications that require periodic data from the network.In this scheme, at every cluster change time, in addition to the attributes, the CH broadcast the following message to its members:

Hard threshold (HT): This is a threshold value for the sensed attributes developed for reactive networks. It is the absolute value of the attributes beyond which the node sensing this value must switch on its transmitter and report to its CH.

Soft threshold (ST): This is small change in the value of the sensed attributes that triggers the node to switch on its transmitter and transmit.

The nodes sense environment continuously. The first time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends the sensed data. The sensed value is also stored in an internal variable in the node, called SV. The nodes will next transmit data in the current cluster period only when both the following conditions are true.

1) The current value of the sensed attribute is greater than HT.
2) The current value of the sensed attribute differs from SV by an amount equal to greater than the ST.

The HT tries to reduce the number of transmission by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The ST further reduces the number of transmissions by eliminating all the transmissions which have otherwise occurred when there is little or no change in the sensed attribute once the HT.But the main drawback of this algorithm is that if the thresholds are not reached, the nodes will not communicate, the user will not get any data from the network, and will not come to know even if the nodes die. Therefore this scheme is not suited for applications where it is necessary to get data on a regular basis. Advantage of this scheme is it is eminently suited for time critical data sensing application. Energy consumption in this scheme can be much less than in proactive network because data transmission consumes more energy than data sensing and in this scheme data transmission is done less frequently.

2.3 APTEEN Protocol

A reactive network protocol called APTEEN is Adaptive periodic threshold sensitive energy efficient sensor network protocol. Hybrid Networks combine the best features of proactive and reactive networks, while minimizing their drawbacks. Nodes in such a network transmit data periodically at relatively longer intervals while at the same

time transmitting data when the sensed value goes beyond its threshold. Thus, the sensor energy is used very efficiently by reducing the number of transmissions of noncritical data. The user can change the periodicity, threshold value(s) and the parameter to be sensed in different regions.This network can emulate either the proactive or the reactive network by suitably changing the periodicity or threshold values. Thus, this network can be used in any type of application by suitably setting the various parameters. However, this flexibility and versatility does increase the complexity at the sensor. Here a new protocol APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network Protocol) is introduced for hybrid networks. There are applications in which the user wants time critical data and also wants to query the network for analysis of conditions other than collecting time critical data. In other words, the user might need a network that reacts immediately to time critical situations and gives an overall picture of the network at periodic intervals, so that it is able to answer analysis queries. None of the above sensor networks can do both jobs satisfactorily since they have their own limitations. APTEEN is able to combine the best features of proactive and reactive networks while minimizing their limitations to create a new type of network called a hybrid network. In this network, the nodes not only send data periodically, they also respond to sudden changes in attribute values.

In this way it works as a proactive protocol as well as reactive protocol. This uses the same model as the TEEN protocols with the following changes. In APTEEN, once the CHs are decided, the following events take place in each cluster period. The CH first broadcasts the following parameter.

Attributes: This is a set of physical parameters which the user is interested in.

Thresholds: This parameter consists of a HT and a ST. HT is a value of an attribute beyond which a node can be triggered to transmit data. ST is a small change in the value of an attribute that can trigger a node to transmit.

Schedule: This is a TDMA schedule, assigning a slot to each node.

Count time: This is the maximum time period between two successive reports sent by a node. It can be a multiple of the TDMA schedule length, and it introduces the proactive component in the protocol. Data values exceeding the threshold value are referred to as critical data. The nodes sense their environment continuously. However, only those nodes that sense a data value at or beyond the hard threshold transmit. Furthermore, once a node senses a value beyond HT, it next transmits data only when the value of that attribute changes by an amount equal to or greater than the ST. The exception to this rule is that if a node does not send data for a time period equal to the count time, it is forced to sense and transmit the data, irrespective to the sensed value of the attribute. Since nodes near each other may fall in the same cluster and sense similar data, they may try sending their data simultaneously, leading to collisions between their messages. Hence, a TDMA schedule is used and each node in the cluster is assigned a transmitter slot. The main features of the scheme are as follow.

1) By sending periodic data, it gives the user a complete picture of the network, like a proactive scheme. It also senses data continuously and response immediately to drastic changes, making it responsive to time critical situations. Thus it behaves as a reactive network.
2) It offers a lot of flexibility by allowing the users to set the count time interval and the threshold values for the attributes.
3) Changing the count time as well as the threshold values can control energy consumption and can support proactive and reactive behavior in a sensor network.

3. Simulation Result

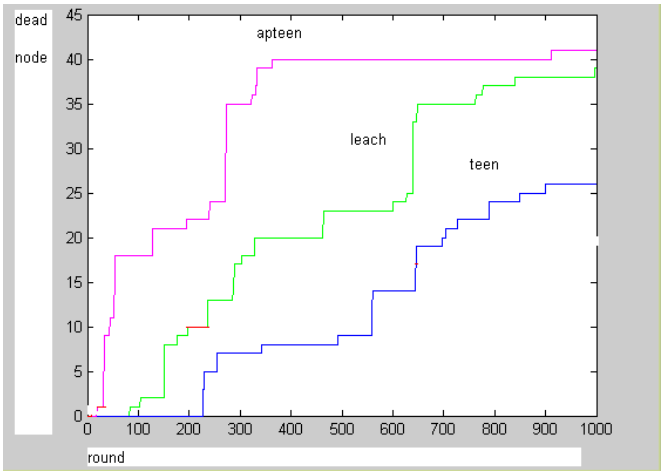

Figure 1: Round vs Dead nodes for 1000 rounds

This simulation done using MATLAB. In fig.1 for LEACH protocol first dead node at 100 round and total dead nodes after 1000 rounds are 39. For TEEN protocol first dead node at 200 rounds and total dead nodes after 1000 rounds are 26. For APTEEN protocol first dead node at 30 round and total dead nodes after 1000 rounds are 41.

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