HIERARCHICAL ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS: A SURVEY

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***Abstract*-In recent years, the use of wireless sensor networks in real life applications has increased rapidly. The building block of WSNs comprises of hundreds or even thousands of sensor nodes. These sensor nodes are battery-powered with a limited lifetime and additional energy can be harvested from the external environment. They are directly connected to each other. The data exchange involves multihop communication. The route discovery and maintenance are governed by the routing protocols. This paper surveys the different hierarchical routing protocols used in the multihop communication in WSNs. Finally these papers summarize and conclude with the different hierarchical routing protocols.**

Keywords: Wireless sensor networks; Routing protocols; Multihop communication.

I. INTRODUCTION

Wireless sensor networks [1] consist of geographically distributed independent sensors for monitoring physical or environmental conditions. More recently, the implementation of WSNs is becoming popular due to its support for connectivity, mobility and flexibility. It passes the data through the network to the base station. The WSNs consists of thousands of sensor nodes which are battery-powered and one or more sinks or base stations which collects data from the nodes.

With the help of radio communication range, the sensor node transmits the data to the base station through multihop path. In multihop routing, an attacker can launch malicious attacks by capturing the nodes which causes traffic collision like dropping or misdirecting the data or by jamming the communication channel.

Security in WSNs [10] [11] is very essential in order to protect the network and also its data. It is used to promote a stable environment which should handle the malicious attack. Routing develops a communication path between the sensor nodes and helps in forwarding the data from sensor nodes to the base station. Resources are generally limited in WSNs.

In order to eradicate the problems occurring in multihop routing, the hierarchical routing protocol was developed in which the sensor nodes in a same communication range is grouped into a cluster. In the same way, many numbers of clusters are formed in a network. Thus a wireless sensor network is formed with one or more levels known as hierarchy. To reduce the hops still, a cluster head is assigned to each cluster. So the sensor nodes need not directly communicate with the base station. A cluster head collects the data from the nodes in its cluster, aggregates it and transmit it to the base station thus reduces the number of hops.

The major challenges which are to be considered in clustering are the

- Cost
- Cluster head selection
- Aggregation of data and quality of service (QoS).

II. LITERATURE REVIEW

A. LEACH

The first developed hierarchical routing protocol is the LEACH [12] which stands for Low-Energy Adaptive Clustering Hierarchy. In a network, if the energy of a node is drained then it is no longer used. In LEACH, the nodes themselves form a cluster with one node acting as a cluster head. The cluster head selection is rotated among all the nodes in a network for obtaining even energy consumption. The responsibility of the cluster head is not only to collect data from their respective clusters but also to aggregate those collected data inorder to reduce the amount of data being sent to the base station. The major drawback of this protocol is that the time taken to select the next cluster head and also increases the amount of energy wasted in the process of cluster head selection.

B. TL-LEACH

To overcome these drawbacks, Two-Level Hierarchy LEACH (TL-LEACH) was developed by extending the LEACH. Instead of selecting a single cluster head, TL-LEACH [2] selects primary and secondary cluster heads in each round. The primary cluster head of each cluster communicates with its secondary cluster head and it in turn communicates with their respective cluster nodes. Data aggregation is performed here as in LEACH and additionally uses TDMA time slots for the inter-cluster communication. Each round involves selecting the primary and secondary cluster head using the same mechanism as LEACH but additionally uses priori probability of elevating to a primary cluster head less than that of a secondary cluster head. This TL-LEACH reduces the number of nodes involved in the communication between the sources to the base station and also reduces the time taken to select the next cluster head when the first cluster drains battery thus reducing the energy consumption.

C. TEEN

The next developed routing protocol is the Threshold Sensitive Energy Efficient Sensor Network (TEEN) [3] Based on the threshold values. It is the combination of both hierarchical clustering and data-centric protocols which is mainly designed for time-critical applications. It is very responsive to sudden a change that occurs in the network (eg: temperature). In TEEN, the first step involves the formation of clusters. Next the cluster head broadcasts two threshold values to the nodes in its respective cluster. They are hard and soft thresholds.

A Hard Threshold (HT) is a value for the sensed attribute at which a node switches on its transmitter and reports to its respective cluster head. A Soft Threshold (ST) is a change made in the value of the attribute which induce the node to switch on its transmitter and report data only when the value is beyond HT or the small change in the value is greater than ST. But TEEN cannot be applied for sensor networks in which the nodes needs to send the data periodically to the sink. The major drawback is that the cluster head only sends the data to the sink so if the cluster heads are not within the transmission range, the data will be lost.

D. APTEEN

In order to overcome the drawbacks in TEEN, Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN) [4] was developed by extending the existing TEEN. As TEEN, the APTEEN reacts to the changes in the network and also in architecture but extends the periodic data collection. It supports historical, one-time and persistent query types.

E. EECS

Another clustering algorithm was developed by extending the LEACH is known as Energy Efficient Clustering Scheme (EECS) [5] in which the candidates chosen for cluster head competes themselves to be selected as a cluster head. This involves the chosen nodes broadcasting its residual energy to its neighbor and if a given node does not find more energy in anode then it becomes cluster head. Unlike LEACH, EECS sizes the clusters dynamically based on the cluster distance from the base station. This improves the resource utilization

and extended lifetime of the network. The problem addressed here is the clusters that are far away from the base station consume more energy for transmission than the clusters that are closer to the base station.

F. HEED

To overcome the drawbacks in EECS, a Hybrid Energy-Efficient Distributed Clustering (HEED) [6] [8] was developed. It mainly focuses on the efficient clustering with proper cluster head selection based on the distance between different nodes. It aims at extending network lifetime, minimizing the energy consumed for selecting cluster head and minimizing the control overhead. The cluster head selection is based on the residual energy and the intra-cluster communication cost. The drawback here is that a node can communicate with cluster head which yields lowest intra-communication cost.

G. PEGASIS

By resolving the problems in HEED, PEGASIS [9] was developed. It is the optimization of LEACH. Unlike LEACH which clusters the nodes and assigning cluster head for each cluster, PEGASIS forms the chain of nodes. Each nodes sends and receives packet from only one closest neighbor node. So, the energy consumption is adjusted. A node collects the data and forwards it to the node in the chain that communicates with the base station. In each round, a node in the chain will be selected to communicate with the base station. This again leads to the large energy consumption thus reducing the network life time.

H. CCS

In order to reduce the energy consumption in PEGASIS, Concentric Clustering Scheme (CCS) is developed. In CCS [7], the entire network is divided into co-centric circular tracks and each track represents a cluster and it is assigned a level. In each track, the nodes form a chain as in PEGASIS. A head node is selected among the nodes present in the chain and a node number is assigned. The nodes other than the head node receives data from its neighbor and attach its own data to it then transmits to its neighbor. A head node in each track receives atmost two messages. The head node then delivers data to the base station. Here, the distance of transmission from head node to base station is reduced thus reducing the energy consumption. As the network is divided into many concentric clusters, the reverse flow of data from base station is reduced. The drawback here is the redundant data transmission.

III. CONCLUSION

In this paper, we have surveyed different hierarchical routing protocols in Wireless Sensor Networks in terms of its energy consumption and network lifetime. The major aim of hierarchical routing protocols is to keep the sensor nodes work as long as possible to increase the network lifetime. The energy consumption of a sensor node is based on the transmission and reception of data. Therefore the routing protocols are designed for WSNs in such a way that it should be energy efficient and with extended network lifetime.

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