A REVIEW ON LEACH-BASED HIERARCHICAL ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORK

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ABSTRACT

A Wireless sensor network (WSN) has been extensively used in a specified area for monitoring environment conditions such as temperature, air pressure, light, humidity, motion or vibration and can communicate with each other using a wireless radio device. Normally, sensor nodes in wireless sensor networks (WSNs) have resource constraints like limited energy, low storage capacity and weak computing ability. Therefore the life time of the Wireless sensor network (WSNs) highly depends on the energy consumption of sensors. This surveying paper highlight the energy-efficient hierarchical cluster based routing protocols based on Low-Energy Adaptive Clustering Hierarchy (LEACH), which is considered as the most popular routing protocol for WSNs, that use cluster based routing in order to minimize the energy consumption. In this paper there is a complete study of different LEACH based WSN clustering routing protocols.

Keywords: ***Cluster Head, LEACH, Network life time, Routing Protocol, Wireless sensor network***

I. INTRODUCTION

Recent advances in Wireless Communication and electronics have enabled the development of Low cost, Low-Power multifunctional sensor nodes that are small in size and communicate untethered in short distances [1]. Wireless sensor networks are collection of hundreds and even thousands of small tiny devices called sensor nodes distributed autonomously to monitor physical or environmental conditions(such as temperature, sound, pressure etc.) and forward such information to a central point for appropriate processing. The Sensor nodes transmit their data to the base station (BS). Each node in a sensor network is equipped with one or more sensors, a radio transceiver or other wireless communication device, a small microcontroller and an energy source. Sensor nodes are battery driven devices with restricted energy resources. [2].

The application of sensor network is very broad such as Military applications, Environmental applications, Health applications, Home applications and other commercial applications. Some other commercial applications include

managing inventory, monitoring product quality and monitoring disaster areas [1]. Sensor networks can contain hundreds or thousands of sensing nodes. It is desirable to make these nodes as cheap and energy efficient as possible [6]. Routing in Wireless Sensor Networks (WSNs) is a challenging issue as because of the limitation of resources in terms of power supply, processing capability and transmission bandwidth. This Paper talk about hierarchical routing Protocols. The main objective of hierarchical routing protocol is minimization of energy consumption of sensor nodes. In a hierarchical routing protocol first of all nodes are grouped together to form a cluster. Afterward the node with higher energy will become cluster head (CH). In this way each cluster comprises of a master node better known as cluster head (CH) followed by member nodes. Cluster head perform the task of data aggregation and also responsible for sending and Processing the information to the base station (BS), whereas the remaining nodes of that cluster will perform sensing operation. In recent few years, many routing protocols have been proposed for Wireless Sensor Networks [4-7].

In this Paper we have discussed the most popular routing protocol (LEACH) that use cluster based routing and also some other LEACH based protocols that have been developed for WSNs.

II. CLUSTER-BASED ROUTING

The basic objective of any routing Protocol is to make the network useful and efficient. A cluster-based routing protocol groups sensor nodes, where each group of nodes has a cluster head (CH) or a gateway. Now sensed information is sent to the CH rather than send it to the base station (BS) by member nodes. Cluster head performs some aggregation function on data it receives and then sends it to the BS where these data is needed. A number of routing protocols have been proposed for WSNs. However, few of them are cluster based. LEACH is one of the most well-known hierarchical protocol which shows significant reduction in the overall network energy over other non-clustering protocol.

III. LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster based routing protocol proposed by W.R. Heinzelman for Wireless Sensor Networks [2]. It is the most popular energy-efficient protocol that reduces power consumption in WSNs. The routing algorithm is designed to collect and deliver data to the data sink typically a base station. The main objectives of LEACH are given below.

(1) Extension of the network life time.

(2) Reduced energy consumption by each sensor node.

(3) Use of data aggregation to reduce the number of communication messages.

To achieve these objectives, LEACH adopts a hierarchical approach to organize the network into a set of clusters. Each cluster is managed by a selected cluster head (CH). The newly appointed cluster head performs various tasks. The first task consists of periodic collection of data from the members of the cluster .After gathering the data, the cluster head aggregates it. The second main task of CH is to transmit the aggregated data directly to the Base station (BS). The transmission of the aggregated data is achieved over a single hop. The network model used by LEACH is depicted in the figure given below.

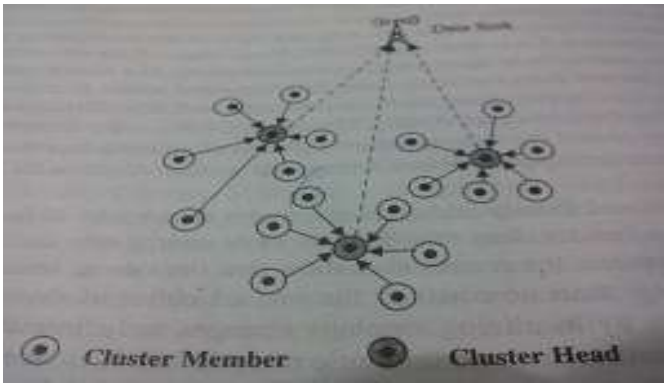

Fig.1: LEACH network model [3]

The third main task of the cluster head is to create a TDMA-based schedule whereby each node of the cluster is assigned a time slot that it can use for transmission. The CH advertises the schedule to its cluster members through broadcasting. To reduce the likelihood of collisions among sensor nodes within and outside the cluster, LEACH nodes use a code-division multiple access-based scheme for communication.

The basic operations of LEACH are organized in two distinct phases. The first phase, the setup phase, consists of two steps, cluster head selection and cluster formation. The second phase, the steady-state phase, focuses on data collection, aggregation and delivery to the base station. The duration of the set up phase is assumed to be relatively shorter than the steady-state phase to minimize the protocol overhead. At the beginning of the set up phase, a round of cluster head selection starts. To determine cluster head (CH), a node, n, generates a random number between 0 and 1 and compares it to the cluster head selection threshold, T (n). The node becomes a cluster head if its generated value is less than T (n). To meet these requirements, the threshold T (n) of a competing node "n" can be expressed as follows.

$$T(n) = P/1-P\ [r \bmod(1/P)] \quad \text{if } n \in G$$

$$= 0 \qquad \text{other wise}$$

The variable 'G' represents the set of nodes that have not been selected to become cluster heads in the last 1/P rounds and 'r' denotes the current round. The predefined parameter 'P' represents the cluster head probability. It is clear that if a node has served as a cluster head in the last 1/P rounds, it will not be elected in this round. At the completion of cluster head selection process, every node that was selected to become a cluster head advertises its new role to the rest of the network. Upon receiving the cluster head advertisements, each remaining node selects a cluster to join. The nodes then inform their selected cluster head (CH) of their desire to become a member of the cluster. Upon cluster formation, each cluster head creates and distributes the TDMA schedule, which specifies the time slot allocated for each member of the cluster. Each cluster head also selects a CDMA code, which is then distributed to all members of its cluster. In this way the set up phase comes to an end and signals the beginning of the steady-state phase. During steady-state phase, nodes collect information and use their allocated slots to transmit to the cluster head the data collected. After gathering the data, the cluster head aggregates it (which not only minimizes redundancy but also reduces the total amount of data sent to the sink) and transmit this aggregated data directly to the Base station (BS). After a certain period of time spent on the steady-state
Phase, the network goes into the set up phase again and enters another round of selecting cluster heads [3]. Simulation results show that LEACH achieves significant energy savings.

IV. HIERACHICAL ROUTING PROTOCOLS

Energy-LEACH (E-LEACH): Energy-LEACH Protocol improves the cluster head (CH) selection procedure. It makes residual energy of sensor node as the main metric which decides whether the nodes turn into CH or not after the completion of first round. Like as LEACH Protocol, E-LEACH is divided into rounds. In the first round, every node has the same Probability to turn into CH that means nodes are randomly selected as CHs. After the completion of first round the residual energy of each node is different. This Protocol proposes the cluster head (CH) selection procedure on the ground of residual energy. That means nodes have more energy will become a CHs rather than nodes with less energy. In this way E-LEACH performs better than LEACH Protocol and makes the network useful and efficient.

TL-LEACH (TWO-LEVEL LEACH): TL-LEACH is a proposed extension to the LEACH Protocol. In LEACH, CH transmits aggregated data to BS directly. Now CH might be located far away from the BS, so it uses most of its energy for transmitting and because it is always on it will die faster than other nodes. Hence a new version of LEACH named TL-LEACH is introduced which utilizes two levels of cluster-heads (Primary and secondary) in addition to the other simple sensing nodes. In this algorithm, CH collects data from other cluster members as original LEACH, but rather than transfer data to the BS directly, it uses one of the CHs that lies between the CH and the BS as a relay. In this way the two-Level structure of TL-LEACH effectively reduces the total energy usage.

M-LEACH (MULTI-HOP LEACH): M-LEACH Protocol is almost the same as LEACH, only makes
Communication mode from single hop to multi-hop between CHs and BS. In LEACH, each cluster head directly communicates with Base station no matter the distance between CH and BS. It will consume lot of energy if the

distance is far. On the other hand, Multi-hop- LEACH protocol selects optimal path between the CH and BS through other CHs and use these CHs as a relay station to transmit data over through them.

First, multi-hop communication is adopted among CHs. Then, according to the selected optimal path, these CHs transmitted data to the corresponding CH which is nearest to BS. Finally, this CH sends data to BS.

LEACH-C: It is an enhancement over the LEACH. This protocol uses a centralized clustering algorithm hence named as LEACH-C. It is having the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the cluster heads throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location and residual energy level to the sink. The sink computes the average node energy and determines which nodes have energy below this average.

Once the cluster heads and associated clusters are found, the sink broadcasts a message that obtains the cluster-head ID for each node. If a cluster head ID matches its own ID, the node is a cluster head otherwise the node determines its TDMA slot for data transmission and goes sleep until it's time to transmit data.

V-LEACH: In this protocol, besides having a CH in the cluster, there is a vice-CH that takes the role of the CH when the CH dies. By doing this, cluster nodes data will always reach the BS. Hence no need to elect a new CH each time the CH dies. This will extend the overall network life time. In the original LEACH, the CH is always on receiving data from cluster members, aggregate these data and then send it to the BS that might be located far away from it. The CH will die earlier than other nodes in the cluster because of its several operations like sending. Receiving and overhearing. When the CH die, the cluster will become useless because the data gathered by CH will never reach to the Bs. Hence in this new version of LEACH, there is a provision of vice-CH [2].

pLEACH (Partition-based LEACH): This is an improved LEACH algorithm named partition-based LEACH. This protocol firstly partitions the network into optimal number of sectors, and then selects the node with the highest energy as the head for each sector, using the centralized calculations. pLEACH adopts the centralized cluster head election scheme. This will consists of following two phases.

(1) Calculation of optimal number of cluster heads by the sink node for a given network and partitions accordingly the whole network into sectors.
(2) Selection of a node with the most energy in each sector as cluster head information by the sink node which finally broadcasts the elected heads to the whole network and all non-head nodes join its closest cluster head after receiving the broadcast message [8].

V. CONCLUSIONS

In this paper we have surveyed LEACH and various other LEACH based hierarchical clustering routing protocol for Wireless Sensor Networks. LEACH is the first and the most important protocol in WSN, which uses cluster, based broadcasting techniques to reduce the network energy consumption and thereby enhance the network lifetime. The various LEACH-based hierarchical routing protocols discussed above have different assumptions. They have their own advantages and limitations.

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