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A Review on Enhancements in Leach Routing Protocol for Wireless Sensor Networks

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Abstract*—Wireless Sensor Network is the network of power-limited sensing devices called sensors deployed in a region to sense various types of physical information from environment. The main task of these sensors is to sense and transmit sensed data to other sensors present in the network. This consumes a considerable amount of energy. The technique of clustering was proposed to increase the lifetime of sensors. LEACH (low-energy adaptive clustering hierarchy) is a well-known hierarchical routing protocol. In LEACH protocol the whole network is divided into different clusters which break the run time of network into many rounds. Based on a predefined criterion the nodes of a cluster in each round contend to be cluster head. Cluster head consumes more energy in aggregating and routing data and it becomes important to have an energy-efficient and load balanced mechanism for CHs' rotation and election. Different routing protocols have been proposed to increase energy efficiency of the sensor nodes. The main purpose of this paper is to study and analyze various enhancements over LEACH protocol.

Keywords*— WSN, LEACH, Clustering, sensor, BS, aggregation.

I. INTRODUCTION

Wireless sensor network (WSN) has attracted considerable attentions during the last few years due to characteristics like feasibility of rapid deployment, self-organizing ability and fault tolerance[9]. A wireless sensor network consists of many sensor nodes, a management and a sink node[5]. A sensor node is composed of units including storage, sensing, communication and calculating units [3]. All the sensor nodes collect local information which is processed and sent to a remote base station called sink [6]. Sensor nodes have to organize among themselves to get information about the physical environment. The base station either directly or through other sensor nodes, receive the information gathered by sensor nodes. The base station may be fixed or mobile capable of connecting the sensor network to an infrastructure network or to the internet where users can access and process data [7]. Such networks are used for variety of purposes like transport and habitat monitoring, military surveillances or forest-fire detections etc. These sensor nodes are wireless and small and can easily be used in remote areas and hilly terrains [1]. But the major concern is limited energy, storage capacity and communication capability of sensor nodes[5].

One of the most important constraints on sensor nodes is the requirement of low power consumption[6]. Random distribution of the nodes in the sensing field makes battery recharge or exchange an impossible fact [5]. The network once established, senses the data and the energy of the nodes keep on dissipating as they receive some information and send it further to other nodes or BS [1]. The nodes in WSNs are usually battery operated sensing devices with limited energy resources and replacing or replenishing the batteries is usually not an option. Hence energy efficiency is one of the most important issues and designing power efficient protocols is critical for prolonging the lifetime [10]. In fact, only some nodes are required to transmit data over a long distance and the rest will need to complete short distance transmission only [9]. The major application of such networks is to monitor environmental data and transmit it to base station. The BS analyzes the data which is then used to initiate some particular action. The data analysis agreed out by sink node is to compute smallest or maximum, or computation of average[7].

Sometimes the nearby nodes sense same data which is sent to BS resulting in inefficient network. Thus to maintain worthy information at the BS, the nodes must be responsible for data aggregation and fusion. To avoid redundancy, a reliable network is needed in which the redundant information is negligible[1]. Routing in WSNs is very challenging. Routing protocols for WSNs can be classified into flat network routing, hierarchical network routing, location-based network routing , based on the network structure adopted [10].

1. Flat based routing protocol: In this routing all the nodes have the same functionality and they work together to perform sensing and routing tasks[3]. In this type of network it is not possible to assign a global identifier to each node due to large number of nodes. Therefore, base station sends queries to different part of the field then waits to receive data from other sensors in the selected parts of the field. [5].

2. Hierarchical routing protocol: In this type of network nodes will be assigned different roles in the network like a cluster head, number of nodes in a cluster. Some of the nodes are responsible for processing and communication, while further nodes can be used for sense the target area. This type of routing is mainly considered as two layer architecture where one layer is engaged in cluster head selection and the other layer is responsible for routing. Cluster head in hierarchical routing is the node responsible for collecting data from other nodes in the cluster, aggregating it and sending

it to sink node , create clusters and passing on communication task to cluster heads contributes to a more scalable and energy efficient network[5].

3. Location-based: In it, location information of nodes is used to be compute the routing path. This information is obtained from the global positioning system(GPS) devices attached to each sensor node. Geography adaptive routing (GAF), Geographic and Energy-Aware Routing are examples of location-based network routing protocols [7].

Hierarchical-based routing protocols also known as cluster based routing protocols. This type of protocols enforces a structure on the network to use the energy efficiency, extend the lifetime and scalability. Nodes of the network are organized into the clusters in which higher energy nodes can be used to process and forwarding the information, while lower energy nodes are used to sense the target. An efficient way to reduce energy consumption and extend the life time of the network is clustering, doing data aggregation and fusion in order to reduce the number of transmitted messages to the BS [4]. **Figure 1** describes this concept:

Figure 1. A sensor network with clustering.

[8].The first hierarchical routing protocol for WSN is Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a cluster-based routing protocol which includes cluster formation in distributed manner. The nodes organize themselves into local clusters, in which one node acts as the local cluster-head. In this protocol randomized rotation of the high-energy cluster head position is done such that it rotates among the several sensors nodes so that the battery of a single sensor is not depleted. CHs also performs local data fusion to compress the amount of data arriving from the nodes that belong to the respective cluster and transmit aggregated data to the base station. This reduces energy dissipation and enhances system lifetime. The cluster head receive data directly from each node and the sink uses single-hop routing. The disadvantage of this is that it is not applicable for large networks. Therefore, it is possible that no or lots of CHs selected and also possible that too many CHs are located in a specific area[4].

The operation of cluster forming and data transmission in LEACH is done in two phases that these phases shown in **Figures 2** and **3**:

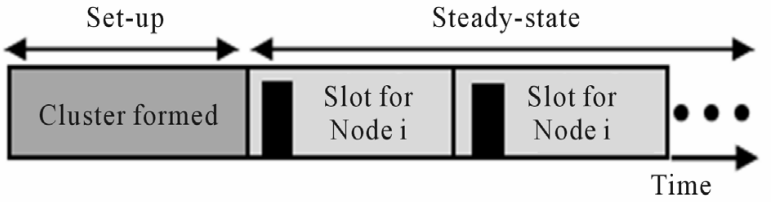

Figure 2. Period of LEACH.

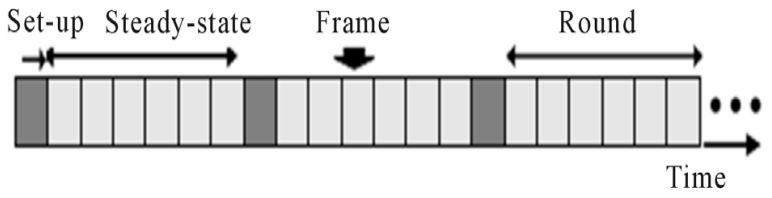

Figure 3. Details of period.

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II. LITERATURE SURVEY

A. Better cluster head management

The author Tripti Sharma in 2012 [1] and Rajni Kamboj in 2014[7] proposed algorithms for better cluster head management. In [1] a fuzzy logic approach is used to elect the cluster-head based on two descriptors - energy and proximity distance .Out of these elected cluster heads one Master cluster head has been elected .The cluster head which has the maximum residual energy is elected as Master cluster head. In [7] using MAX-HEAP the no of nodes in under one cluster head is adjusted so that no Cluster Head is over loaded. In max-heap cluster head with maximum nodes is selected so that some of the nodes can be shifted to other cluster head's to achieve load balancing**.**

B. Energy efficiency

The authors Yi Liu in 2012 [3], Meenakshi Diwakar in 2012 [4], Vikas Nandal in 2012 [5] and Lianshan Yan in 2011 [9] proposed algorithms for efficiently managing energy in Leach clustering protocol. In [3] a low energy uneven cluster

protocol design method is proposed in which the election model of cluster head is improved considering the residual energy of nodes to improve the whole network life circle. In [4] a new algorithm EELBCRP is proposed in which the network is partitioned into annular rings by using various power levels at base station and each ring having various sensor nodes. The residual energy of each node and distance from the BS of nodes is considered as the principle of cluster-head election. In [5] a mechanism to increase the lifetime of sensor nodes by controlling long distance communication, balancing of nodes and efficient delivery of information is developed. In [9] an improved energy-efficient communication protocol for wireless sensor networks (WSNs) in the presence of distributed optical fiber sensor (DFS) links located at the center of WSN fields is presented.

C. Load balancing

The author A.Babu Karuppiah in 2013 [6] proposed an Energy Efficient Load Balanced Clustering Technique which is a min heap based Clustering algorithm. In this technique efficiency of WSNs is measured by the total distance between nodes to the base station and data amount that has been transferred.

D. Data gathering

The author Jafar Amiri in 2012 [8] proposed LEACH-C method that which performs the clustering in centralized mode by collecting the energy level of information of every node directly in each period. Also the phenomenon that is seen by sensor nodes continually change over time. Hence the information received by nodes is correlated. Energy is dissipated as time correlated data is sent in the network.

Table I

PROTOCOL	AUTHOR & YEAR	APPROACH	PARAMETERS	CONCLUSION
O LEACH	Lianshan Yan 2011	Distributed optical fibre sensor link	No. of nodes:100 Dimension of sensor field:50x200	20% better lifetime
LEACH C	Jafar Amiri 2012	Data gathering	No. of nodes:100 Dimension of sensor field:100x100	Saves energy of nodes by sending only position information
Uneven Cluster Protocol	Yi Liu 2012	Cluster head election model and residual energy	100 nodes Initial energy of node 3J	Longer life circle
EELBC	A.Babu Karuppiah 2013	MIN heap	N nodes m cluster	Run time O(n log m)
LEACH_MH	Rajni Kamboj 2014	MAX heap	100 node 100x100 area	More bits transmitted Better load balance

III. CONCLUSIONS

Main disadvantage of LEACH is that the cluster head dissipates a lot of energy to sense, process and send this data to the BS node. In order to increase the life time of the network it becomes necessary to replace role of cluster head among other nodes. Various improvements have been studied over the LEACH method which focus mainly on doing best clustering, data aggregation, better cluster head selection and cluster management, reducing overhead , energy efficiency and load balancing of the protocol.

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