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LEACH Enhancement to Improve the Life Time of Wireless Sensor Networks

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Abstract-Advances in the fields of computer hardware and software technologies have led to the development of the small wireless devices that will provide access to the information that was difficult to get or really impossible, some decades before. The Wireless Sensor Networks (WSNs) have now become one of the most common and cost effective solutions to monitor the physical environment characteristics that aids a variety of fields like military, rescue applications, security systems, engineering and medical fields and so on. But the main drawback of the WSN is the limited power source. As majority of the energy is consumed for communication, it is very much necessary to focus on an effective routing strategy. This paper gives an overview of the most popular energy efficient routing protocol Low Energy Adaptive Clustering Hierarchy (LEACH). An improvement of the LEACH called LEACH-I is also proposed.

Keywords: energy efficiency, life time enhancement, routing protocols, clustering,wireless sensor networks.

I. INTRODUCTION

The influence of Wireless Sensor Networks (WSNs) in real life applications is very prominent in the recent years due to the innovative developments in this technology. Energy conservation is always an important issue to be dealt with even though energy harvesting methods through renewable energy sources exists. To extend the life time of the entire network energy consumption of the nodes have to be planned properly.

The WSNs generally consists of a large number of energy constrained tiny sensor nodes which are deployed in various types of environments. They have limited memory and processing capacity. The sensor nodes are powered by batteries of low power that are usually non replaceable. A major part of the energy is consumed for communication compared to sensing and processing. Due to this reason development of energy efficient routing protocols has been a major research area in WSN. The distributed nature and the dynamic topology of WSN make routing always a challenging issue.

WSNs are usually used to monitor or measure the frequently varying environmental characteristics in areas where human intervention is difficult or impossible. Due to the resource constraint nature of WSNs it is essential to have an energy efficient routing protocol to reduce energy consumption thereby enhancing the life time of the entire network. The routing strategies are classified into three main categories like flat, hierarchical and location based on the network structure. Literature shows that the hierarchical cluster based routing protocols are the best suited techniques for enhancing energy efficiency. Many cluster based protocols like LEACH, LEACH-C, TEEN, APTEEN, and PEGASIS etc falls into that category. In this paper an effort to analyze the working of LEACH protocol is done by a thorough study of the different phases.

This paper is organized as follows. A thorough study of the LEACH protocol is done. After that a brief summary of the different variants of LEACH is discussed followed by the introduction of the new algorithm. The implementation results are shown and concluded with final remarks and future scope.

II. LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH)

The protocols under hierarchical routing strategies are concerned more about the energy consumption. LEACH is a widely accepted protocol that uses the concept of hierarchical routing for wireless sensor networks which focuses on network lifetime enhancement. According to this protocol all the nodes organize themselves into clusters and one node acts as the leader called the cluster head which is responsible for receiving data from all other nodes and do data aggregation and transmit to the base station . Because of this reason the cluster head should be always active which in turn leads to the earlier energy depletion of the cluster head ending the life of the entire network.

LEACH incorporates randomized rotation of the cluster heads which helps to distribute the energy load evenly among the cluster members. It also uses TDMA scheduling wherein the exact time of transmission for each node is given which helps to avoid intra-cluster collisions. Besides that it allows all other nodes who are not taking part in data transmission at that slot to go to sleep thereby reducing the energy loss. The operation of LEACH is divided into rounds. Each round begins with a set-up phase followed by steady-state phase.

Each node takes independent decisions to form clusters by using a distributed algorithm without any centralized control during the set-up phase. The cluster formation algorithm should be designed such that all nodes get the same probability of becoming the cluster head with the assumption all nodes have the same amount of energy at the beginning. The probability of becoming the cluster head is based on a threshold value T (n) where T (n) is given by

T (n): T (n) = p/1-p ×(r mod p-1).

Each sensor node chooses a random number, r, between 0 and 1; if this random number is less than a threshold value, T (n), the node becomes a cluster-head for the current round. After the cluster head election is done, an advertisement message (ADV) is broadcasted. ADV is a small message containing the node's ID and a header that distinguishes this message as an announcement message. The non cluster-head nodes decides to which cluster head is it's leader by sensing the minimum communication energy, based on the received signal strength of the advertisement from each cluster-head. After this, it must inform the cluster-head node that it is a member of the cluster by transmitting a join-request message (Join-REQ) back to the chosen cluster-head. The cluster head will act as the co-ordinator in that cluster.

The steady-state operation is broken into frames. The nodes send their data to the cluster-head once per frame during their allocated time slot. The cluster head have to be turned on always to receive the data send by all other nodes. Once this is done it process the data and sends to the base station.

The LEACH protocol has many drawbacks. During the cluster head selection the energy level of that node which can be the cluster head is not taken into consideration. There is no guarantee that the nodes are evenly distributed among the cluster heads and as a result the data received by each cluster heads varies. To reduce energy dissipation, the radio of each non-cluster-head node has to be turned off until its allocated time slot. The cluster head communicates directly with the sink using multi-hop. Moreover this protocol is not that scalable also [1][2].

III. VARIANTS OF LEACH PROTOCOL- AN OVERVIEW

There are different versions of LEACH protocol. The following section gives some details regarding this. In [3] the authors propose a new version of LEACH protocol called VLEACH which aims to increase network life time. They have introduced the concept of selecting vice cluster head, the alternate head that will work only when the cluster head will die. The vice cluster head selection is based on three factors like minimum distance, maximum residual energy, and minimum energy. Since there are vice cluster heads to take over the functions of cluster heads in case it dies, the network life time will be enhanced. The author's claims VLEACH outperforms LEACH protocol by increasing the network life time 49.37%.Fan Xiangning and Song Yulin puts forward energy-LEACH and multihop-LEACH protocols. The first one improves the cluster head selection method by selecting the nodes with more left out energy as the cluster head. The latter gives a modification by changing from single hop to multi-hop communication between the cluster head and the sink. The authors claims that according to the simulation results the energy-LEACH and multihop-LEACH protocols have better performance than the LEACH protocol [4].

The concept of uneven clustering is used in [5].The authors consider the load balance of network, the residual energy and protocol overhead factors. An improved protocol is proposed which gives a conclusion that the number of cluster head generated by this is more stable than that of LEACH protocol and a better life time is achieved. This improved version of LEACH protocol called LEACH-R is proposed by Ningbo Wang and Hao Zhu in [6].

LEACH-B, proposed in [7] has balanced the system energy consumption and has better performance of prolonging the network lifetime than LEACH protocol. The concept of mobility is taken into consideration by Kumar et.al. Here the basic LEACH protocol is improved in the mobile scenario by ensuring whether a sensor node is able to communicate with its cluster head. The life time improvement of LEACH protocol is considered in [8] where the authors analyses and identifies the shortcomings of LEACH protocol. Improved-LEACH is then qualitatively and quantitatively analysed. The quantitative and qualitative metrics presented by them can also be used as design guidelines for the development of new energy efficient protocols for WSN. A three-layered routing protocol for WSN based on LEACH (TL-LEACH) is given in [9].Reducing the power consumption compared to LEACH and PEGASIS is mentioned in this paper. According to the simulation results TL-LEACH protocol greatly improves WSN lifetime than LEACH protocol.

In the survey paper [12] the authors present energy efficient hierarchical routing protocols, developed from the classical LEACH. They clearly mention the working of these in order to increase the life time and also mentions the issues faced by LEACH and solutions for that. They gives an opinion that the variations of LEACH are similar in many ways like all routing protocol are hierarchical and homogeneous, having fixed BS and also uses the concept of clustering LEACH, sLEACH and M-LEACH are routing protocol in which BS is at single-hop and in Multi-Hop LEACH, BS can be at multi-hop distance from the CH. LEACH and M-LEACH allows limited scalability [11][12].

IV. PROPOSED MODEL

In the proposed model an attempt to enhance the energy efficiency is done with initially assuming that all nodes have the same energy and they are static. After the first round before the cluster head is selected find the residual energy of all the nodes. This is not done in the case of LEACH as it just randomly checks for the threshold value to select the cluster head. The nodes with the highest energy should be given chance to become cluster head rather than randomly choosing the cluster head (CH).Another characteristic of the proposed model is that it calculates the average number of neighbouring nodes of each node to make sure cluster heads are distributed evenly. Subordinate cluster head has to be thought of in case the energy of cluster head drains out completely .Specific node deployment strategies to be followed to ensure uniform distribution of nodes. Cluster heads should do data fusion before sending data to the sink in order to avoid redundant data. Rather than the CH's sending data directly to the base station it can be aggregated in central

location and only that CH will transmit to the base station (BS) so that every node need not waste energy for transmission.

Algorithm

Assumptions: All nodes are static and the initial energy of all the nodes is same.

Step 1: Deploy nodes.
Step 2: Find the energy level of each node.
Step 3: Find the distance of each neighbouring node.
Step 4: Select cluster heads based on the above information's.
Step 5: Form clusters and perform the operation.
Step 6: Check for the residual energy of each node and data fusion for avoiding data redundancy.
Step 7: If the energy of the cluster head is almost drained out select a subordinate cluster based on Step2 and Step 3.
Step 8: Transfer the information from the cluster head to the subordinate cluster and continue the operation until all nodes dies off.

V. SIMULATION PARAMETER SETTINGS AND SAMPLE SCREEN SHOTS

The field dimensions maximum x and y in meters are given as xm=ym=100.The location of the base station is kept at the centre The maximum number of nodes in the deployable area is 100 and the initial energy values in Joules in each node is E0=0.5.Energy dissipation of the transmission amplifier per bit in Joule Eamp= 100*10^(-12) and the energy consumption for receiver or transmitter per bit in Joule Eelec= 50*10^(-12).The maximum number of rounds is set as 3000 and the Steady state time per round is t=120.The Fig:1 shows the node deployment followed by Fig:2 giving the dead nodes in particular round. The same result is shown with respect to LEACH-I in Fig:3 which shows a drastic improvement in the enhancement of the entire network.

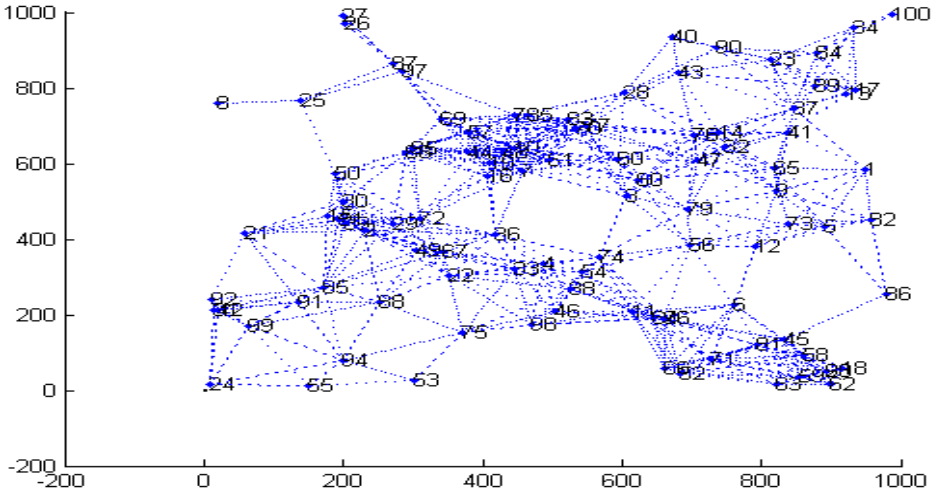

Fig:1.Node Deployment

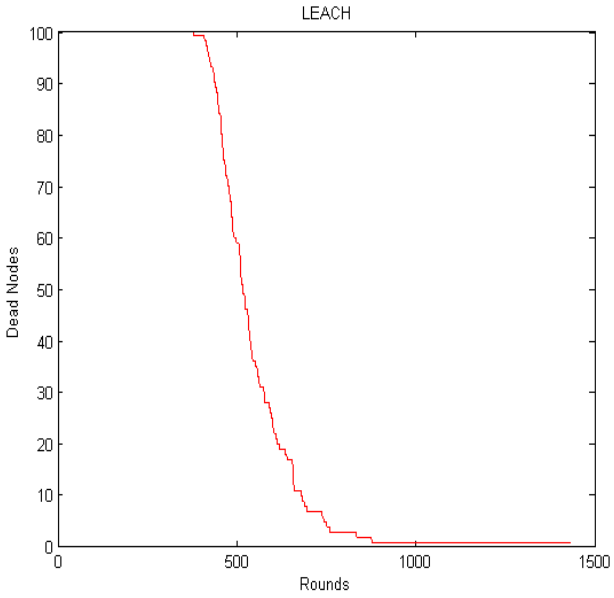

Fig:2. LEACH

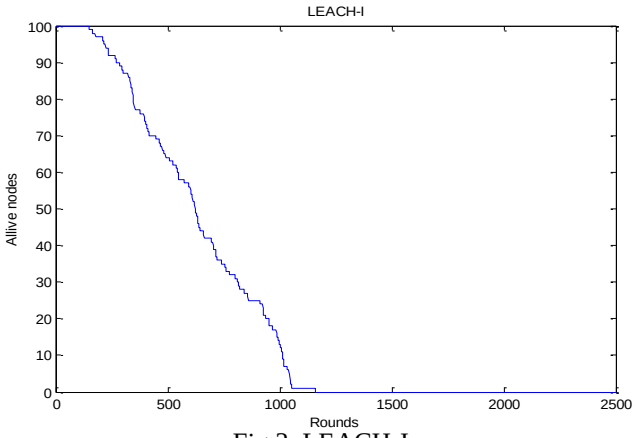

Fig:3. LEACH-I

VI. CONCLUSION AND FUTURE SCOPE

In this paper a thorough study of the most classical clustering energy efficient routing protocol LEACH is done with an exploration in to the different advancements of the LEACH protocol. A new model which outperforms LEACH in terms of energy efficiency is proposed. The proposed protocol enhances the life time of the network compared to the ordinary LEACH. Since the subordinate cluster takes charge in case of energy drain of the main cluster loss of data can be avoided to a great extend. Besides that since data fusion is done it saves energy and avoids the need of each cluster to send data and also helps in the avoidance of redundant data. The future work will be focussing more on the data aggregation techniques which emphasize on the node deployment strategies which can affect the energy level of the deployed nodes.

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