



Improvement of Advanced LEACH Protocol for Wireless Sensor Network

Gokul Sondhi*, Yamini Sood
CSE, Sri Sai University, Palampur,
Himachal Pradesh, India

Abstract— *Wireless networks are the systems used to monitor environmental or physical conditions like temperature, pressure etc. These systems contain nodes to sense. But the main problem occurs because of available energy. Energy is lost during communication due to which their life becomes very short. This report contains the information about the LEACH, and the improvement of advanced leach. Our work contains the improvement in setup phase, which contains the selection of cluster head as well as the creation of cluster. In LEACH, the selection of cluster head is done in random manner, in which random no is given to every node and a threshold value is calculated, if the random no given to node is greater than that of the threshold value, then the node is selected as cluster head. In our work, the cluster head is selected by the sink node and another improvement that has been done is in the phase in which the node selects its cluster head. Simple leach selects the nearby cluster head. Proposed work allows the node to select that cluster head which is near to sink, which increases the life time of the nodes. In this, the simulation of current work and the proposed work is done in MATLAB and comparison of these two.*

Keywords— *Sensors, Nodes, Energy, Wireless Sensor Network, LEACH*

I. INTRODUCTION

Wireless Sensor Networks (WSNs) play a crucial role in this communication era because they have the ability to real time monitoring and controlling the physical environment from remote locations. Though networked sensors has the advantage to improve the accuracy of information obtained from the network by proper coordination and collaboration between sensors, communicating information between the networked sensors consumes more energy than processing the same. Sensors are deployed in an ad - hoc manner in the area of interest to monitor events and gather data about the environment. They have the ability of sensing, data processing [1] and communicating with each other in the network environment. Furthermore, the major concern is, these networks are unattended after deployment and the sensor nodes are battery operated, often limiting available energy. This demands innovative design techniques and communication algorithms to utilize the limited energy source efficiently in order to extend the network lifetime. The job of developing a generic protocol framework for Wireless Sensor Networks (WSN) is challenging because, limited processing capabilities, memory and power supply [2, 7] of sensor node make it difficult to cater requirements of versatile applications of these networks. This has forced researchers to dissect the traditional layered protocol design approach. As a result cross layer protocols and architectures that attempt to exploit richer interaction among communication layers to achieve performance gains with limited resources have emerged. From among the cross layer protocols proposed in the literature Low Energy Adaptive Clustering Hierarchy (LEACH), is well referred protocol architecture for WSN. WSNs are ad hoc networks where each node has the recent advancement of Micro-Electro-mechanical (MEMS) technology including sensors, actuators and RF communication components. Sensors nodes are randomly dispersed over the area of interest, capable of RF communication, contain signal processing engines to manage the communication protocols, and data processing tasks. Due to all these attractive characteristics, sensor networks are used in numerous areas of application e.g. large scale environmental monitoring, medical monitoring and security management. The goal is to enable the scattering of thousands of these nodes are typically battery-powered, replacing and recharging batteries are often not possible. So reducing the energy consumption is an important design consideration for sensor networks. For these reasons, many end-to-end communication protocols that have been proposed for ad hoc networks in recent years are not suitable for WSNs. The main problem in using these networks is limited battery life. This is due to fact that the size of a sensor node is expected to be small and this leads to constraints on size of its components i.e. battery size, processors, data storing memory, all are needed to be small. So any optimization in these networks should focus on optimizing energy consumption in the network [3].

II. WIRELESS SENSOR NETWORK

A wireless sensor network is a collection of independent low cost sensors randomly deployed to monitor environment conditions in remote or hostile environment. A wireless sensor network is a heterogeneous network composed of a large number of tiny low-cost devices, denoted as nodes (or motes), and one or few general purpose computing devices referred to as base stations (or sinks). A general purpose of the WSN is to monitor some physical phenomena (e.g.,

temperature, barometric pressure, light) inside an area of deployment. Nodes are equipped with a communication unit (e.g., radio transceiver), processing unit, battery and sensor(s). Nodes are constrained in processing power and energy, whereas the base stations have laptop capabilities and not severely energy resources. The base stations usually act as gateways between the WSN and other networks (e.g., Internet). It consists of a number of sensor nodes (few tens to thousands) working together to monitor a region to obtain data about the environment. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. A Wireless Sensor Network is a network of sensors that, continuously observes a physical phenomena, processes observed data locally and wirelessly communicates information to central Base Station (BS). The BS analyzes information and initiates suitable response if required. The main objective of protocol design of this kind of network is to reliably detect/approximate observations from the combined data provided by sensor nodes and respect their limited energy, memory, and computing capabilities. For most of the networks, protocols are independently developed and optimized for different communication layers, i.e., application, transport, network, data link, and physical layers. Such protocols exhibit very high performance in terms of metrics specific to each of the individual layers, but they are not jointly designed and optimized to maximize network performance in general while reducing the network energy consumption.

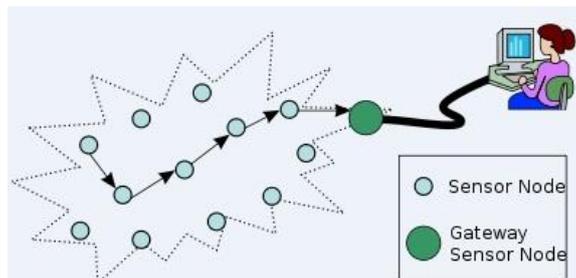


Fig.1. A Multihop Wireless Sensor Network

III. LEACH (LOW ENERGY ADAPTIVE CLUSTERING HEIRACHICAL) PROTOCOL

LEACH is the first and most popular energy efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption and also to increase the lifetime of the network [2, 4]. The current researches, the clustering routing technology is the most widely influential. Low-Energy Adaptive Clustering Hierarchy (LEACH) is a classical clustering routing in wireless sensor networks [5].

LEACH performs self-organizing and reclustering functions for every round. Sensor nodes organize themselves into clusters in LEACH routing protocol [8]. Leach partitions the nodes into clusters and in each cluster are a dedicated node and the cluster head [9,10] is responsible for creating and maintaining the TDMA schedule, all other nodes of a cluster are member nodes. To all the member nodes, TDMA slots are assigned, which can be used to exchange the data between the member and cluster head. With the exception of their time slots, the member can spend their time in sleep state. The cluster head aggregate the data of its members and transmits it to the sink node or to the other nodes for further relaying. Since the sink is often far away, the cluster head must spend significant energy for this transmission. For a member, it is typically much cheaper to reach to reach the cluster head than to transmit directly to the sink. The cluster head role is energy consuming since it is always switched on and is responsible for the long- range transmissions. If a fixed node has this role, it would burn its energy quickly, and after it died, all its members would be “headless” and therefore useless. Therefore this burden is rotated among the nodes. Specifically each node decides independent of other nodes whether it becomes a cluster head and therefore there is no signalling traffic related to cluster head election. This decision is taken into account when the node served as cluster head the last time, such that a node that has not been a cluster head for a long time is more likely to elect itself than a node serving just recently [6]. The Protocol is round based, that is, all nodes make their decisions whether to become a cluster head at the same time and the non clusters head nodes have to associate to a cluster head subsequently. The non cluster heads choose their cluster head based on received signal strengths. After the clusters have been formed, each cluster heads picks a random CDMA code for its cluster, which it broadcast and which its member nodes have to use subsequently.

The Protocol is organised in rounds and each round is subdivided into a set up phase and a steady-state phase. The set up phase starts with the self election of nodes to cluster heads. In the following advertisement phase, initially, when clusters are being created, each node decides whether or not to become a cluster-head (cHead) for the current round. This decision is influenced by the number P (optimal cluster-heads) and also whether it has been the cluster-head in last 1/P rounds. At the start of each round, the nodes chose a random number between 0 and 1. If the value of chosen number is less than a threshold value T (n), then the node becomes the cluster head. Value of T (n) is calculated as:

$$T(n) = \begin{cases} \frac{P}{1 - P(r \bmod 1/P)} & n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where r is the current round in progress and G is the set of nodes that have not been cluster-heads in the last 1/P rounds. It is clear that as the number of rounds increases, the value of T (n) also increases. Thus, during round 0 all nodes have equal probability (=P) of becoming the cluster heads. Nodes chosen as cluster heads during round 0 can't be made cluster heads for the next 1/P rounds. After 1/P-1 rounds, T (n) = 1 and after that the cycle will get repeated. After this,

the cluster heads inform their neighbourhood with an advertisement packet. The non cluster head nodes pick the advertisement packet with the strongest received signal strength. In the following cluster set up phase, the members inform their cluster head, again using a CSMA protocol. After the cluster set-up phase, the cluster heads knows the number of members and their identifiers. It constructs a TDMA schedule, picks a CDMA cod randomly and broadcast this information in the broadcast schedule sub phase. After this, the TDMA steady-state phase begins. Fig. 2 shows the organisation of LEACH rounds.

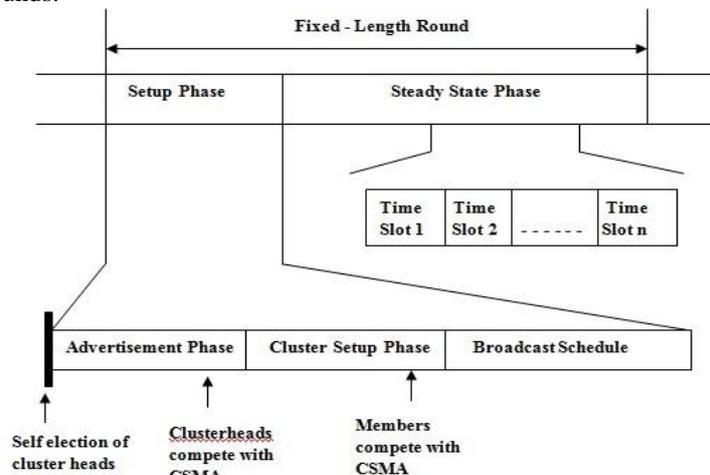


Fig.2. Organisation of LEACH rounds

A) ALGORITHM for LEACH (LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY)

The algorithm is described as below:

1. Initialize $r = 0$ and $P = 0.05$
2. Determine the threshold value $T(n)$ using equation:

$$T(n) = \begin{cases} \frac{P}{1 - P(r \bmod 1/P)} & n \in G \\ 0 & \text{otherwise.} \end{cases}$$

3. For each cluster node i , determine value of $cHead$.
 - a) If $cHead=0$, it denotes that this node has not been cluster head for last $1/P$ rounds.
 - i) Choose a random number num
 - ii) If $(num < T(n))$ set $cHead = 1$ and $is\ Head = 1$. Send out a message advertising node i 's status to all nodes.
 - iii) Otherwise exit
 - b) If $cHead=1$, exit
4. for each node i , receive all advertisement messages
 - a) if $(is\ Head=0)$ choose the node that had the best signal strength. Transmit an acknowledgement to this node.
 - b) if $(is\ Head=1)$ discard all the message received.
5. for each node i , receive all acknowledgements and prepare a TDMA schedule. Transmit the schedule.
6. for each node i , transmit the data at the given slot and sleep.
7. After pre-determined t , $r = r+1$ and $is\ Head=0$
Repeat the procedure.

IV. ADVANCED LEACH (LOW ENERGY ADAPTIVE CLUSTERING HEIRACHICAL) PROTOCOL

In advanced leach, cluster head and vice cluster heads are selected to send the data to base station. Due to over loading of receiving, gathering and sending the data, cluster head dies early. If cluster head dies then the secondary or the vice cluster head is selected to send the data to the base station. The vice cluster head does the same role as that of the cluster head. Three factors are there for the selection criteria i.e. minimum distance, maximum residual energy and minimum energy. Distance between cluster head and node is calculated by the received signal strength to the each node. Higher the signal strength closer is the cluster head and hence less is the energy required. Table 1 shows the input test network parameters for advanced LEACH.

Table 1 Input test network parameters for advanced leach

Parameter	Variables
Node	100
Network size	100m*100m
BS location	(50,50)
Node energy	0.5J

Node position	Based on network topology
No of rounds executed	5000
Energy dissipation for transmission	50*0.000000001 j/bit
Energy dissipation for reception	50*0.000000001 j/bit
Probability that a node can be cluster head	0.2
Data aggregation energy	5*0.000000001 j/bit

V. PURPOSED TECHNIQUE: IMPROVEMENT OF ADVANCED LEACH (LOW ENERGY ADAPTIVE CLUSTERING HEIRACHICAL) PROTOCOL

We propose techniques to overcome drawbacks of LEACH and Advanced LEACH. In our proposed work, two improvements have been done in setup phase, to improve the Energy dissipation.

A) CLUSTER HEAD SELECTION

There are various ways to select the cluster head. In leach the cluster head is selected in random manner and the node which has been elected for the cluster head, can't participate for $1/p$ rounds where p is the probability of cluster head selection. Threshold value of each round is compared with the random no given to each node in a round. If the random value of a node is greater than that of the threshold, that node is elected for the cluster head. This concept leads to the situation in which two or more consecutive nodes may become cluster heads and the clusters thus formed may overlap. Thus by overlapping of clusters, the energy dissipation may occur fast and the nodes get died.

In our work cluster head is elected on the basis of $E_{CURRENT}$ i.e. current energy of the node and the E_{AVG} - average energy of each round. 2nd factor which is considered is the distance of the node from the sink and the average distance of the total nodes from the base station.

If $E_{CURRENT} > E_{AVG}$ and $d_{N-BS} < d_{AVG}$ then that node will be treated as cluster head. Suppose if the total no of nodes under this condition are less than that of the cluster head probability then $E_{CURRENT} > E_{AVG}$ condition is checked for other nodes. In this way the cluster head is selected. Fig. 3 shows the cluster head selection.

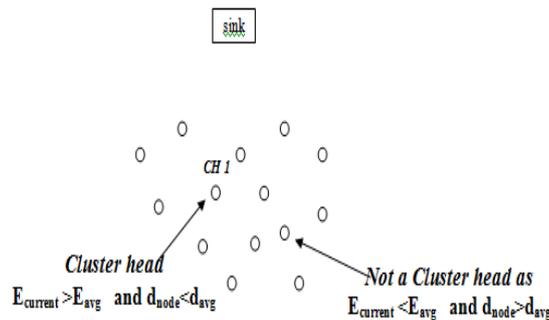


Fig.3. Cluster head selection

B) CLUSTER SELECTION

Cluster selection is one of the important facets which can be considered to minimize the energy loss per round per node. Cluster is always elected by the non cluster head nodes and thus forms the cluster. In leach the cluster is generated by the minimum distance parameter. After the cluster head selection, the advertisement phase occurs. In this phase cluster head sends the information and id of its own to every node and hence the node responds to that cluster head, which is near to that node. But suppose if the node is near to sink and cluster head is very far to sink, then that node will not directly send its data to the base station rather it will first select that cluster head and then will send the data, which leads to the more energy loss. This is one of the main disadvantages of the leach and advanced leach.

Our work overcomes the above disadvantage by considering both three main parameters. First parameter is d_{MIN} - minimum distance between cluster head and node, second parameter is the d_{CH-BS} - distance between cluster head and sink and the third parameter is the d_{N-BS} - distance between node and the base station.

Firstly, the min distance from node to cluster head is found. After that, the comparison of 2nd parameter i.e. distances between cluster head and sink and 3rd parameter i.e. distance between node and the base station is done. If $d_{N-BS} > d_{CH-BS}$ statement is true, then node selects that cluster head and the cluster head aggregates the data from its member nodes and then sends the data to the sink.

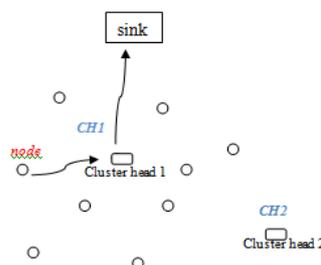


Fig.4. Cluster selection

But if the above statement is false then another cluster head having the 2nd min distance is calculated and same conditions are applied.

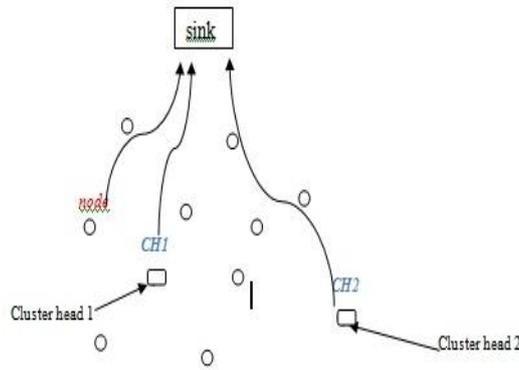


Fig.5. Node directly sends data to base station

If again the statement falls false, 3rd min distant cluster head is selected and so on till the last cluster head. But if for every cluster head statement comes false, the node then directly sends its data to the base station and does not select any cluster head which is shown in Fig 5.

VI. SIMULATION AND RESULTS

All the simulation of purposed work is done in MATLAB. In the simulation we compare LEACH, Advanced LEACH with improvement LEACH.

Simulation results in fig. 6 shows that in basic leach, first node dies in round 277. In advance leach, first node dies in 925th round and in our proposed work, first node dies in round 1675, shows that simple leach has better result for FND.

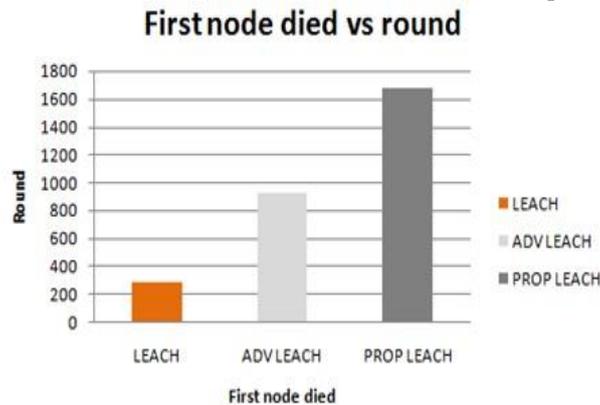


Fig.6. First Node Died

Fig.7 shows that proposed work has better results and the half node dies in the round 2176. In adv leach, half node dies in 1797th round and simple leach reaches up to round 687.

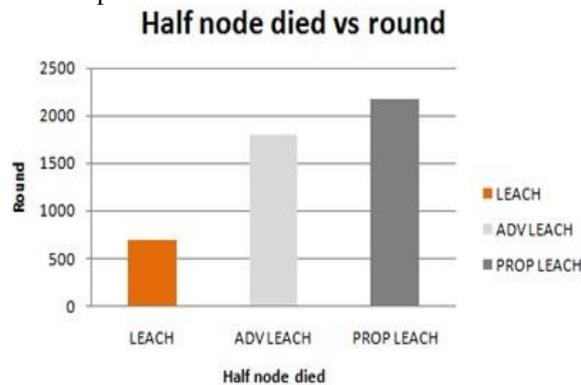


Fig.7. Half Node Died

All the above results i.e. for first node die, half node die and last die has better results for the improved advanced leach. From fig. 9 shows the comparison of LEACH, advanced LEACH and Improvement of Advanced LEACH for the alive nodes and it is observed that improvement in advanced LEACH has better result as compare to LEACH and Advanced LEACH.

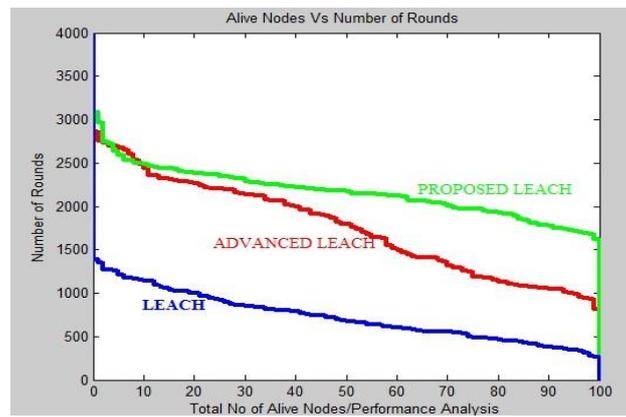


Fig.9. Graph Showing the comparison for LEACH, Advanced LEACH and Improvement of Advanced LEACH for alive nodes

VII. CONCLUSIONS

In order to reduce the energy consumption, a better approach is used to reduce the energy consumption in wireless sensor network. In this paper, we have discussed about the basic LEACH, Advanced LEACH and then Improvement of Advanced LEACH. The Improvement in advanced LEACH allows the node to select that cluster head which is near to sink, which increases the life time of the nodes. Our simulation results are based on Matlab as mentioned above and from simulation results it is clear that the purposed improvement in the advanced leach has far better results than simple LEACH and advance LEACH for 1st node die, half node die and all nodes dies.

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