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RESEARCH ARTICLE

Novel Clustering Approach to Reduce Energy Consumption in Wireless Sensor Network based on LEACH

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Abstract- Energy efficiency is recognized as a critical problem in Wireless Sensor Network (WSN).The routing in the WSN consumes more amount of energy, thus routing protocol for communication must be energy efficient. In energy efficient routing protocols the energy efficient path depletes quickly and an unbalanced distribution of energy among nodes may cause death of node or network. LEACH (Low Energy Adaptive Clustering Hierarchy) is a hierarchical-based routing protocol which uses random rotation of the nodes required to be the cluster-heads to evenly distribute energy consumption in the network. This paper proposes an improvement on the LEACH routing protocol to decrease energy consumption and prolong network lifetime. In this CH selection is based on residual energy and threshold value of nodes. Simulation results show better working of nodes in the network through the proposed approach.

Keywords: WSNs, Homogeneous; Routing, Networks, Energy Efficiency, Network Lifetime, LEACH.

I. INTRODUCTION

Wireless Sensor Network (WSN) has become one of the cutting edge technologies for low power wireless communication. Wireless Sensor Network consists of nearly about hundred and thousands of small tiny devices, which are distributed autonomously, called as sensor nodes. Each and every node in a sensor network consists of one or more sensors, a radio transceiver or other wireless communication devices, a very small microcontroller and the energy source. These nodes can forward the information and cooperate with each other to accomplish some specific tasks. These nodes used to monitor physical or environmental conditions such as temperature, acoustics, sound, pressure, vibration and motion. Data collection process can be continuous, event driven or query based [2]. In most of the cases of WSN applications, energy plays an important role as routing in WSN consumes more amount of energy comparatively. Thus preserving the consumed energy of each node must consider while making a routing protocol for Wireless Sensor Network (WSN).

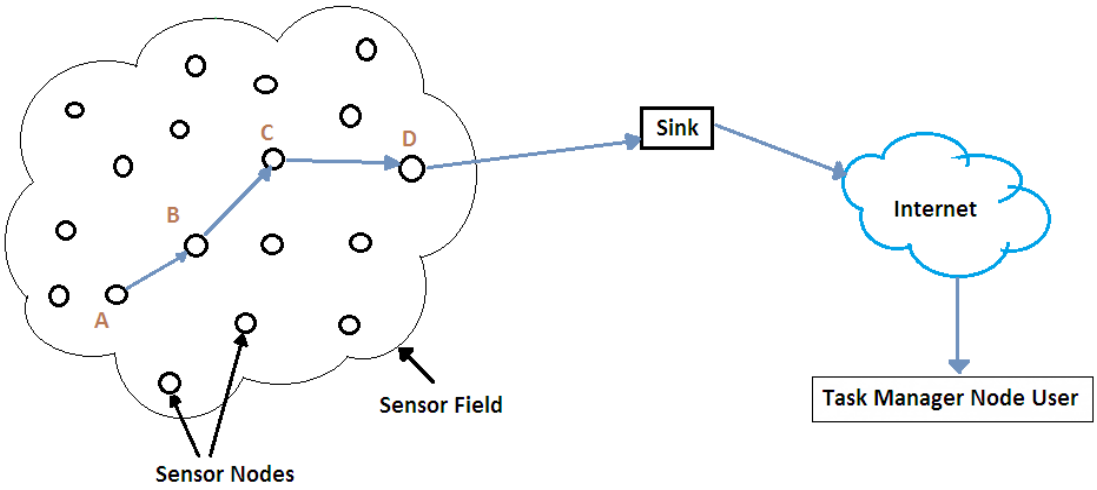

Figure 1: Basic Architecture of Wireless Sensor Network

The main objective of routing protocol is to utilize network efficiently. Routing protocol is categorized into three parts based on the structure of network, which are flat routing; Hierarchical routing and location based routing. In flat routing all the sensor nodes of the network performs the same functionality and works together. The directed diffusion protocol and Sensor Protocol for Information via Negotiations (SPIN) protocol are some of the examples which belong to this flat routing. In the hierarchical routing, the whole network is partitioned into many clusters for the improvement of scalability and utilizations of the energy of the nodes efficiently. Low Energy Adaptive Clustering Hierarchy (LEACH) protocol belongs to hierarchical routing. In location based routing, each and every node's location is monitored continuously, for finding the routing path for the communication purpose. Global Positioning System (GPS) devices are used along with network nodes. Geographic Adaptive Routing (GRA) belongs to location based routing [3].

LEACH is Low Energy Adaptive Clustering Hierarchy. It is most popular routing protocol as it uses the cluster based routing for minimizing the energy consumption by evenly distributing energy consumption in the network [1]. This paper proposes an improved LEACH protocol that will improve the energy consumption and make it energy efficient.

II. LEACH PROTOCOL

LEACH protocol is the hierarchical cluster based routing protocol, proposed by Wendi. B. Heinemann, et al. for wireless sensor network. It divides the nodes into clusters with a dedicated node in cluster with extra privileged called CH (Cluster Head). LEACH selects the CH randomly and assigns to the nodes by following the policy of round robin management to ensure fair dissipation of energy between nodes. The CH carries out multiple tasks, such as periodic collection of data from the members of the cluster, aggregation of data to remove redundancy among correlated values, transmission of the aggregated data directly to the base station through a single hop method, creation and advertisement of a TDMA schedule. The CH is then responsible for creating and manipulating the TDMA (Time Division Multiple Access) schedule in order to reduce the amount of information transmitted to the BS (Base Station). The CHs broadcast the schedule to their corresponding cluster members. For reducing the likelihood of collisions among sensor nodes, LEACH nodes use a Code Division Multiple Access (CDMA) based scheme for communication [4].

The basic operation of LEACH is divided into two phase [5]:

1. Setup Phase
2. Steady State Phase

A. Setup phase

Each node decides independently that it will become a CH or not. The first phase i.e. Setup phase consist of three steps:

(i) Cluster-head advertisement.
(ii) Cluster set-up.
(iii) Transmission schedule creation.

B. Steady State phase

The second phase, the steady-state phase, focuses on

(i) Data transmission to cluster heads,
(ii) Signal processing
(iii) Delivery to the base station.

In accordance to prove the function or operation of our proposed protocol we used first order radio model equation, by making the assumption about the radio channel being symmetric, which provides us the meaning that energy will used as in equal amount when transmission takes place between two nodes; a node A sends data to node B and a node B sends data to node A with a given signal to noise ratio [4].

Collection of data in the cluster is performed periodically. Then, all data is gathered by the cluster head and then CH aggregates those data to release the redundancy and further forward these aggregated data to the base station. Assumptions which are taken by LEACH protocol may cause many real-time system's problems. Assumptions taken by LEACH are as below [4]:

- All nodes can broadcasts the data to the sink with sufficient power if needed.
- To having the enough computational power each node should supports different MAC protocols.
- Nodes have data constantly that is waiting to be sent.
- Nearer situated nodes may have data correlation.
- Since the first node dies, the system becomes unstable.
- It assumes that the amount of energy of rest of the nodes will be same in selection round.

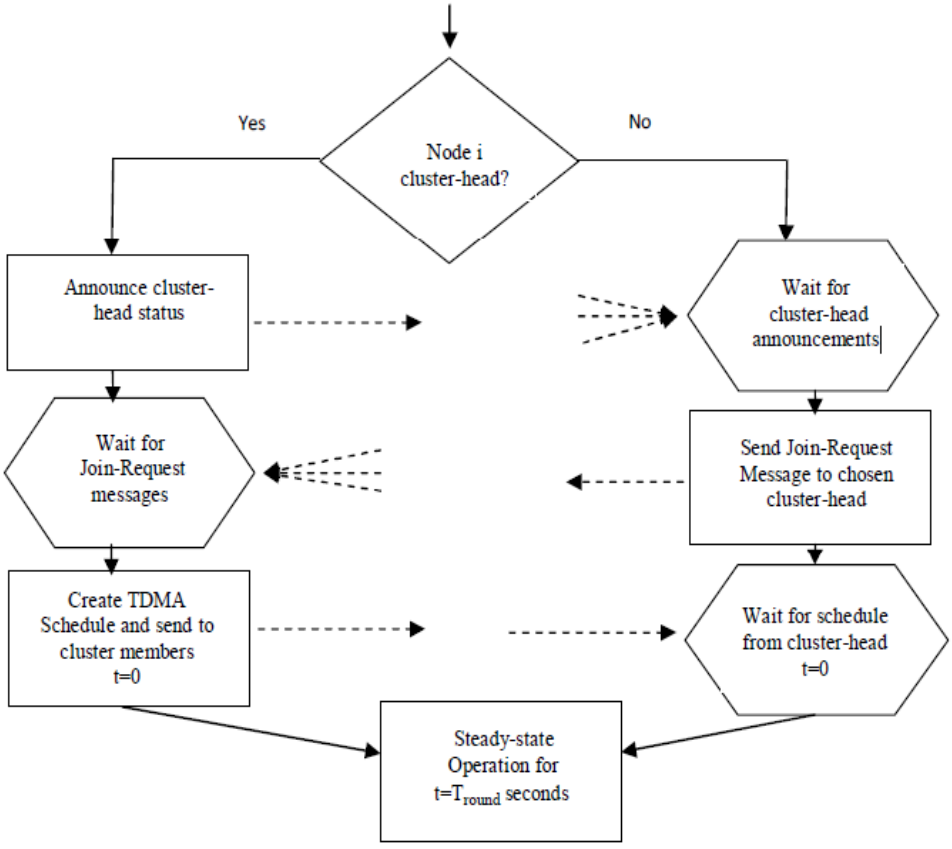

Figure 2: Flowchart of the distributed cluster formation algorithm [1]

Advantages of LEACH

- It comprises data unification into routing protocol.
- Over direct communication it is 4-8 times valuable to extending enlarge the lifetime of network.
- LEACH performs random selection of some sensor nodes and makes it as cluster-heads so that it can assign the energy load between the sensors in the network.
- Minimization of energy spending of intra-cluster and as well as inter cluster network.
- Reduction Number of information packet.

Drawbacks of LEACH

- Cluster head selection is random so it is possible that node with fewer energy may be chosen and that makes the node die earlier.
- Single hop. It may escort to large number of clusters.
- CHs are un-uniformly distributed in the network. .
- There is a lesser amount of number of data signals received at BS.
- Uniform distribution of sensor nodes in the given area.
- It does not work well with the applications that require large area coverage along with multi-hop inter-cluster communication.

III. RELATED WORK

A. Enhanced LEACH (E-LEACH)

In Enhanced LEACH protocol is divided into rounds and each round is divided into three phases Setup phase, Pre-Steady phase and Steady State phase. In setup phase Enhanced LEACH starts with the cluster setup phase. During this setup phase the cluster head nodes are randomly selected from all the sensor nodes and several clusters are constructed dynamically.

In Pre-Steady phase, CH tries to elect cluster member node that can handle the aggregation processes through all frames in the round. If such node doesn't exist than cluster head will handle the aggregation process for frames. In Steady State phase, the operation is divided into frames; in each frame cluster member nodes send their data to the aggregation node according to their time slots. The aggregation node must keep its receiver on to receive all the data from the nodes in the cluster. When all the data has been received, the aggregation node sends it to the base station after performing data aggregation [6].

B. LEACH Protocol with Two Levels Cluster Head (LEACH-TLCH)

LEACH-TLCH is an improved one based on LEACH Protocol. In this method of cluster-head selection and clusters forming are same as LEACH protocol. If a cluster head's current energy is less than the average energy, or the distance between the cluster head and base station is longer than the average distance, then the common node with maximum energy in this cluster will be selected as the secondary cluster head (CH). The secondary cluster head is responsible for receiving and fusing data collected from the member nodes and sending them to its cluster head, the cluster head is only responsible for transporting data to base station. In a cluster without secondary cluster head the cluster head is responsible for collecting data from the member node and send them to base station after the data was fused [7].

C. Quadrant–LEACH (Q-LEACH)

In this approach sensor nodes are deployed in the territory. In order to acquire better clustering we partition the network into four quadrants, by doing such partitioning better coverage of the whole network is achieved. Additionally, exact distribution of nodes in field is also well defined. It represents an idea of efficient clustering mechanism which yields significantly for better coverage of whole network. Partition of network into quadrants yields in efficient energy utilization of sensor nodes. Through this division optimum positions of CHs is defined and transmission load of other sending nodes is also reduced. In Q-LEACH network is partitioned into sub-sectors and hence, clusters formed within these sub-sectors are more deterministic in nature. Therefore, nodes are well distributed within a specific cluster and results in efficient energy drainage. Concept of randomized clustering (same as LEACH) for optimized energy drainage is applied in each sector [8].

D. Centralized- LEACH (C-LEACH)

LEACH doesn't take the responsibility of the placement and the number of cluster heads. In this an enhancement over the LEACH was proposed. The protocol is known as the LEACH-C which uses a centralized clustering algorithm and after that following the same steady state phase as the original LEACH. At the time of set-up phase of LEACH-C, each and every node sends its current location and residual energy information to the BS. Once the energy cost of communication with BS become higher than energy cost of cluster formation. LEACH-C no longer performs good performance and dependence of BS location becomes a major disadvantage [9].

E. Advanced Low Energy Adaptive Clustering Hierarchy (A-LEACH)

In LEACH the CH expends greater amount energy than any other node of the cluster. Therefore, energy conservation and reliability of transfer of data is improvised in LEACH-A. Here the data is worked on using a mobile agent strategy which is derived from LEACH. It is a heterogeneous energy protocol, which is suggested to reduce the node's failure rate and to elongate the life of the first sensor node. This is called stability period [10].

IV. PROPOSED WORK

In LEACH protocol, due to the random procedure of cluster formation, the energy is varying of cluster head in the cluster. Cluster head has many responsibilities in the cluster so it is more important for the cluster head to stay alive for a long time in the cluster if cluster head died early then the entire network will down. To make stay cluster head alive for a long time we can consider possible ways like: if cluster head consumes less energy or second option is, to make a selection of cluster head in a way so that it could be stay alive for a long time. Here we use second option that is make selection of cluster head by measuring its residual energy at the end of each round. If the condition regarding to residual energy will be satisfied then only current node is allowable to become a cluster head.

During establishment of cluster, cluster head generates threshold value and as well as each node call random function and generate its random values and compare that generated value with threshold values, here by using another parameter, residual energy supports to reduce the energy consumption. In each round residual energy becomes dissimilar for different cluster head. So by applying new parameter in the existing protocol to elect the cluster head provides us better results than the original LEACH protocol. Work flow of proposed methodology is shown as below:

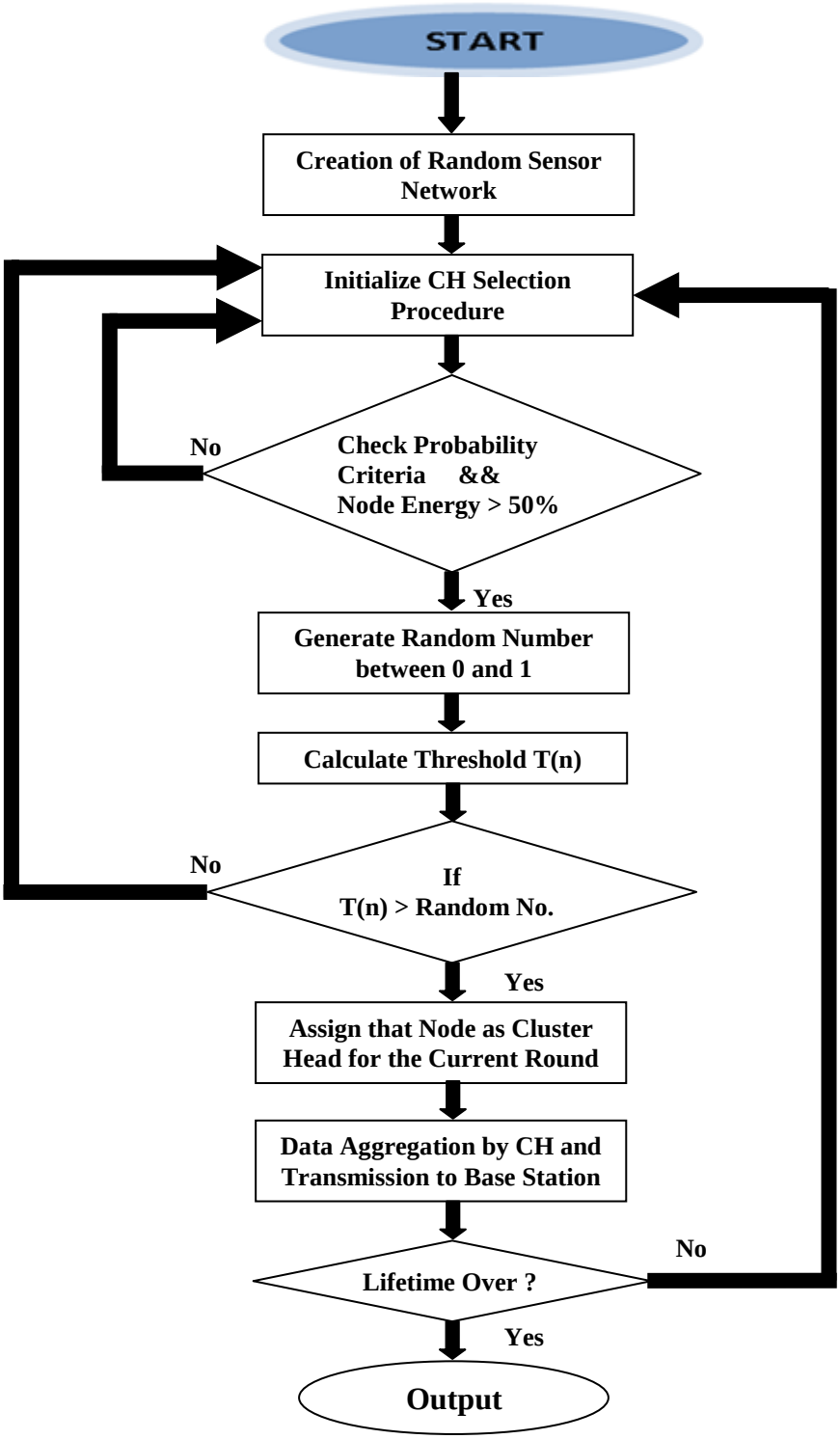

Figure 3: Work flow of proposed method

V. SIMULATION RESULTS

Network simulator provides proper environment for generating ad-hoc network or any wireless network. The experiments were carried out using the network simulator (ns-2.27). NS simulator is based on two languages, a C++ object oriented simulator and OTCL (an object oriented extension of TCL) interpreter. It has two class hierarchies, the compiled C++

hierarchy and the interpreted TCL hierarchy having one to one correspondence. The scenarios developed to increase the network lifetime as well as to reduce the dissipation of energy by every node in the network. In our simulation 100 nodes are randomly distributed within the area of 100m * 100m and location of the sink(base station) is at X-50, Y-175. To reduce the energy dissipation, modification is done in the leach protocol and results are given below,

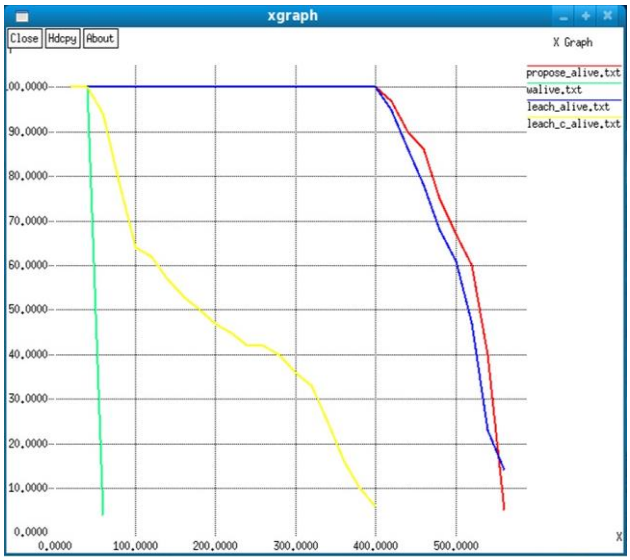

Figure 4: Time v/s No. of Nodes Alive

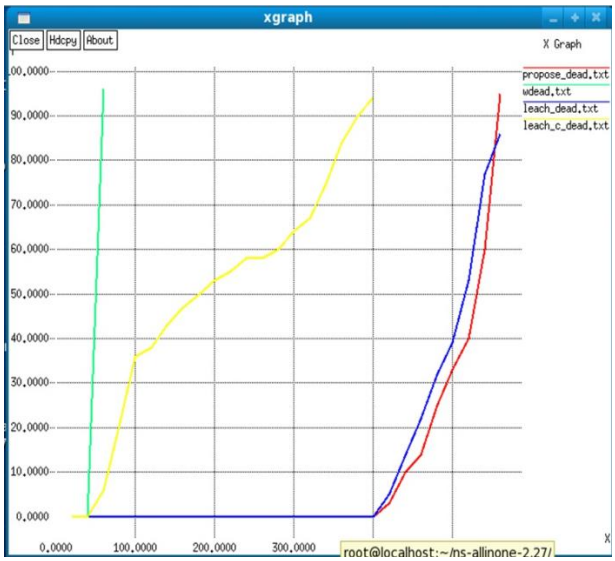

Figure 5: Time v/s No. of Nodes Dead

Figure 4, shows better performance of proposed LEACH. We consider four different protocols which are LEACH(Blue Line), LEACH-C(Yellow Line), LEACH without Cluster head(Green Line), and Modified LEACH(Red Line). Simulation of Modified LEACH runs for long time in comparison to the other protocols which shows proposed protocol's lifetime will be increased. In figure 4, the total number of alive nodes is shown in which we can see our proposed LEACH gives better result than other. In figure 5, we can see the result of dead, initially up to 400 seconds LEACH and proposed LEACH shows better result all nodes are alive in the network and then there is a minor difference between them but again here Modified LEACH performs better among all. Algorithm shows constant and steady result for certain time duration. At a certain point, the graph shows abrupt decrease. In Modified leach nodes become dead after a long time so network is not get down in a short time.

In compare of others, nodes are staying alive for a long time in Modified LEACH. Here we consider four different protocols and comparison of them is clearly shown in these four graphs. In simulation study we used four performance matrices which are: ALIVE NODE, DEAD NODE, ENERGY, and DATA PACKET.

A. Simulation Parameters

Parameters	Value
Simulation Area	100*100 m
Number of Nodes	100
Simulation Time	600 s
Position of the sink node	X-50,Y- 175
Initial energy	2 Joules
Length of data packet	1000 bytes
Transmitter/ receiver Electronics	50 nJ / bit

After adding our new parameter which is Residual Energy in existing LEACH protocol, performance rises up. In figure 6, red line shows better result by Modified LEACH. It decreases the amount of energy dissipation. We considered the comparison of LEACH with LEACH-C because LEACH-C is centralized algorithm so that we can make better comparison of it and existing LEACH is distributed. Another point is here in the graph we also consider one protocol is without cluster head which shows very worst result in figure 6 because without cluster head in the network nodes cannot able to send data efficiently for a long time to the base station. They are randomly located in the network and all have to pass their data separately so those

consumes more energy which are located more far away from the sink and for that reason entire network goes down very rapidly in figure 6 we can see green line shows worst result which represents protocol without cluster head.

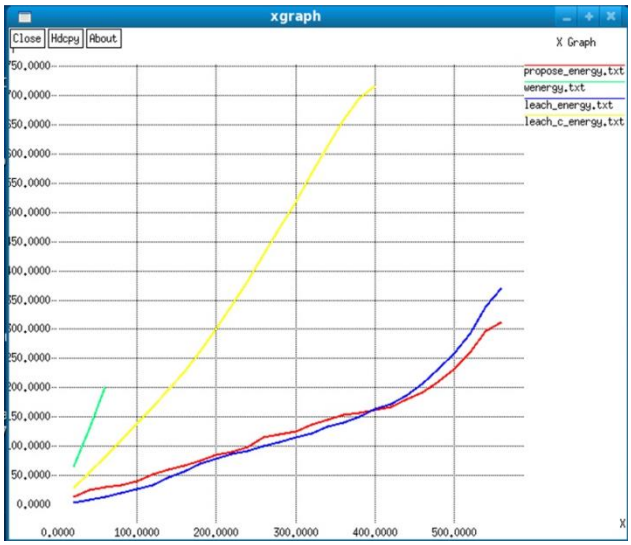

Figure 6: Time v/s Energy Dissipation

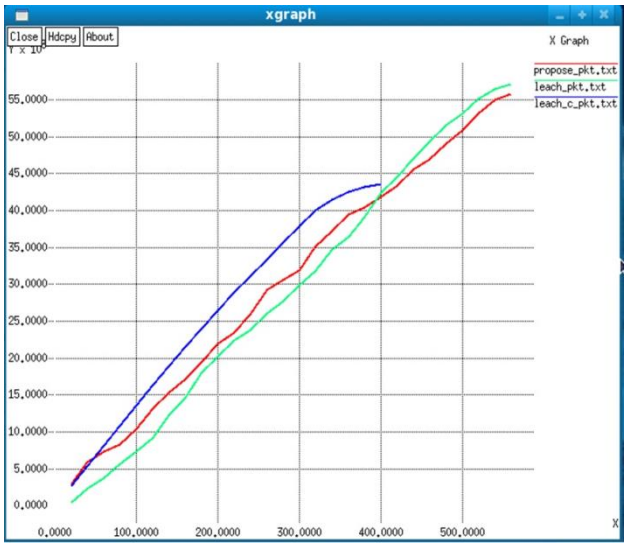

Figure 7: Time v/s Data Packets

Figure 7, represents result of only three protocols there is not any line of protocol without cluster head, because working of existing LEACH supports hierarchical clustering and here without cluster head there isn't any clusters are formed in the network all the nodes are individually pass their data to the sink. So for that reason there isn't any data passed by the protocol without cluster head. Graph in figure 7 shows the comparison of the efficiency of sending packets of LEACH, proposed LEACH, and centralized LEACH. The graph expresses that the packet sending efficiency of proposed system is more than the existing system.

VI. CONCLUSION

In this paper, we have discussed conventional LEACH protocol for a Wireless Sensor Networks. This paper also gives brief introduction to the variants of LEACH protocol. Cluster heads in each round are selected proportional to their residual energy. The purpose of proposed approach is to reduce the dissipation of energy and to prolong the network lifetime by making changes in the Cluster Head election process. In all graphs we can see that energy dissipation is reduced and network lifetime is enhanced quite significantly when compared with other approaches i.e., LEACH-C, LEACH without cluster head, Proposed LEACH performs better. After Simulating we found out the better result of the proposed methodology in compare of existing LEACH.

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