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# IMPROVEMENT OF LEACH PROTOCOL FOR PROLONGING NETWORK LIFETIME IN HETEROGENEOUS WIRELESS SENSOR NETWORKS

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***Abstract:*** *Wireless Sensor Network (WSN) consists of hundreds or thousands of sensor nodes which have limited energy, computation and memory resources. WSNs are highly affected by the energy dissipation of the nodes. LEACH is a cluster based routing for sensor networks for efficient data collection problem where small numbers of clusters are being formed in a self-organized manner. In this paper the advancement of the LEACH protocol has been done for heterogeneous networks. .We have proposed a cluster based routing protocol for heterogeneous WSN in order to minimize the energy consumption and increase the network lifetime. Simulation results using MATLAB shows that the proposed Leach-heterogeneous system significantly reduces energy consumption and increase the total lifetime of the wireless sensor network.*

***Keywords:*** *LEACH, WSN, DBS, EESR, ESDC, BS, CH*

## 1. INTRODUCTION

The widespread advancement in sensor technology has made possible to have extremely small and low powered sensing devices equipped with programmable computing power, multiple parameter sensing and wireless communication capability. Also, low cost makes it possible to have a network of hundreds or thousands of sensors, thereby to enhance the reliability and accuracy of data and the area coverage. Wireless sensor networks offer information about remote structures, wide spread environment changes, etc. WSNs are ad-hoc networks comprised mainly of small sensor nodes with limited resources (low power, low bandwidth, and low computational and storage capabilities) and one or more base stations (BSs), which are much more powerful nodes that connect the sensor nodes to the rest of the world.

Wireless networks use some sort of radio frequencies in air to transmit and to receive data. Therefore, the wireless networks are formed of routers and hosts & the routers are responsible for forwarding packets in the network & hosts may be source or sink of data flows. Ideally, a cluster-based network can be partitioned into disjoint clusters and each cluster consists of one Cluster Head (CH) and multiple Member Nodes (MNs). CHs collect data from MNs and relay processed data to the Base Station (BS).For sake of energy efficiency, it is preferable to create stable and optimal number of clusters and dynamic Cluster Head selection and rotation is desirable over a static CH assignment. Also, CHs are expected to be distributed evenly in WSN . Therefore, a clustering scheme designed for large Wireless Sensor Networks (WSNs) should be distributed and employ dynamic Cluster Head selection, formation of cluster and periodic CH rotation.

Routing in the wireless networks are categorized into 3 types based on the structure of the network. They are Flat routing, Hierarchical Routing and Location Based Routing [1]. In flat routing, all the nodes of the network perform the same functionality and work together to collect/generate the data and routing to the destination. The Sensor Protocols for Information via Negotiation (SPIN) protocol and Directed Diffusion protocol belong to flat network routing. In the hierarchical routing, the entire network is divided into many clusters to improve the scalability and utilize the energy of the nodes efficiently. For Example LEACH routing protocol. In Location based routing, location details of each node are monitored continuously to find the routing path for the communication. Global Positioning System (GPS) devices are used along with network nodes. For example: Geographic Adaptive Routing (GRS). At present the research on wireless sensor networks has generally assumed that nodes are homogeneous. In reality, the homogeneous sensor networks hardly exist, even the homogeneous sensors also have different capabilities like different levels of initial energy and depletion rate. This leads to the research on heterogeneous networks where at two or more types of nodes are considered. However the most researchers prevalently assume that the nodes are divided into two types with different functionalities, normal nodes and advanced nodes. The powerful nodes have more initial energy and fewer amounts than the normal nodes and they act as clustering heads as well as relay nodes in heterogeneous networks. Moreover they all assume the normal nodes have identical length data to transmit to the base station. In [5], we have researched a heterogeneous sensor networks with two different types of nodes that they have same initial energy but different length data to transmit. Basic description of LEACH protocol is explained in section 2.

## 2. LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) protocol is widely used for the wireless networks which contain small battery powered devices, for example Wireless sensor networks. When the battery power is drained in these devices/nodes then the network cannot be used and all the nodes spend most of the energy while transmitting the data. Therefore, to increase the lifespan of

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network, each of the nodes has to do only minimal work for transmitting the data. LEACH protocol is used in wireless sensor network because this protocol dissipates the energy in low level. In LEACH protocol, all nodes are grouped into the clusters, and in each cluster one of the nodes is assigned as a Cluster Head (CH). CH collects the data from the surrounding nodes and passes it to the base station. Usually, initial assignment of CH is random and the role of CH is rotated for every fixed duration so that each node will act as a CH at least once in its life span.

LEACH algorithm has two phases. They are set up phase and steady state phase. In Setup phase , a CH is chosen and steady state phase is used to maintain the CH during data transmission, therefore , a node n is selected as a CH in next round based on applying the following formula. If T(n) is 1 then the node n will be the CH in next round.

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

where, p is the probability of node n being selected as a CH, r represents the current round number and G is the set of nodes that are not selected as a CH in the last 1/p rounds.

Some of the unique features of the LEACH protocol are:

1. The coordination and control in the cluster is localized in the set up phase.
2. The role of the CH is rotated and randomized to distribute the energy requirements among the nodes of the network.
3. To reduce the total amount of data transmission, local compression techniques are used in the CH.
4. LEACH is suitable for homogeneous networks.

The structure of the cluster of nodes in a wireless network is given in fig.1 below. In this figure the non-cluster nodes are represented in blue color, these nodes send the data to the corresponding cluster head and CH forwards to the base station after performing aggregation or data fusion [3]. Cluster head allots the time intervals to the cluster member nodes so that non cluster nodes can transmit the data to the bases station in the assigned schedule. TDMA schedule is maintained by CH.

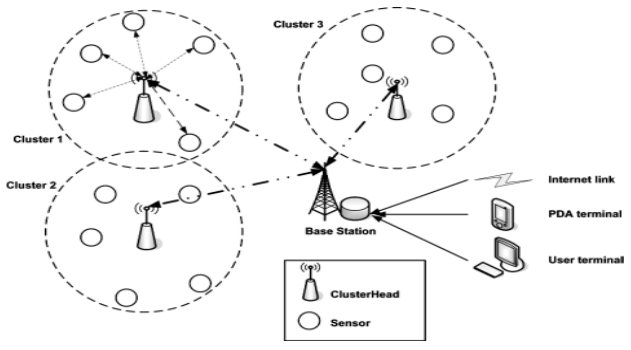


**Figure 1:** General Sensor Network Architecture

Some of the limitations of LEACH routing protocol are:

1. Selection of CH is done randomly and does not consider the consumption of the energy. The possibility of selecting as a CH is equal to all the nodes.
2. LEACH clustering does not cover the entire network area.
3. Distribution of the CH is not uniform. Some of the clusters may have CH at the edge of the cluster.

## 3. EXISTING SOLUTIONS

**Vikas Nandal and Deepak Nandal [1]** proposed a progressive algorithm for the cluster head selection. This proposed algorithm for cluster head selection is based on residual energy, distance & reliability. LEACH (low-energy adaptive clustering hierarchy) is well-known & divides the whole network into several clusters & run time of network is broken into many rounds. In each round, the nodes in a cluster contend to be cluster head according to a predefined criterion. As we have seen that CHs consume more energy in aggregating and routing data, therefore it's important to have an energy-efficient mechanism for CHs' election and rotation. The cluster head generation algorithm with the original LEACH clustering protocol can cause unbalanced distribution of cluster heads, which often leads to redundant cluster heads in a small region and thus cause the significant loss of energy.

**Alper[2]** explained Wireless sensor networks (WSN) are event-based systems based on the collaboration of several micro sensor nodes. Due to the limited Supply of energy at SN's, energy- efficient configuration of WSN's has become a major design goal to improve the lifetime of the network. Many of the clustering algorithms have been proposed as energy efficient, however, existing classical pre-event clustering solutions form clusters in the entire network unnecessarily that brings significant overheads in maintaining the network configurations. Unlike pre- event clustering, energy-efficient operation of WSN requires the event-to-sink directed clustering, which forms clusters when and where they are needed and in the direction of data flow from event location to sink. To best of our knowledge, energy-efficient clustering in WSN has not been studied from this perspective before. In this paper, a Event to-Sink Directed Clustering (ESDC) protocol for WSN is being proposed. ESDC realizes the energy efficiency in sensor network configuration by employing two techniques: (1) clustering of the nodes only within the event-to-sink data flow corridor to avoid unnecessary cluster formations, (2) the directional clustering to minimize the number of hops for data forwarding. Directional clustering process in ESDC also sets up the routing path of the event flows over clusters. The performance results revealed that the ESDC protocol achieves the energy-efficiency objectives and outperforms the existing conventional pre-event clustering approaches.

**Lindsey et.al [3]** has proposed PEGASIS (Power-Efficient Gathering in Sensor Information System), an optimal chain-based protocol that is an improvement over the LEACH protocol. In PEGASIS protocol, each of the nodes communicates only with a close neighbour and takes turns transmitting to the base stations, thus, reducing amount of

energy spent as per each round. Thus, simulation results shows that the PEGASIS performs better than LEACH by about 100 to 300% when 1%, 20%, 50%, and 100% of nodes die for different network sizes and topologies. In this paper, the model of proposed sensor network has the following properties:

•The base station (BS) is located or fixed at far distance from the sensor nodes.

• Sensor nodes are homogeneous in nature and energy constrained with uniform energy.

•No mobility of sensor nodes in the network.

Here BS is located at (25, 150), which is at least 100m from the nearest node. In each round of this data gathering application, all of the data from all the nodes need to be collected and transmitted to the Base Station, where the end user can access data. PEGASIS: Power Efficient Gathering in Sensor Information Systems directly to the BS. Since the Base Station is located far away, so the cost to transmit to the BS from any node is high and nodes will die very quickly. Therefore, an improved approach is to be used as few transmissions as possible to the BS and minimizes the amount of data that must be transmitted to the BS. In the sensor networks, data fusion helps in reducing the amount of data transmitted between sensor nodes and the Base Station. Data fusion helps in combining one or more data packets from different sensor measurements to produce a single packet. Due to this LEACH protocol is an elegant solution to this data collection problem, where small numbers of clusters are being formed in a self-organized manner. A designated node in each of the cluster collects and fuses data from nodes in its cluster and transmits the result to the BS. LEACH protocol uses randomization to rotate the cluster heads and achieves a factor of 8 improvement compared to the direct approach, before the first node dies. Further improvements can be obtained if each node communicates only with close neighbors, and only one designated node sends the combined data to the BS in each round.

**Parul Saini and Ajay K. Sharma[4]** stated that in recent advances, many routing protocols have been proposed based on heterogeneity with main research goals such as achieving the energy efficiency, lifetime, deployment of nodes, fault tolerance, latency, in short high reliability and robustness. In this paper, we have proposed an energy efficient cluster head scheme, for heterogeneous wireless sensor networks, by modifying the threshold value of a node based on which it decides to be a cluster head or not, called TDEEC (Threshold Distributed Energy Efficient Clustering) protocol. Simulation results show that proposed algorithm performs better as compared to others.

In this paper we proposed Threshold Distributed Energy Efficient Clustering (TDEEC) protocol which improves stability and energy efficient property of the heterogeneous wireless sensor network and hence increases the lifetime. Simulation results show that Threshold Distributed Energy Efficient Clustering (TDEEC) performs better as compared to SEP and DEEC in heterogeneous environment for wireless sensor networks.

**Haung Lu et.al [5]** in wireless sensor networks (WSNs), gathered sensed information, transforming the information data to the base station in an energy- efficient manner and lengthening of the network lifetime are important factors. A clustering is an energy efficient way that divides sensor nodes into number of clusters, where each of which has a cluster head node. The routing from cluster head nodes to the base station (BS), however has not been yet well studied. In this paper, we have studied the routing problems for wireless sensor networks (WSNs). Specifically, we proposed a novel energy efficient cluster-based routing algorithm for hierarchical WSNs, where we hierarchalized sensor nodes into different levels using the hop number of transmissions to the BS. Cluster head nodes are being selected autonomously and transmit data to the base station using multi-hop transmission technique, while the non-cluster-head sensor nodes communicate with cluster-head sensor nodes directly. Therefore, we conducted a comprehensive simulation experiments for the performance evaluation. Simulation results shows that for a large scale wireless sensor networks (WSNs), proposed algorithm performs better in terms of lifetime of the network. Moreover, algorithm mitigates the effect of self-induced black hole and balance the energy usage in the network by employing alternative sensor nodes.

**Hayoung Oh et.al [6]** proposed that the energy efficiency, low latency, scalability are the important requirements for the wireless sensor networks because sensor nodes are usually battery powered and have a high resource constrained, energy efficient routing with sensor routing scheme in which low latency, scalability in wireless sensor networks are very important. In this paper, we presented a sensor routing scheme, Energy Efficient Sensor Routing (EESR) that provides energy-efficient data delivery from sensors to the BS. This proposed scheme has divided the area into sectors and located a manager node to each sector. This manager node will receive the collected data from sensor devices in its corresponding sector and then transfers the data to the base station through the shortest path of the 2-dimensional (x, y) coordinates. In this process, we have used a relative direction based routing in the 2-dimensional (x, y) coordinates in wireless sensor networks. Through analysis and simulation, we showed that the proposed scheme achieves significant energy savings and outperform idealized transitional schemes (e.g. directed diffusion, broadcasting and clustering) under the investigated scenarios.

**M. S. Fareed et.al [7]** compared problems of cluster formation and cluster-head selection between different protocols for data transmission and aggregation. We focus on the two aspects of the problem: (1) how to guess number of clusters required to proficiently consumes available sources for a sensor network, and (2) how to select number of cluster-heads to cover up sensor networks more proficiently. A sensor in WSNs (Wireless Sensor Networks) can communicate directly only with other sensors that are within a radio range of a cluster. In order to enable communication between sensors not within communication range forms new clusters in distributed sensors. Different clustering algorithms such as LEACH, DEEC, and SEP have been proposed with the objective of energy minimization, route path selection and increase in

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connectivity and network longevity. LEACH and the similar protocols assume an energy homogeneous system where a node is not likely to fail due to failure in connectivity and packet dropping.

## 4. PROPOSED WORK

In this paper we are going to use clustering in heterogeneous nodes in WSN. Every cluster would have a leader, often referred to as the cluster head (CH).In addition to collect data from non-cluster nodes the cluster head will aggregate the data which is to be transmitted to base station here we will use multi hop routing technique to transmit data to the base station .In addition to just use shortest path (Energy Conserved) we will also prefer to transmit data through the other nodes which have high energy difference as compared to the nodes which is transmitting data to base station. The cluster membership may be fixed or variable. if we take 500 nodes. Then there would be 7-10% CH. We send data to the B.S, according to Sensor nodes energy level & we compare the energy level with the given threshold value and energy level of cluster head would be more than their sensor nodes which are in their group. We also check their distance from the Cluster Head, if they have shorter distance but not have sufficient energy then does not take that nodes .We also take the nodes previous history of their energy level. In short, some time we will prefer longer path to increase the network stable life time.

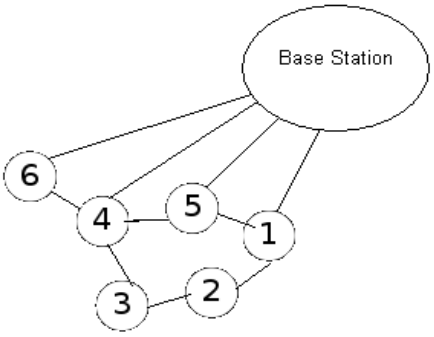


**Figure 2:** Connection Of Different Cluster Heads With Base Stations

In addition here we are considering heterogeneous nodes, so here all nodes doesn't having same energy .Initially a node chosen randomly as a cluster head will communicate with the base station .After some time this node will be replaced by some other node which will act as cluster head for a short period and this procedure will be repeated for the entire network. We will implement this with the concept of Max-Priority queue. The node having the highest energy will be chosen as cluster head. After some time when energy of cluster head is reduced we will call heapify procedure for the rearrangement of nodes such that the node having high energy will be placed as the root of heap. We will call the heapify procedure after a particular interval which can be defined by a particular threshold value.

Here we have considered a heterogeneous network. Heterogeneous network is one in which all the nodes doesn't have equal energy. Let us assume that the total number of nodes is n & m fraction of the nodes has α time more energy than the other nodes. They are called advanced nodes. For this,

Number of normal nodes = (1-m) x n
Energy per normal node = e0
Number of advanced nodes = m x n
Energy per advanced node = e0 x (1 + α)
Hence the total energy of the network =
((1-m) x n) x e0 + (m x n) x (e0 x (1 + α)

In our proposed algorithm 10% of nodes are having more initial energy than the other nodes in the wireless sensor networks. In this system, 50 nodes are having 1 Joule of initial energy out of 500 nodes in the network. The remaining 450 nodes are having 0.5 joules of initial energy. Depending upon application, the no. of advanced nodes can be increased thus; the total system lifetime can be increased significantly.

## 5. SIMULATION RESULTS

This section focuses on result and its analysis based on the simulation performed in Matlab 2008. To compare the performance of LEACH-CM and proposed algorithm, we considered the performance metrics for the round number when First node die, Last node die, varying message packet size and varying Base Station position.

The simulation parameters used in the experiment is shown in Table I. The nodes are randomly distributed between x=0, y=0 and x=200, y=200 with the base station (BS) at location x=50,y=50. The number of nodes in each protocol is assumed to be 500.

**TABLE 1:** SIMULATION PARAMETERS

| PARAMETERS | VALUES |
|---|---|
| Network Size | 200m *200m |
| No. of Nodes | 500 |
| Node Distribution | Nodes are uniformaly distributed |
| Initial Energy | 0.5J |
| Data Packet Size | 4000bits |
| BS Position | (50,50) |
| Eelec | 50nJ/bit |
| $Etx = Erx$ | 50nJ/bit |
| $\in fs$ | 10 pJ/bits/$m2$ |
| $\in amp$ | 0.0013 pJ/bit/$m4$ |
| EDA | 5nJ/bit |

To see the results of simulation of proposed algorithm in Matlab 2008, first of all run the proposed algorithm as shown in figure below:

**1) Network Lifetime (First node dead):** Since dead nodes are the reason for short network lifetime, we observe the result of first node dead. The base station position is at the centre with 4000 packet size. Data values are shown in Table 2 and figure 3 concludes that in the proposed algorithm, first node dies earlier in the network.

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**TABLE 2:** NETWORK LIFETIME (FIRST NODE DEAD)

| Simulation Run | Round Number when first node dies | |
|---|---|---|
| | LEACH-CM | Proposed Algorithm |
| 1 | 1030 | 489 |
| 2 | 1042 | 490 |
| 3 | 1049 | 491 |
| 4 | 1064 | 491 |
| 5 | 1051 | 490 |

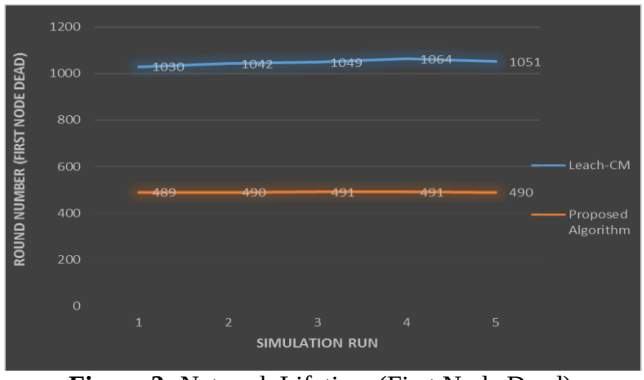


**Figure 3:** Network Lifetime (First Node Dead)

**2) Network Lifetime (Last node dead):** When all nodes are dead in the network, the lifespan of a network is over. Less the round number, lesser is the lifetime of network. The base station position is at the centre with 4000 packet size. Data values are shown in Table 3 and figure 4 concludes that in the proposed algorithm, last node dies later in the network.

**TABLE 3:** NETWORK LIFETIME (LAST NODE DEAD)

| Simulation Run | Round Number when Last node dies | |
|---|---|---|
| | LEACH-CM | Proposed Algorithm |
| 1 | 2247 | 3621 |
| 2 | 2540 | 5284 |
| 3 | 2464 | 5253 |
| 4 | 2601 | 5265 |
| 5 | 2542 | 5246 |

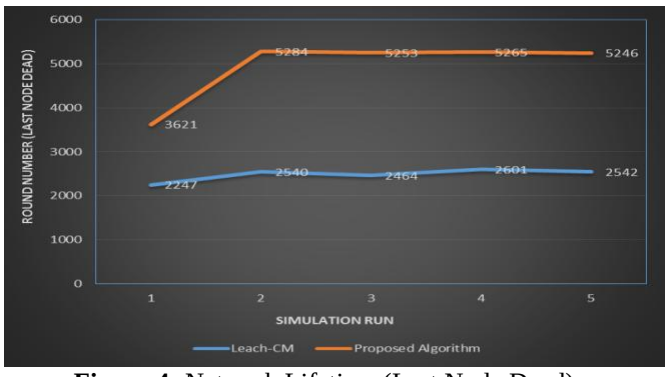


**Figure 4:** Network Lifetime (Last Node Dead)

**3) Network Lifetime with varying message size:** We simulated the proposed method with different message size to observe the lifetime of network. The base station position is (50, 50). The results are shown in Table 4.

**TABLE 4:** NETWORK LIFETIME WITH VARYING MESSAGE SIZE

| Packet Size | Round Number | |
|---|---|---|
| | LEACH-CM | Proposed Algorithm |
| 12000 | 350 | 2510 |
| 10000 | 372 | 3428 |
| 8000 | 515 | 2890 |
| 6000 | 567 | 3630 |
| 4000 | 650 | 5284 |
| 2000 | 810 | 6987 |

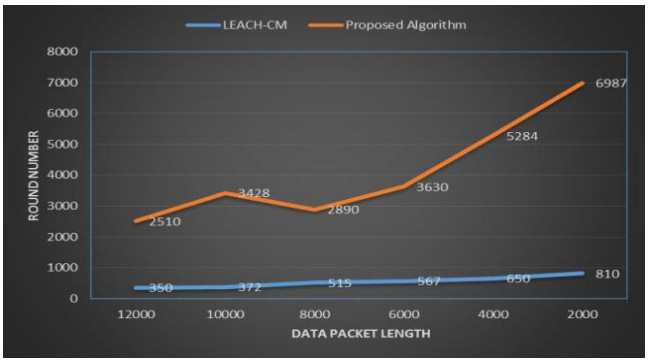


**Figure 5:** Network lifetime with varying message size

**4) Network Lifetime with varying Base Station position:** In this simulation we have observed the network lifetime by varying the location of Base Station (Sink). Table 5 shows the value of Base Station position.

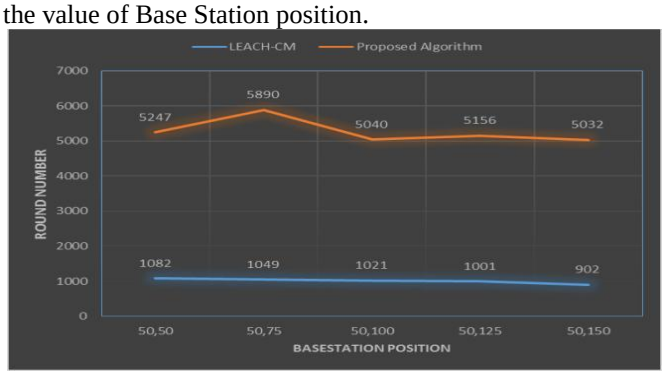


**Figure 6:** Network Lifetime with varying Base Station (Sink) position

**TABLE 5:** NETWORK LIFETIME WITH VARYING BASE STATION POSITION

| Base Station Position | Round Number | |
|---|---|---|
| | LEACH-CM | Proposed Algorithm |
| (50,50) | 1082 | 5247 |
| (50,75) | 1049 | 5890 |
| (50,100) | 1021 | 5040 |
| (50,125) | 1001 | 5156 |
| (50,150) | 902 | 5032 |

Fig. 4 illustrates the graph that indicates the statistics of Last dead node in different simulation runs in our proposed algorithm as well as in LEACH-CM. In LEACH-CM Last node die in 2247 round. But in our proposed scheme last nodes work satisfactorily until 3620 rounds and then died at 3621 round. Hence network lifetime is increased.

## 6. CONCLUSION

In this paper, we have analysed and compared the performance of the two cluster-based routing protocols viz. LEACH-CM and Proposed LEACH for heterogeneous networks in terms of their network lifetime, energy consumed and data transmission. In this, we have considered various parameters such as packet size and Base Station position. Through simulation results we demonstrated that the proposed algorithm shows good energy distribution and thus prolongs the network lifetime in comparison to LEACH-CM routing protocol.

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