International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 11 (2015) pp. 29267-29282

http://www.ripublication.com

Admin Leach: A New-Fangled Well-Organized Energy Efficient Routing Protocol For Wireless Sensor Networks

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ABSTRACT

Wireless sensor networks (WSNs) have gained increasing attention from both the research community and actual users. The efficient utilization of energy source in a sensor node is very important criteria to prolong the life time of wireless sensor network. Wireless sensor networks have explored to many new protocols specifically designed for sensor networks where energy consideration is very crucial. Most importance, given to hierarchical routing protocols based on clustering has better scalability. As sensor nodes are generally battery powered devices, the critical aspects to face concern is, how to reduce the energy consumption of nodes, so that the network lifetime can be extended to reasonable times. Several energy efficient hierarchical routing protocols are so for implemented, out of that LEACH (Low Energy Adaptive Clustering Hierarchy) is still famous protocol because of its clustering concept and features. The power consumption of wireless communication between two nodes is based on the transmission distance, which has an exponential increment with the distance. Therefore, the routes of the data transmission to the sink will affect the energy consumption. The proposed algorithm which is modified version of LEACH and implemented using MATLAB simulator. We evaluated the performance of improved protocol in terms of network lifetime, number of dead nodes and number of live nodes which is in comparison with existing protocol. The proposed algorithm mainly concentrates the transmission distance between node to cluster head and cluster head to base station, to reduce the distance; it is implemented by ADMINISTRATOR NODE amalgamation to collect the data from cluster heads and passed to main base station. So the Administrative sensor node is placed at different locations in between the cluster head and base station, which yield good energy consumption and increased network lifetime. The proposed algorithm leads more energy efficient outcome for Homogeneous and Heterogeneous system of wireless sensor networks by proper incorporation of ADMINISTRATOR NODE

KEYWORDS: Cluster, Cluster head, Homogeneous and Heterogeneous system, Administrator node, LEACH, Wireless sensor networks

1.0 INTRODUCTION

The wireless sensor network consists of hundreds or even thousands of sensor nodes deployed in a remote region to sense events. The sensor nodes communicate with each other to transmit their sensed data to sink node (or base-station). Then, the sink node transfers the data to the human director to know events from the remote region. In the sensor networks, wireless direct transmission is the most energy consuming operation [1]. In addition, each sensor node has very limited batteries, and it is very hard to recharge them. Therefore, energy-efficient transmission protocol is required to maximize network lifetime of the entire sensor networks. Many kinds of efforts have been done on developing energy-efficient transmission protocols for wireless sensor networks. Those can be categorized into routing, and clustering protocols. Particularly, the clustering protocols can significantly reduce energy consumption by aggregating multiple sensed data to be transmitted to the sink node (or destination node).

The power consumption of wireless communication between two nodes is based on the transmission distance, which has an exponential increment with the distance. Therefore, the routes of the data transmission to the sink will affect the energy consumption.

The proposed algorithm mainly concentrates transmission distance between cluster head to base station, to minims this distance we implement administrator node to collect the data from CHs to main base station. In our simulation, evaluation results show that outperformed LEACH in term of energy consumption and network lifetime [2], [3]. The rest of this paper is organized as follows.

In section 2, we present existing works relating to the routing and clustering protocols for wireless sensor networks. In Section 3, we present the proposed algorithm in detail with several examples. Section 4 shows evaluated performance of the new algorithm using MATLAB simulator. Finally several concluding remarks are given in Section 5.

2.0 RELATED WORKS

LEACH-L (Energy Balanced Low Energy Adaptive Clustering Hierarchy) Leach-L is an advanced multi hop routing protocol and considers only the distance. It is suitable for large scope wireless sensor network and the optimum hop counts are deduced. The cluster heads can communicate directly to the base station when they are located close to it. When they are located far away from the base station, they can communicate by the method of multi-hop way and the shortest transmission distance is limited. In this, the sensors are allowed to use different frequencies and gaps to communicate with base station. The clusters re-established in each round consisting of the setup and steady state phase. And in each round new cluster heads are elected and the load is distributed and balanced among the nodes in the network. Since Leach-L makes power equally distribute among all sensors, in the pre-period, the network ‘s activity nodes and cover areas of Leach-L are greatly larger than that of Leach-M.

In 2002, Lindsey and Raghavendra [4] proposed PEGASIS. It makes a communication chain using a TSP (Traveling Sales Person) heuristic. Each node only communicates with two close neighbors along the communication chain. Only a single designated node gathers data from other nodes and transmits the aggregated data to the sink node.

Chan and Perrig [5] proposed an ACE algorithm (Chan and Perrig 2004). It forms clusters based on connectivity information of each node. A node which has the highest connectivity becomes cluster head. If multiple nodes have the highest degree of connectivity, a node which has low unique identifier will be selected as a cluster head. The cluster formations based on a connectivity of nodes are not an appropriate way because every node must maintain connectivity each other.

In 2005, [6] Li et al. proposed EEUC, which is an energy-efficient unequal clustering protocol. It partitions nodes into clusters of unequal size; clusters closer to the base station have smaller sizes than those farther away from the base station. Thus cluster heads closer to the base station can preserve energy for the inter cluster data forwarding.

Hongjoong Sin et al. [2008] [7] adopted biologically inspired approaches for wireless sensor networks. Agent operates automatically with their behavior policies as a gene. Agent aggregates other agents to reduce communication and gives high priority to nodes that have enough energy to communicate. Agent behavior policies are optimized by genetic operation at the base station [8]. Simulation results show that our proposed framework increases the lifetime of each node. Each agent selects a next-hop node with neighbor information and behavior policies.

Yuhua Liu et al. [2009] [9] has discussed that the non cluster-heads choose optimal cluster-head, they consider comprehensive nodes' residual energy and distance to base-station, then compare their performance, the simulation results show that the new strategy of cluster-heads election achieve great advance in sensor and networks' life-time.

Reetika Munjal et al. [2012] [10] has studied that the main problem with the LEACH lies in the random selection of cluster heads. There exists a probability that cluster heads formed are unbalanced and may remain in one part of network making some part of network unreachable. Here our main purpose is to select a cluster head depending upon its current energy level and distance from the sink node. This increases the energy efficiency and hence network lifetime.

Huu Nghia Le et al. [2012] [11] has proposed a distributed, energy efficient algorithm for collecting data from all sensor nodes with minimum latency called

Delay-minimized Energy-efficient Data Aggregation algorithm (DEDA).The DEDA algorithm minimizes data aggregation latency by building a delay-efficient network structure. At the same time, it also considers the distances between network nodes for saving sensor transmission power and network energy. Energy consumption is also well balanced between sensors to achieve an acceptable network lifetime.

2.1. CLUSTERING SCHEME

If the number of nodes used in the application is large, then data aggregation process is mandatory and it has to be done in any method of routing protocols [12]. If all the nodes try to send the sensed data to the BS (Base Station), more energy will be consumed; eventually more nodes will die frequently. The data gathered by a set of nodes has to aggregated and sent to the BS from that point. A tree like arrangement of wireless sensor nodes is used in this work. All the nearby nodes are grouped to form different clusters. This idea is inspired from the work of LEACH (Low Energy Adaptive Clustering Hierarchy) [13]. In this algorithm, different set of nodes become the cluster heads each time. Every time the node which is the cluster head takes the responsibility of aggregating the data from its nearby nodes and sends the data to the BS, there by reduces the energy wastage of all the nodes. Other types of routing techniques are also available and most of them are derived from the LEACH [14], [15]. In Random walk protocol type the nodes are simply arranged like a grid. The nodes are assumed to be present at the grid junctions, and then the desired route is found out. In Directed Diffusion method, the query will be broadcasted from the node; it will reach only the active (alive) nodes. The interested nodes will then send back the data to the desired node. In turn this will lead to lot of energy wastage, since broadcasting needs lot of energy. So the cluster based routing is best suitable routing protocol for environmental monitoring applications. In this work, the clusters are formed based on a weight attached to each node [16]. While forming the clusters, the following rule should be followed- No two clusters should have one or more nodes in interference range. Interference range is that , the two nearest nodes in two different clusters should not be in either transmitting or receiving state. This will cause interference and overhearing of packets and thereby wastage of energy. The time slots will be allocated to the nodes in a decreasing order of weight to the nodes in the tree structure. If this mechanism is followed for scheduling the nodes in a WSN for environmental monitoring applications, surely the overall energy consumption of the WSN can be reduced by a considerable range [17].

2.2 RADIO MODEL FOR ENERGY CALCULATION

Analyzing the basic distributed clustering routing protocol i.e. LEACH (Low Energy Adaptive Clustering Hierarchy), which is base routing protocol system and data aggregation method. The sensor nodes form the cluster and cluster-head elected based on the residual energy of the individual node calculation [18], [19]. Energy efficiency of LEACH protocol is better in heterogeneous system than Homogeneous system. In this research work, the first order radio model for energy calculations is used as shown in Figure 1. Here some of very essential and required assumptions are desired for the new routing protocol implementation.

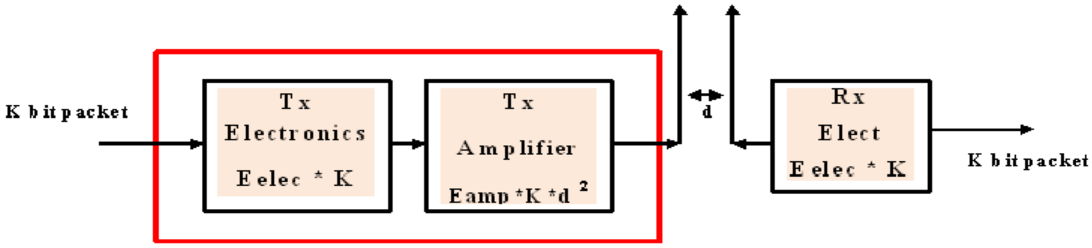

Fig1. First order radio model.

This uses the initial energy level of the sensor nodes to select the cluster heads. Using Equation (1) the distance (d_o) is decided by the parameter values ε_{amp} and ε_{fs}(Friss-amp). Calculate the distance between energy per bit (ε_{fs} (Friss-amp) and energy per area (ε_{amp})

$$d_o = \frac{\varepsilon_{fs}}{\varepsilon_{amp}} \quad (1)$$

Cluster head selection algorithm

From Equation (2) each sensor node generates a random value and compares it to a predefined threshold T(n). If random value is less than T (n), the sensor node becomes cluster-head in that round, otherwise it acts as a cluster member and '*p*' is a probability to become cluster head nodes. Where '*p'* is the percentage of the number of clusters in the network (usually '*p'* is 0.1), 'n' is the number of node, '*r*' is the number of the election rounds, and round (1 / *p*) is the number of nodes which have been elected as cluster heads in the round.

$$T(n) = \begin{cases} \dfrac{p}{1 - p\,(r \bmod 1/p)} & if\ n \in G \\ 0 & otherwise \end{cases} \quad (2)$$

In radio model for a shorter distance transmission, such as within clusters, the energy consumed by a transmit amplifier is proportional to d^2. However, for a longer distance transmission, such as from a cluster head to the base station, the energy consumed is proportional to d^4. Using the given radio model, the energy consumed to transmit an l-bit message for a longer distance is given in equation (3)

$$E_T = lE_e + l\epsilon_l\, d^4 \qquad (3)$$

Similarly, the energy consumed to transmit an l-bit message for a shorter distance is given in equation (4)

$$E_T = lE_e + l\varepsilon_s d^2 \qquad (4)$$

Moreover, the energy consumed to receive the l-bit message is given in equation (5)

$$E_R = lE_e + E_{BF} \qquad (5)$$

Equation (5) includes the cost of beam forming approach that reduces energy consumption. The constants used in the radio model are given in Table 1.

Election Phase

For a sensor network of ‘n’ nodes, the optimal number of clusters is the given task. All nodes are assumed to be at the same energy level at the beginning of operation or simulation. The amount of consumed energy is same for all the clusters. At the start of the election phase, the base station randomly selects a given number of cluster heads.

Table 1: Simulation Parameters

Name of the Simulation parameters	Parameter values
Network Area in (m)	100 m ×100 m
No. of Sensor nodes in field	100
Initial Energy of Homogeneous nodes	0.5 Joules
Initial Energy of Heterogeneous nodes	1.0 Joules
E_{elec}	50 Nano-Joules/bits
$E_{TX}=E_{RX}$	50 Nano-Joules/bits
ε_{fs}(Friss amp)	10 Pico-Joules/bits/m^2
ε_{mp}	0.0013 pico-Joules/bits/m^4
Distance(d_o)	Sqrt(ε_{fs} / ε_{mp})
E_{DA} (Data Aggregation)	50 Nano-Joules/bits/signal
Data Packet Size	4000 bits

First, the cluster heads broadcast messages to all the sensors in their neighborhood. Second, the sensors receive messages from one or more cluster heads and choose their cluster head using the received signal strength [20]. Third, the sensors transmit their decision to their corresponding cluster heads. Fourth, the cluster heads receive messages from their sensor nodes and remember their corresponding nodes. For each cluster, the corresponding cluster head chooses a set of ‘m’ associates, based on signal analysis. For uniformly distributed clusters, each cluster contains n/k nodes. Using Equation (3) and Equation (4), the energy consumed by a cluster head is estimated as follows. Calculate the distance between nodes and sink node using the equation (6)

$$d_1 = \sqrt{(XR(i) - sink.x)^2 + (YR(i) - sink.y)^2} \qquad (6)$$

The ‘E_d’ is the each node energy per bit and it is the amplifier energy that depends on the transmitter amplifier model. E_{TX} is a transmitted energy. The E_{DA} is the energy required for data aggregation. Length of the packet ‘ρl’ sends the packet from base station to cluster head. If the distance is greater than or equal to initial energy the ‘E_d is given by the equations (7) & (8)

$$E_d = E_d - \left((E_{TX} + E_{DA}) * \rho l + E_{mp} * \rho l * (d_1^4)\right) \qquad (7)$$

$$E_d = E_d - \left((E_{TX} + E_{DA}) * \rho l + E_{fs} * \rho l * (d_1^2)\right) \quad (8)$$

Minimun Distance calculation

To find the minimum distance for election of associated clusterhead for normal node, it is denoted by m_d using equation (9)

$$m_d = \sqrt{XR(i) - C(c.xd)2 + (YR(i)2 - C(c).yd)2} \quad (9)$$

In LEACH, to find the minimum distance by which only we can send data from base station to cluster head. If the minimum distance greater then the initial energy control length of the packet '*cpl'* is send between nodes .It is calcluted using Equations (10) to(14)

$$E_d = E_d - (EXT * (Cpl) + E_{mp} * cpl * (m_{d^4}) \quad (10)$$

Packet of the length *'pl'* is send between nodes

$$E_d = E_d - (EXT * (pl) + E_{mp} * pl * (m_{d^4}) \quad (11)$$

If the minimum distance less than the initial energy

$$E_d = E_d - (EXT * (Cpl) + E_{fs} * cpl * (m_{d^2}) \quad (12)$$

$$E_d = E_d - (EXT * (pl) + E_{mp} * pl * (m_{d^2}) \quad (13)$$

$$E_{CH-elec} = (lE_e + l\varepsilon_s d^2) + \left(\frac{n}{k} - 1\right) l(E_e + E_{BF}) \quad (14)$$

The first part of Equation (14) represents the energy consumed to transmit the advertisement message; this energy consumption is based on a shorter distance energy dissipation model. The second part of Equation (14) represents the energy consumed to receive n/k−1 messages from the sensor nodes of the same cluster. Equation (14) can be simplified as equation (15)

$$E_{CH-elec} = lE_e \frac{n}{k} + lE_{BF}\left(\frac{n}{k} - 1\right) + l\varepsilon_s d^2 (15)$$

Data transfer Phase

During data transfer phase, the nodes transmit messages to their cluster head and cluster heads transmit aggregated messages to a distant base station. The energy consumed by a cluster head is given in Equation (16)

$$E_{CH/frame} = (lE_e + l\epsilon_l d^4) + \left(\frac{n}{k} - m\right) l(E_e + E_{BF}) \quad (16)$$

The first part of Equation (16) shows the energy consumed to transmit a message to the distant base station. The second part of Equation (16) shows the energy consumed to receive messages from the remaining n/k−m nodes that are not part of the cluster. Equation (16) can be simplified as equation (17).

$$E_{CH/frame} = l\varepsilon_l d^4 + \left(\frac{n}{k} - m + 1\right) lE_e + \left(\frac{n}{k} - m\right) lE_{BF} \quad (17)$$

The energy consumed by a non-cluster head node to transmit the sensor data to the cluster head is given in Equation (18)

$$E_{non-CH/frame} = lE_e + l\epsilon_s d^2 \quad (18)$$

Using Equation (18), the optimum value of k for minimum dissipation of frame energy is given in Equation (19)

$$k = \sqrt{\frac{n}{2\pi}} \sqrt{\frac{\epsilon_s}{\epsilon_l d^4 - (2m - 1E_e - mE_{BF})}}\, M \quad (19)$$

Time to complete one round Sensor nodes transmit messages according to a specified schedule, which is based on TDMA. The frame time t_{frame} is the addition of transmission times of the messages transmitted by all the nodes of a cluster. For a data transfer rate of R_b bits/second and message length of l bits, the time to transfer a message, t_{msg}, is as follows in Equation (20)

$$t_{msg} = l/R_b \qquad (20)$$

In one frame, messages are transmitted by all the non-cluster head nodes and the active member of the cluster. Since at one time only few member of cluster active, the inactive cluster members, which are m−1, do not transmit during the frame transmission. The time for one frame is given as follows Equation (21)

$$t_{frame} = \left[\sum_{i=1}^{\frac{n}{k}-m} t_{msg_i}\right] + t_{msg_{cluster\_head}} \qquad (21)$$

The first part of Equation (21) is due to n/k –m messages from non-cluster head nodes. The second part of Equation (21) is due to the transmission of the active member of the cluster.

Analysis of Normal LEACH Protocol

Depends upon the location of base station network life time have to be varied. In normal LEACH protocol 100 sensor nodes are randomly deployed at x=100m, y=100m area and base station located at x=150m, y=50m [21]. According to LEACH protocol operation the cluster and cluster heads also selection being done and data transmitted between the sensor node to CH and CH to base station [22], [23]. At 1400 rounds of simulation all the sensor node are dead out of 100 sensor nodes except two sensor node only alive as shown in Figure 2.

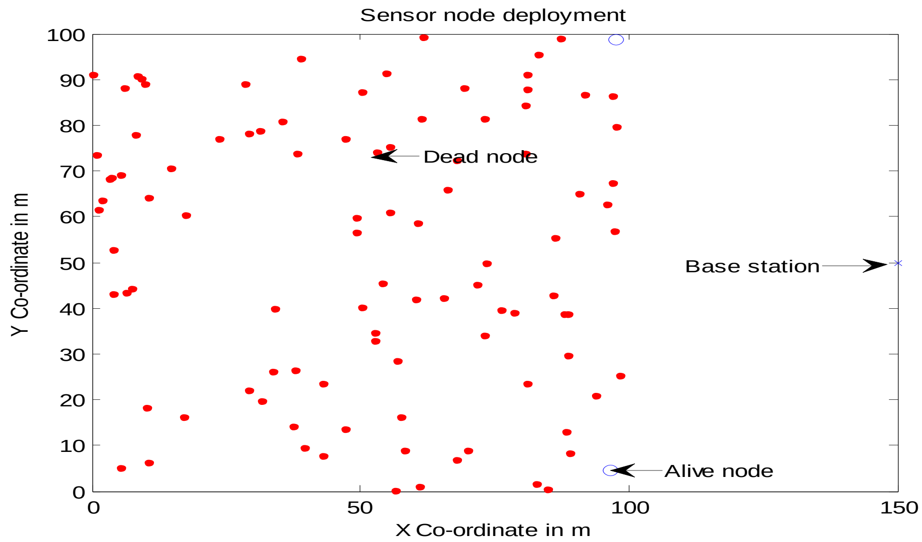

Fig.2 Sensor node deployment with base station located at (150,50) on 1400 rounds two nodes are alive.

In the proposed approach one administrator node is deployed at x=100m, y=50m as shown if Figure 4. The administrator node is collect the data from all cluster head nodes in the sensor network then aggregate the data and transmit the data to base station in every simulation round. This approach reduces the overhead problem of cluster head in the sensor network and hence the proposed approach leads the better lifespan of the network [24]. The details of flow diagram are representing the proposed system of approach as shown in the Figure 3.

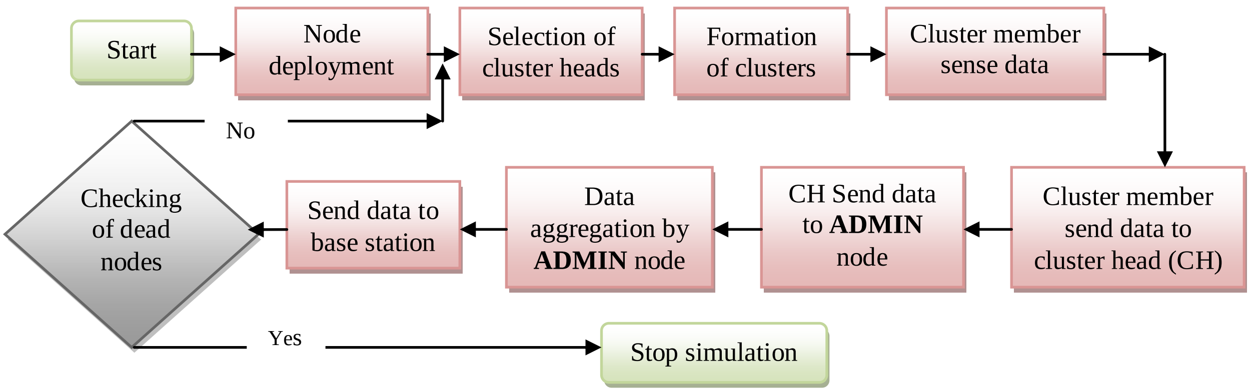

Fig.3 Flow diagram of the proposed system approach

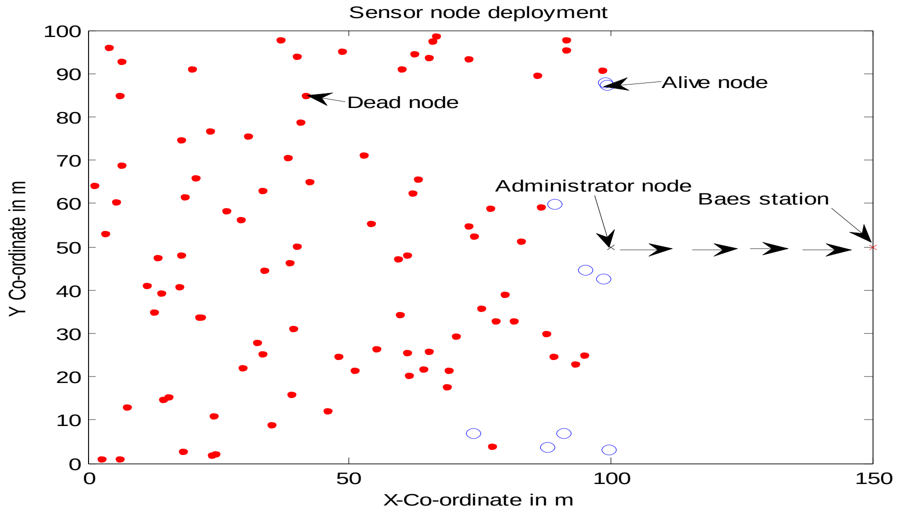

Fig.4 Sensor node deployment with base station located at (100,50) (150,50) on 1400 rounds using Administartor node eight nodes are alive.

In LEACH opertion system the administrator is placed in between the cluster head and base station.After 1400 rounds of simulation the administrator node system have eight nodes as live and it is depicted in Figure 4.

III. PROPOSED APPROACH

There are many energy efficient approaches proposed for cluster formation and cluster head selection to reduce the inter cluster communication. But most of the approaches cannot be implemented because of complex and non intelligent computing in distributed clustering algorithms. Sensor nodes have low storage capacity and the computing is extremely energy consuming, therefore, a distributed approach is required for cluster formation that should be simple for implementation and energy efficient. As sensor nodes are generally battery-powered devices, the critical aspects to face concern how to reduce the energy consumption of nodes, so that the network lifetime can be extended to reasonable times. There is much energy efficient hierarchical routing protocols among this LEACH is famous protocol. Each sensor node has its sensing request the capabilities of sensing, computation, and wireless communications. Each Cluster-Head directly communicates with BS, no matter the distance between CH and BS. It will consume lot of its energy if the distance is far. The CH uses most of its energy for transmitting and collecting data, because, it will die faster than other nodes. The CH is always ON and when the CH die, the cluster become useless because the data gathered by cluster nodes never reach the base station. The power consumption of wireless communication between two nodes is based on the transmission distance, which has an exponential increment with the distance. Therefore, the routes of the data transmission to the sink will affect the energy consumption. The proposed algorithm mainly concentrates transmission distance between cluster head to base station, by introduced ADMINISTATOR NODE at the center of four divisional areas such as (100m, 100m) node deployment area. Base station is located at (50m, 50m) as shown in the Figure 5.

The Energy Efficient Clustering Protocol

The clustering process is accomplished in two phases: setup phase and steady state phase. In the setup phase, cluster head selection and clusters formation process is completed. In the steady state phase, data transmission between node to CH and CH to BS completed.

Admin node concept in Homogeneous System

By referring the normal LEACH concept, the base station is located at corner of the node deployment area as shown in Figure 2. From the normal LEACH concept the administrator node is properly located and through the administrator sensor node the sensed and collected or aggregated data are passed to the base station as shown in Figure 4. The research work mainly concentrating the data communication distance as the main task, by reducing the distance between the cluster head to base station and such a way the place of locating the administrator node is giving the best solution of energy consumption in the whole network. Hence the system gives good performance of enhanced lifetime. This administrator node implementation concept in normal LEACH system is focused in different ways is shown in Figure 5, Figure 7. So, the system of implementation of administrator node concept is mainly decreasing the data communication distance and hence enhances the network lifetime. From Figure 5 the deployment of sensor node are in four zones. Each zone has equal number of sensor nodes and it has one administrator node at center of the zone. Each zone administrator node collect the information from their cluster head and pass the data communication to base station which is at middle of the topology area. It has 41 sensor nodes live after taking 1400 simulation rounds is depicted in Figure 6.

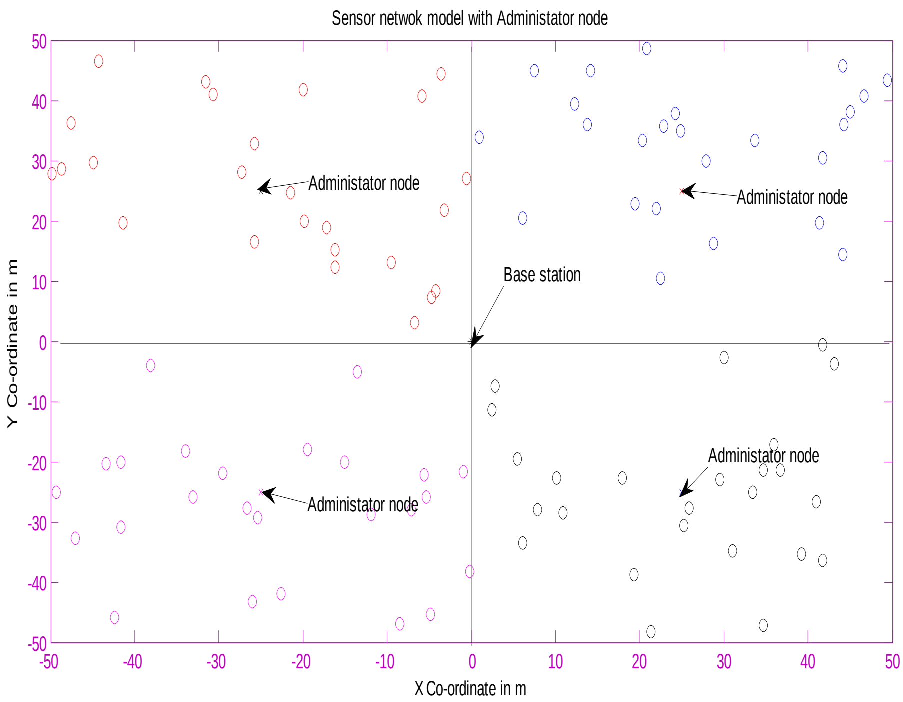

Fig.5 Implementation of Admin node in four zone with base station at center.

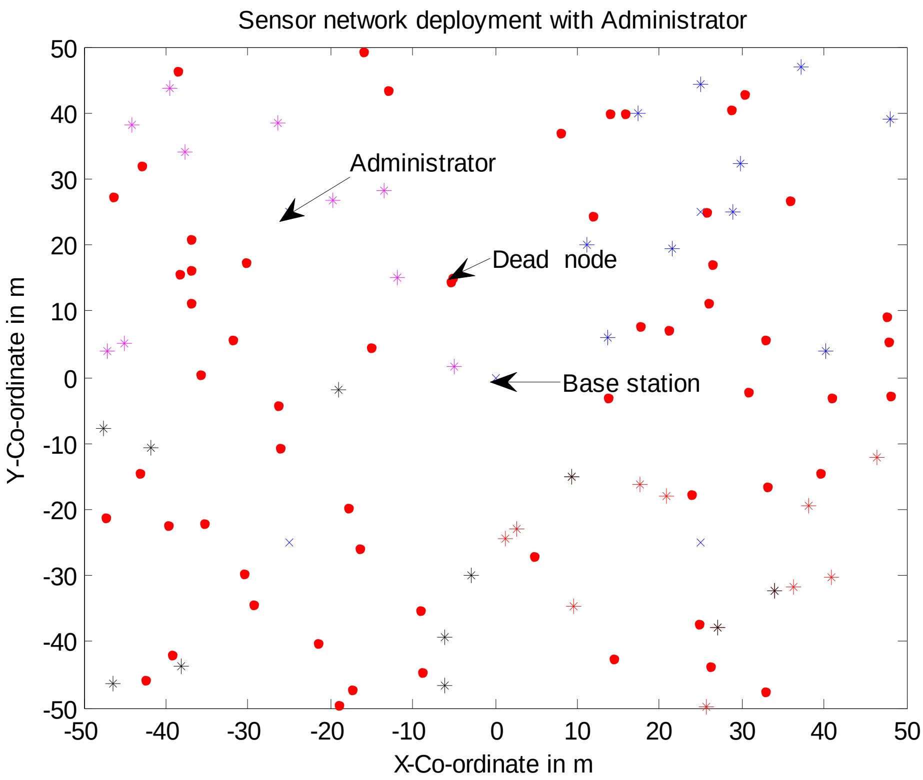

Fig.6 Implementation of Admin node in four zone with base station at center, after 1400 rounds 41 nodes is alive

The proposed algorithm cluster formation and cluster head procedure are same as that of LEACH protocol, then Administrative nodes are collect the data from the CHs and aggregated data is send to base station. Administrative node is fixed at center of the four divisional areas as shown in Figure 5. For energy efficiency the transmission distance of cluster and base station can be reduce and energy consumption for data aggregation also reduced by introducing of administrative nodes at each divisions.

The proposed algorithm lead the better energy the result is compared with various methods of existing protocols. Better results are proved by the simulation results. From the above deployment of four zones of sensor nodes has individual admin node at center, after each simulation collecting the sensed information is passed to the respective admin node then it is forwarded to the base station.

From Figure 7 the deployment of sensor node are in four zones. Each zone has equal number of sensor nodes and it has one administrator node at center of the zone. Each zone administrator node collect the information from their cluster head and pass the data communication to its principal administrator node by multi-hop communication and then it is forwarded to base station as shown in Figure 7. It has 66 sensor nodes live after taking 1400 simulation rounds is depicted in Figure 8.

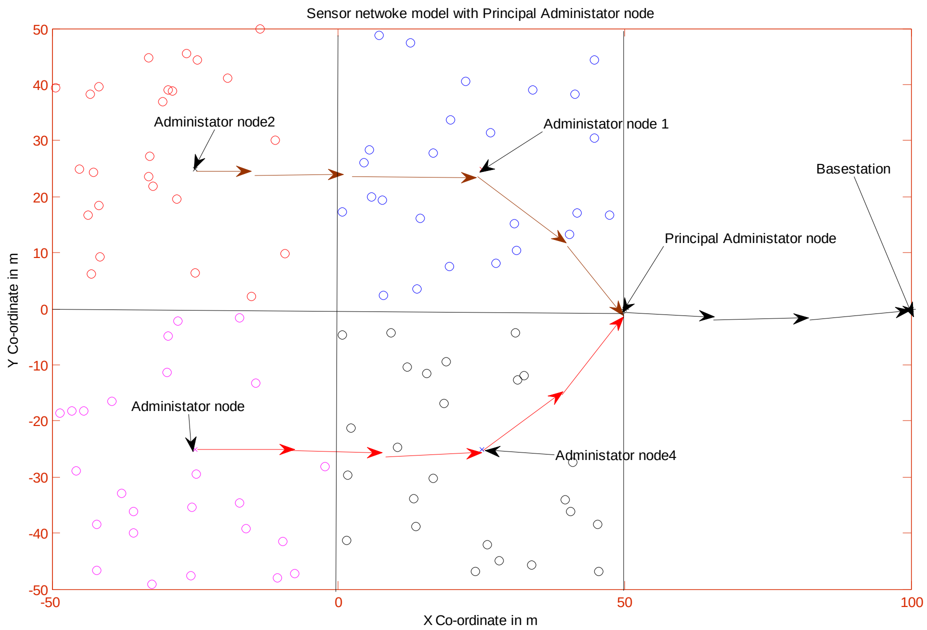

Fig.7 Implementation of Admin node in four zone with base station at 100m x 0m

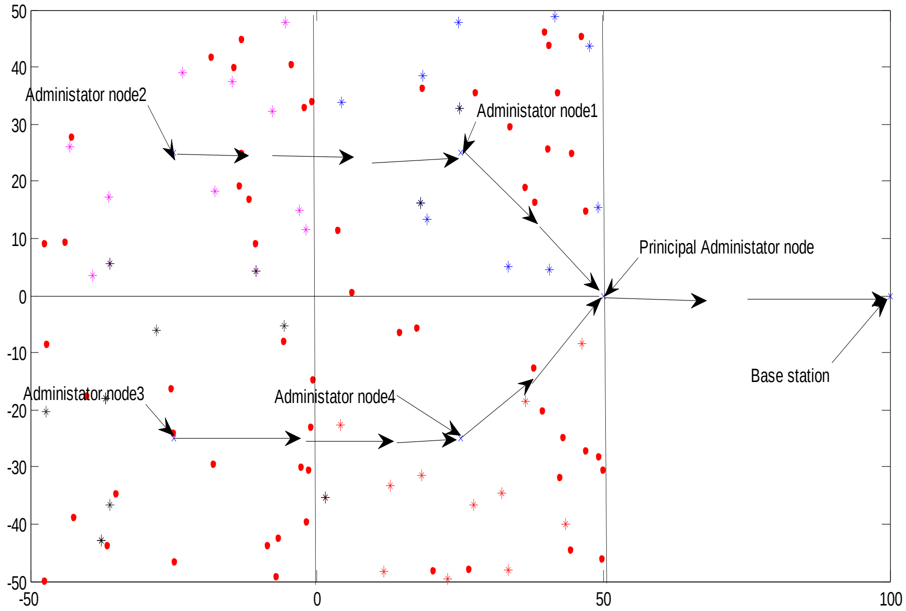

Fig.8 After simulations of 1400 rounds 66 nodes are live.

IV. RESULT ANALYSIS

Main task of the research work is based on the data communication distance among the sensor nodes to cluster head, administrator node, principal administrator node and finally base station. The location of administrator node, principal administrator node and the base station is the main part and it is implemented in different scenarios, eventually in each type of system evidently proved the increased lifetime of the network by means of number of simulation rounds and their live nodes. This is clearly observed and given in the graph as shown in Figure 9. From the figure it is observed that the data communication by using the administrator node along with principal administrator node of four zone system is giving the best performance in number rounds and enhanced lifetime. It is clearly proved through the Figure 9. All sensor nodes are lost their energy after 6800 rounds of simulation. So it is obvious that the number of rounds proportionate the lifetime of the network. The information observed from the graph illustrated in Figure 9 is evidently proves that the data communication part is the main task, which is properly handled using the location of administrator node in a right place.

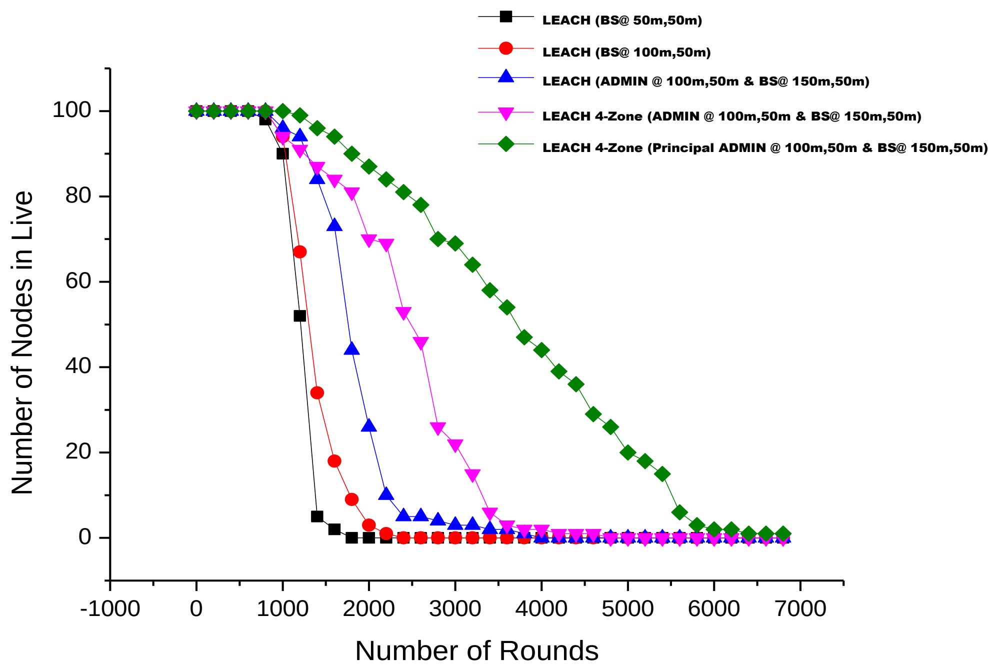

Fig.9 Comparison of various ADMIN node implementations by simulations

V. CONCLUSION

Main focus of proposed system is initially developed without administrator node system. By admin node implementation concept the obtained simulation result is better than the normal LEACH. Then it is promoted to four separate zones, in each zone it has an admin node. Each admin node collects the data from the sensor node and aggregates it and then sending it to the base station which is at center. In this case the available live nodes are more than the previous one, which is in Figure 5 and Figure 6. Now at this end one more principal admin node is introduced on between the admin node and the base station. It is given in Figure 7 and its simulation is given in Figure 8. Here the number of live nodes is higher than the last one. Cumulatively all the obtained data are converted as graphical representation in Figure 9, which is absolutely, prove the concept admin node implementation. So the data communications distance is also the main factor to reduce the lifetime of the network. Hence it is properly handled the data communication distance and found the location of placing of the admin node indifferent scenarios, which proportionately give enhanced lifetime of the network in terms of simulation rounds.

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