International Journal of Advance Research in Science and Engineering
Vol. No.4, Special Issue (01), Spetember 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

ENERGY ENHANCEMENT USING AREA ZONING IN WIRELESS SENSOR NETWORKS

Shubhi Bansal[1], Vishal Kumar Arora[2]

[1]*Department of Computers Science & Engineering, SBSSTC, Ferozpur, (India)*

[2]*Assistant Professor, Department of Computers Science & Engineering, SBSSTC, Ferozpur, (India)*

ABSTRACT:

Research is being carried out for discovering various techniques to efficiently utilize the sensor node's energy in a wireless sensor network. We have observed that most energy efficient technique for data transmission in a wireless sensor network is considered to be Clustering approach. It is very effective in reducing the energy dissipation of a WSN upto a great extent as compared to rest of the techniques. Now, we should try to concentrate on the ways to improve the clustering techniques so that good and energy efficient clusters are formed. This paper proposes an effective clustering technique for large area networks which is based on a combination of centralized and distributed clustering approaches. First of all the whole network area is subdivided into different zones on the basis of a threshold value. In this paper, we have divided the deployment region into two zones, the zone closer to base station is known as NEAR zone and the one which is away from BS is known as FAR zone. Since, the nodes closer and farther to BS suffer from energy loss due to different reasons. Depending upon those causes of fast energy drainage we have decided to use different clustering techniques in different zones. In near zone we have implemented centralized clustering technique and in far zone distributed clustering has been carried out. We have studied the behavior of our proposed protocol for network lifetime and average remaining energy and have observed that it performs better than the LEACH, C-LEACH protocols.

Keywords: Base Station, Cluster Head, Leach, Relay Node, Sensor.

I. INTRODUCTION

Wireless technology has evolved at a very fast rate in the previous decade. The use of wireless devices is overtaking the wired devices which makes WSN a broad area of research. Wireless sensor networks has a wide range of applications such as Environmental monitoring, high-precision agriculture, industrial monitoring and control, structural health monitoring, medical research, health care and, homeland security, military applications etc. WSN consists Sensor nodes as the most basic and important component. A sensor node carries out all the operations from sensing the environment, processing the data and transmitting it to Base station for further evaluation. Sensors are equipped with a battery which has limited power. A sensor node has four main components: Sensing unit, Processing unit, Transceiver unit and Power unit. It can also has two additional units called location detecting unit and mobilize. Firstly, the sensing unit consists of a number of sensors that sense the surrounding, collect data and give it to the processing unit. It also consists of an Analog to digital converter to convert analog data signals into digital form. Processing unit consists of a microcontroller which processes the data and a storage unit to store the processed data. Transceiver unit is made up of two components, transmitter and receiver for transmitting and receiving information to other nodes and Base station. Then comes the power unit which provides the required amount of power to perform all the tasks. Location finding system helps the sensor node to locate its position in the network. Mobilizer is required in those sensor nodes where there is a need of mobile nodes. These two components are optional and are based on the network requirements. Since the batteries can not be recharged due to their remote locations, therefore the energy needs to be used efficiently.

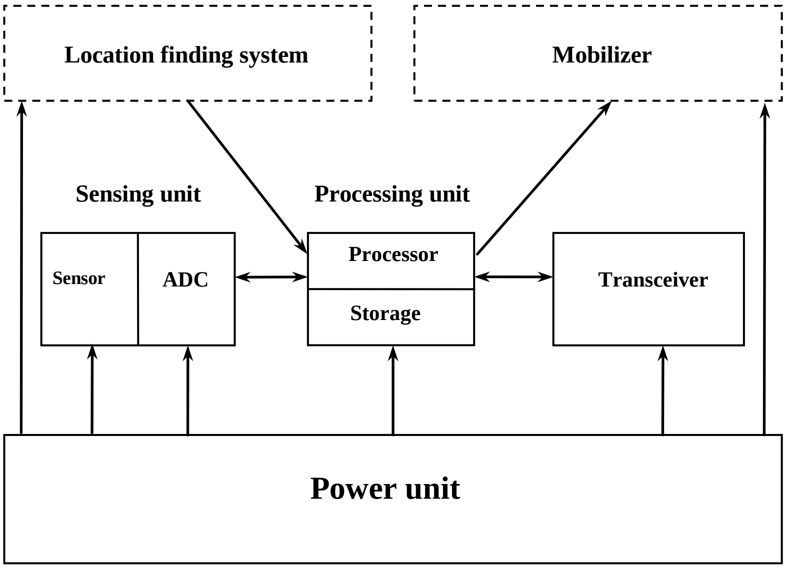

Fig. 1 Components of a Sensor Node

Out of many techniques proposed for efficient energy utilization clustering technique is considered most effective. Clustering is a technique which divides the network into small clusters and each cluster has a Cluster head which collects data from all the member nodes that fall into its cluster, aggregates the data to remove redundant values and transmits it to Base station. Apart from carrying out sensing operations the cluster head node has to carry out these additional tasks hence require more energy than the member nodes.

This paper is divided into five sections. In section II we discuss the related work that has been carried out on this topic. Section III consists of the proposed work which gives the details of the algorithm being implemented. Section IV discusses the simulation and results. Finally we discuss the conclusion and future scope in section V.

II. RELATED WORK

The nodes that become cluster heads drain out of energy before the other nodes resulting in a less stable wireless sensor network. To avoid this problem a Low Energy Adaptive Clustering Hierarchy (LEACH)[1] was proposed by W R Heinzelman in 2000. LEACH was based on cluster head rotation in order to evenly distribute the Cluster head overload among all the sensors. The working of LEACH protocol is divided into two phases: SET UP PHASE and STEADY PHASE.

2.1 Set Up Phase :- In set up phase the cluster head selection and then formation of clusters is carried out. The decision for becoming a cluster head is taken by nodes themselves. The optimal number of cluster heads that are to be chosen is already determined and is generally found to be 3 to 6 percent. Each node generates a random number which is between 0to1. A threshold value is calculated by using following formula:

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

where, P is desired percentage of cluster heads, r is number of rounds, G is a set of nodes that has not become cluster head yet. If the value of random number generated by each node is greater than threshold value then it is eligible for becoming a cluster head. When $K_{optimum}$ cluster heads will be formed then they will send an advertisement message to rest of the nodes in network to join their cluster. Nodes will calculate their distance from each cluster head and the one with minimum distance will be chosen. Nodes will send a joining message to their respective cluster heads to become a member of that cluster. Now, cluster heads will generate a TDMA schedule for each node to send its data.

2.2 STEADY PHASE:- After the set up phase the cluster heads are selected and nodes are divided into small clusters. TDMA schedule is given to every node. Then nodes will gather required data and will transmit it to their cluster head. Steady phase is longer as compared to set up state because it consists to actual data transmission.

Leach was very successful in prolonging the lifetime of sensor network, it almost doubled the network lifetime. Although leach was a revolutionary routing protocol with a significant amount of advantages over direct transmission and minimum distance multihop routing protocols but it also had some disadvantages. These are the main drawbacks of leach-

(a)Randomized cluster head election sometimes results in selection of a low energy sensor node as Cluster Head.

(b)Cluster heads are not evenly distributed all over the network.

(c) distributed clustering results in control message overhead.

(d) leach is not suitable for large networks because of these two reasons - it is a single hop routing protocol, and it make the assumption that every node can communicate to each other and are able to reach the Base station which is not always true in large networks because their may be a lot of obstacles in the way such as large buildings, trees etc.

Various versions of Leach were introduced to overcome these disadvantages. E-Leach(Energy leach)[6] considers the residual energy of the nodes in subsequent rounds so that sensor node with low remaining energy could not be chosen as cluster head. F-Leach(fixed clusters Leach)[9] proposed that the clusters will be fixed while cluster heads will rotate within that cluster. This approach reduced the cluster formation over head in the beginning of each round. For large networks another version of leach that is M-Leach(Multihop leach)[4][5] was introduced which consisted of multihop communication between cluster heads and BS. Cluster heads which were far away from BS communicated through intermediate/relay cluster heads to transmit data. Centralized leach[2] was proposed by heinzelman in 2002 in which the clustering process was completely centralized. Base Station is responsible for carrying out all the operations related to cluster head selection and cluster formation.

Since, the BS had the complete information of the network therefore it formed evenly distributed cluster heads which resulted in balanced work load all over the area of network. Also, the BS is aware of energy level of each node so, only those nodes are chosen for cluster head candidature which have ample amount of residual energy. Generally, the remaining energy of each node is compared with an average energy and only node having energy more than average energy are considered. The steady phase of centralized leach is similar to that of leach protocol. C-leach performed better than leach and increased the network lifetime upto a great extent. but it also suffers from the limitation of not operating well in large networks.

III. PROPOSED WORK

The protocol that we propose in this paper is a combination of centralized and distributed clustering approaches. For carrying out efficient clustering we have divided the network area into two zones : NEAR ZONE and FAR ZONE. Both the distributed and centralized clustering have their advantages and disadvantages, so we have considered these pros and cons for each approach to design a network set up where both techniques cover up shortcomings of one another. For near zone centralized clustering is implemented because nodes are closer to base station and can easily send their initial status messages containing residual energy and location information. Since, the distance is small as compared to far away nodes so the amount of energy required to send these status messages can be neglected. Also, the clustering done by base station in near zone ensures the appropriate cluster head selection i.e., chosen cluster heads are evenly distributed all over the zone. Member node selection procedure is also carried out by BASE STATION only because it is well aware of all the nodes and can easily put the nodes under best suited cluster heads that ensures an energy efficient network arrangement. Both the centralized and distributed clustering techniques have some limitations and some advantages. So, before discussing the cluster head selection process in FAR ZONE let us compared the two clustering techniques on the basis of a number of parameters:

TABLE I. Centralized vs Distributed Clustering

PARAMETER	DISTRIBUTED	CENTRALIZED
Cluster Head Election	CHs election process is carried out by the nodes themselves.	CHs selection process is carried out by the base station.
Number of CHs	Number of CHs to be selected is not fixed.	Number of cluster heads to be selected is fixed by the BS.
CH Rotation	Each node gets a chance to become a cluster head in every epoch rounds.	Each and every node becoming a cluster head is not guaranteed.
Energy dissipation at start up	Energy required at the start up of the network is less.	Energy required at the start up of the network is large.
Overall energy dissipation	Overall energy dissipation is large.	Overall energy dissipation is less.
Data Signals received at BS	Less number of data signals are received at BS.	More number of data signals are received at BS.
Network over head	Network overhead is less.	Network overhead is more.

Far zone consists of nodes that are situated significantly far away from the BS therefore it would not be energy efficient to carry out centralized clustering in far zone as we know that the start up energy dissipation is quite large in centralized approach. Nodes will have to spend large amount of energy in sending initial status messages (containing current energy level information) to BS in beginning of each round. Therefore we decided to opt for the distributed clustering approach. Nodes do not require to communicate directly to the base station at any point during the whole network lifetime because Cluster set up phase is governed locally by the far zone nodes and during steady phase the data is transmitted through the relay nodes that belong to near zone. Now, the energy enhanced clustering techniques in both the near and far zone are being discussed as follows:

3.1 Energy Enhanced Centralized Clustering

Base station knows the location of each and every node. It calculates a threshold value T_h using equation (1) then it sends "HELLO" message to all the nodes in the deployment region, this message consists of the location information of BS and the value of T_h. Using this location information every node calculates its distance from BS. If the distance of node from BS is less than T_h , it falls into near zone else it joins the far zone. Now, all nodes are divided into their respective zones. Base station takes into account three main parameters for selecting cluster heads (a) current energy level of each node, (b) number of nodes falling within the sensing range of a particular node, (c) distance between any two cluster heads. All these factors play major role in choosing cluster heads that are energy rich, efficient and well scattered in the network.

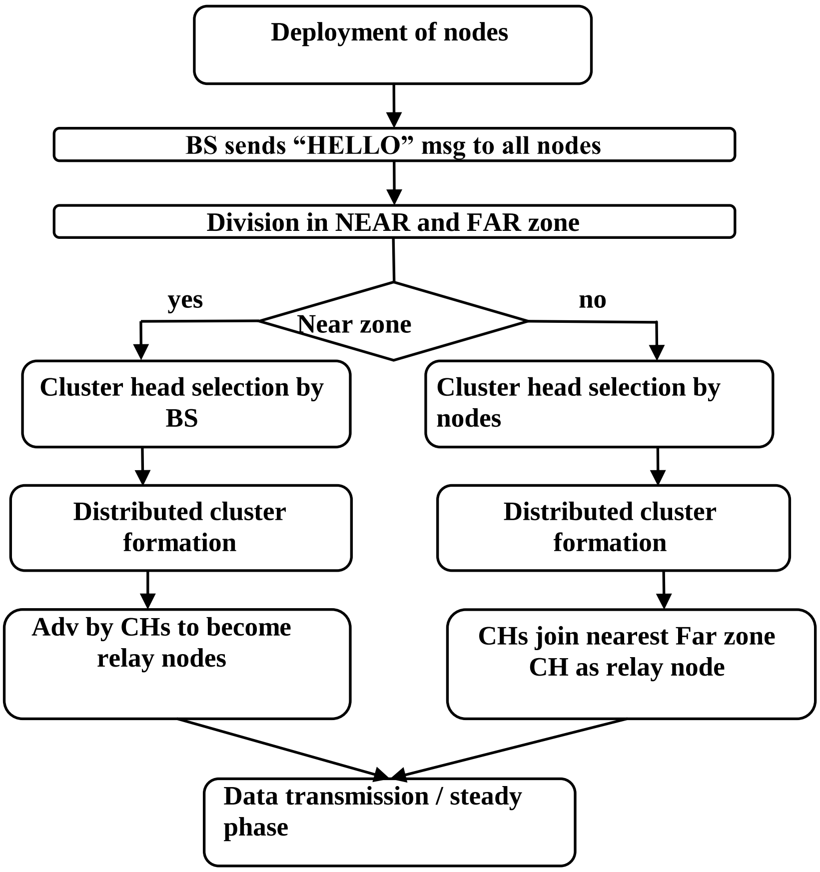

Fig. 2 Flow Chart of Operations of EEAZ.

The current energy level of the node is taken into consideration so that node with lesser amount of current energy could not be given the responsibility of becoming a cluster head because if node having less energy will become cluster head then it will die soon resulting in an unstable network. Secondly, a list of all the nodes in descending order is formed so that the node having maximum number of nodes within its sensing range is at the top. Due to this parameter those nodes are selected as cluster heads which have maximum number of neighboring nodes. Finally, distance between the cluster heads is considered and it should me more than a threshold value. No two cluster heads can be formed with a distance less than this threshold value. This parameter helps in evenly distributing the cluster head nodes all over the network. Once the K_{opt} (optimum number of cluster heads) clusters heads are selected then the BS sends an CH announcement message to all the near zone nodes. This message consists of the CHs Ids, each node checks whether it has become a cluster head or not. If it has chosen as a CH then it advertises all the nodes falling within its sensing range to join it as their CH. If it has not become a cluster head then it waits for advertisement from nearby CHs and joins the one which is nearest to it. This sums up the set up phase in near zone.

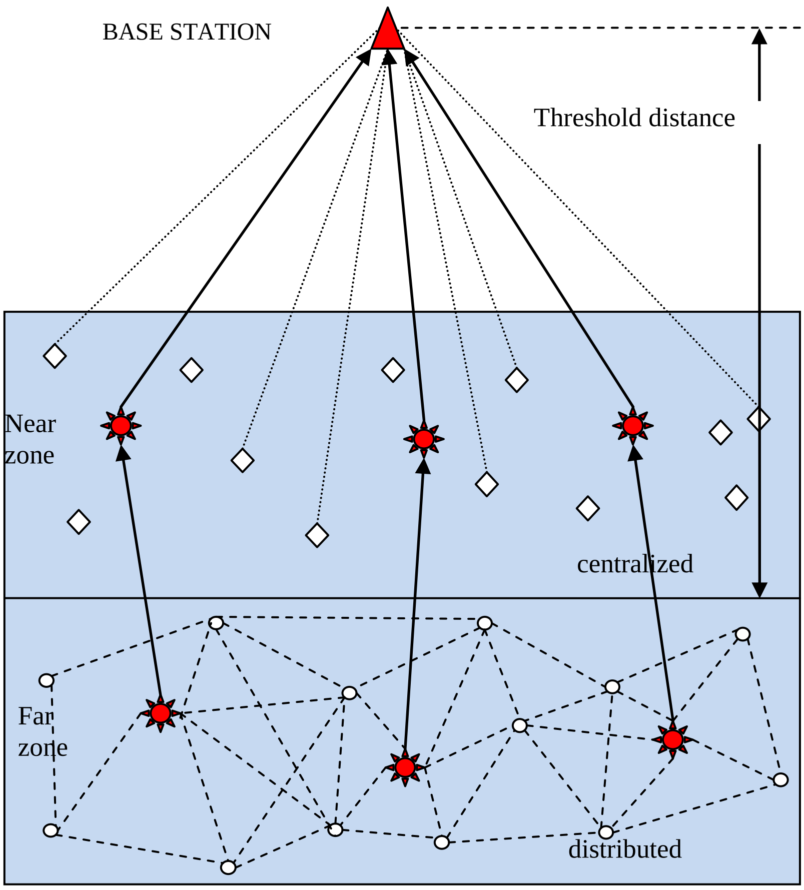

Fig. 3 Clustering in Near and Far Zones

3.2 Energy Enhanced Distributed Clustering

The nodes having greater distance from base station than the T_h value fall into far zone. In this case, although the clustering is distributed that is nodes have to communicate with each other using control messages and select appropriate cluster heads. Unlike LEACH protocol e have added two more parameters for CH selection, (a)

Residual energy of node, (b) Distance between two cluster heads. Minimum distance between[10][11] two cluster heads can be obtained by using following formula:-

$$MSD = \sqrt{\frac{xm * ym}{K_{opt}}}$$

Where, xm and ym are length and breadth of the network area,

K_{opt} is the optimum number of cluster heads.

These two parameters help in selecting evenly distributed and energy abundant cluster heads in the zone. In this case the optimum number of cluster heads is not fixed as a distributed approach is used but an upper limit for the number of cluster heads is set so that a near about optimal CHs could be chosen. We have set the maximum number of cluster heads to be five percent of the total number of nodes in the zone. Similar criteria is followed for the near zone in which BS selects five percent of the total nodes present in the near zone.

3.3 Division Into Zones

The decision of zone division was one of the challenge that must be taken with utmost care. Different zonal protocols[14][15] have been proposed in previous researches, we studied some of them to find out the different points that need to be taken care of while partitioning of a network into zones. The main points that should be considered are as follows:

- Almost equal number of nodes should fall into each zone.
- A generalized algorithm or formula should be used that can be used for different network dimensions.

Keeping in mind these two important factors we generated a formula that can be used for any number of nodes and for networks of different dimensions. The threshold value for node division is calculated by dividing the sum of distances of all the nodes from base station by total number of nodes in the network. Threshold (T_n)formula is as follows:

$$T_n = \frac{\sum_{n=0}^{n}(\text{dis\_to\_bs})_i}{n}$$

Where, n= total number of nodes

$(\text{dis\_to\_bs})_i$ = distance of node_i from BS.

3.4 Relay Node Selection

Clustering procedure is complete in both the near and far zones. Now, as we see that the network is very large therefore the (far zone CH-BS) distance is also longer. So, here we need an intermediate/bridge node for transmitting data between far zone and base station. All the cluster heads in near zone advertize in far zone for becoming relay node. Cluster heads in far zone calculate their distance from near zone cluster heads according to the received signal strength. Far node CHs selects nearest cluster head in near zone as their relay nodes/next hops.

3.5 Data Transmission Phase

Cluster heads are selected and clusters are formed in the cluster set up phase. Also, the relay nodes in near zone are selected which will be used as next hops by the cluster heads in far zone. Now data transmission phase continues which carries out the actual data transmission. Each and every node senses the data, converts it from analog to digital form and passes on to the microprocessor. Processor processes the data and sends to the transceiver where the signal is amplified and transmitted to the cluster head. Cluster head receives data from each node present in its cluster and then aggregates it, then transmits it to base station. Data transmission phase is comparatively large to set up phase because actual data transmission is carried out in data transmission phase only.

VI. SIMULATION AND RESULTS

Wireless sensor networks can be simulated on a number of simulators for studying the effect of various protocols, topologies. We have simulated our protocol on matlab simulator version R2013b. Following table consists of the various network parameters assumed for studying the working of EEAZ protocol :-

TABLE II Network Parameters

NETWORK PARAMETER	VALUE
Number of nodes	100
Network area (meters)	300x300
Location of BS	150,450
Initial energy of node	0.5 joules
Data message packet length	1000 bit
Control message packet length	50 bit
Sensing distance	50 m
Kopt (optimum number of cluster heads)	5%

The Matlab plot for node deployment is as follows:

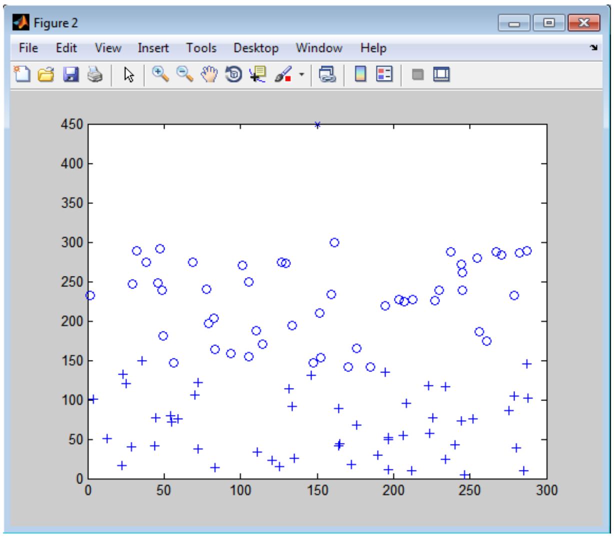

Fig. 4 Node Deployment and Zone Division in EEAZ.

First of all in the starting of each simulation the network is divided into two zones i.e., near and far zone. This division is done only once and remains same for the rest of rounds. Since the deployment of nodes is done randomly throughout the network area therefore the decision of zone division is completely dependent on the way in which nodes are deployed. Almost equal number of nodes fall into both the zones. The following figure depicts the deployment of nodes in the network and the division into zones. The circles represent the nodes lying in near zone and far zone nodes are represented by plus sign(+).

We have implemented our protocol for different network scenarios. Such as:

- Average remaining energy VS Number of rounds.
- Network lifetime VS Number of rounds.

The results of the comparison carried out for average remaining energy and Number of rounds is shown in fig 5 and fig 6. Our protocol consumes less amount of energy than both the LEACH and C-LEACH. As shown in the plot the average remaining energy of nodes is more at every particular instant of time.

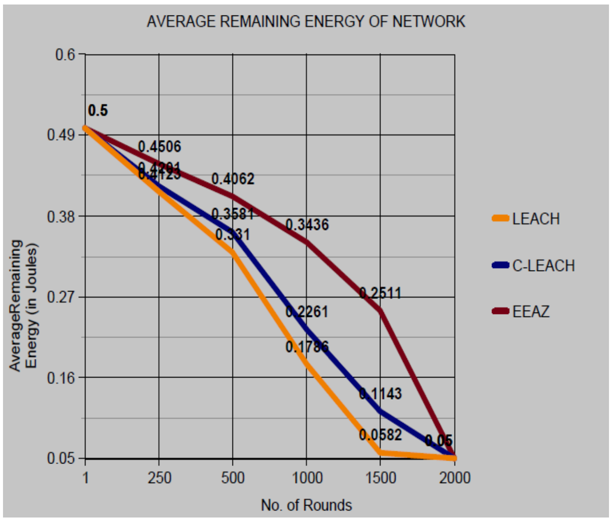

Fig. 5 Plot for Average Remaining Energy VS No. of Rounds in all the Three Protocols LEACH,C-LEACH and EEAZ.

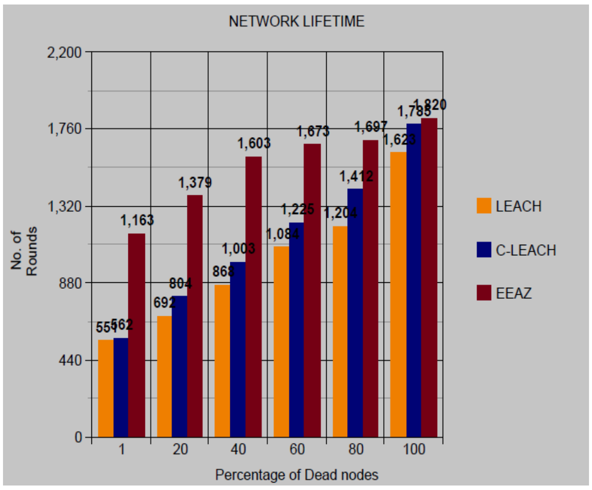

Fig. 6 Plot for Network Lifetime VS No. of Rounds in all the Three Protocols LEACH, C-LEACH and EEAZ.

This significant amount of improvement in using energy efficiently within the network is achieved due to the appropriate clustering scheme and use of additional parameters that are considered at the time of cluster head selection. Second plot depicts the number of nodes dead with respect to the number of rounds. This plot clearly shows that our protocol has much better network lifetime as we can see that the first node in leach dies at round 551 whereas in case of EEAZ first node dies at round 1163 which approx twice than leach. This kind of behavior is observed because the load is evenly distributed on all the nodes, low energy nodes are avoided to become cluster heads. Unlike leach where cluster heads are randomly chosen which results in early death of low energy nodes and those situated far from the BS.

VI. CONCLUSION

In this paper we have proposed a new protocol i.e., energy enhancement using area zoning (EEAZ) which turns out to be more energy efficient than both LEACH AND C-LEACH protocols. In this protocol, we have divided the network into two zones based on the distance of nodes from base station. we have implemented different clustering strategies in these two zones. Near zone clustering is done by using centralized technique governed by the base station while in far zone distributed clustering is implemented which is completely based on nodes themselves. The Proposed methodology works efficiently for large networks with a significant amount to increase in network lifetime which is almost twice for first node dead than leach protocol. We have studied the proposed methodology by varying the location of base station, number of nodes, initial energy and found that our results are better than the previous work in terms of average remaining energy and network lifetime. Cluster heads are evenly distributed all over the network resulting in a balanced load over all the nodes. Enhancements in future can be done by implementing this protocol for mobile nodes or mobile sink as well.

VII. ACKNOWLEDGEMENT

I would like to express my heartfelt gratitude to **Mr. Vishal Kumar Arora**, Assistant Professor in Department of Computer Science and Engineering, SBSSTC for his valuable time, support and guidance. He has been a constant source of motivation and encouragement throughout the research work. I would also like to thank all the authors for their valuable research papers, seminars and other sources of information.

REFERENCES

[1]. Wendi Rabiner Heinzelman, Anantha Chandrakasan, and Hari Balakrishnan, “Energy-Efficient Communication Protocol for Wireless Microsensor Networks,” IEEE 2000.

[2]. Wendi B. Heinzelman, Anantha P. Chandrakasan, “An Application-Specific Protocol Architecture for Wireless Microsensor Networks,” IEEE 2002.

[3]. Geetha. V., Pranesh.V. Kallapur, Sushma Tellajeera, “Clustering in Wireless Sensor Networks: Performance Comparison of LEACH & LEACH-C Protocols Using NS2,” ELSEVIER 2012.

[4]. Jos´e Henrique Brand˜ao Neto, Antoniel da Silva Rego, Andr´e Ribeiro Cardoso, Joaquim Celestino Jr., "MH-LEACH: A Distributed Algorithm for Multi-Hop Communication in Wireless Sensor Networks," ICN 2014.

[5]. Muhamnmad Omer Farooq, Abdul Basit Dogar, Ghalib Asadullah Shah, "MR-LEACH: Multi-hop Routing with Low Energy Adaptive Clustering Hierarchy," 2010 Fourth International Conference on Sensor Technologies and Applications.

[6]. Fan Xiangning, Song Yulin, "Improvement on LEACH Protocol of Wireless Sensor Network," IEEE 2007.

[7]. Gurbej singh, harneet arora,"Review on data dissimination and gathering in Wireless Sensor networks," International journal of emerging research in Management & Technology, 2013.

[8]. D. Hema Sumitha, M. Vivek Kumar, M. Priya, M. Alamelu Mangai, "Energy Optimizion In Leach Algorithms Using Ns2."

[9]. Sapna Choudhary, Sandeep Sharma, " A Survey of LEACH Protocol and its Modified Versions in Wireless Sensor Network," IJARCS Volume 4, Issue 1, January 2014.

[10]. Ewa Hansen, Jonas Neander, Mikael Nolin and Mats Bj¨orkman, "Efficient Cluster Formation for Sensor Networks."

[11]. Cosmin Cirstea, Mihail Cernaianu, Aurel Gontean, "A Cluster Head Election Method with Adaptive Separation Distance and Load Distribution for Wireless Sensor Networks,"*EMERGING 2012.*

[12]. Gurbej singh, harneet arora,"Design and architectural issues in Wireless Sensor Networks," International journal of Advanced research in computer science and software engineering, 2013.

[13]. Vipendra Kumar Mehra, "A Multi-Hop Routing Protocol With Pre-Cluster Head Announcement," 2013 International Conference on Cloud & Ubiquitous Computing & Emerging Technologies.

[14]. Ashim Kumar Ghosh, Anupam Kumar Bairagi, Dr. M. Abul Kashem, Md. Rezwan-ul-Islam, A J M Asraf Uddin, " Energy Efficient Zone Division Multihop Hierarchical Clustering Algorithm for Load Balancing in Wireless Sensor Network," *IJACSA Vol. 2, No. 12, December 2011.*

[15]. Zain ul Abidin Jaffri and Yueping Cai, "ZET: Zone and Energy Threshold based Clustering Routing Protocol for Wireless Sensor Networks," IEEE 2014.

[16]. Mr.Soumen Chatterjee, Mr.Mohan Singh, "A Centralized Energy-Efficient Routing Protocol for Wireless Sensor Networks," Int. J. Advanced Networking and Applications Volume: 03 Issue: 05 Pages:12-18 (2012).

[17]. Divya prabha, vishal arora, "A survey on leach and its Descendant protocols in Wireless Sensor Networks," Inernational conference on communication,computing &systems (ICCCS-2014).

[18]. Manisha Choudhury, "A Centralized Clustering approach for Wireless Sensor Networks," Nit Rourkela Thesis 2013.

[19]. M. Tripathi,, M.S. Gaur, V. Laxmi and R.B. Battula, "Energy Efficient Leach-C Protocol For Wireless Sensor Network," IEEE 2013.