ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijircce.com*

**Vol. 5, Issue 4, April 2017**

# Performance Comparison of Energy Efficient Cluster based Protocol in Heterogeneous Wireless Sensor Network

Priyanka.B.Patil[1], Dr.A.N.Jadhav[2]

PG Student , Dept of Electronics &Telecommunication, D.Y. P. College of Eng.& Tech., Kolhapur, Maharashtra, India[1]

Professor & H.O.D., Dept of Electronics &Telecommunication, D.Y. P. College of Eng & Tech, Kolhapur, Maharashtra, India[2]

**ABSTRACT**: Wireless sensor network consists of small battery powered sensors. Therefore, energy consumption is an important issue and several schemes have been proposed to improve the lifetime of the network. In this paper we propose a new approach called energy-driven adaptive clustering hierarchy (EDACH), which evenly distributes the energy dissipation among the sensor nodes to maximize the network lifetime. This is achieved by using proxy node replacing the cluster-head of low battery power and forming more clusters in the region relatively far from the base station. Comparison with the existing schemes such as LEACH (Low-Energy Adaptive Clustering Hierarchy), Energy Efficient Clustering Head Selection (EECHS) and reveals that the proposed EDACH approach significantly improves the network lifetime.

**KEYWORDS**: Wireless Sensor Network (WSN), Normal Node, Advanced Node, Cluster Head (CH), Base Station, proxy node, LEACH, EECHS, EDACH

## I. INTRODUCTION

A wireless sensor network consists of spatially distributed sensor nodes, which are connected without use of any wire. In a WSN, sensor nodes sense the environment and use their communication components in order to transmit the sensed data over wireless channels to the other nodes and to a designated sink point, referred to as the Base Station (BS). Now days in most wireless sensor network (WSN) applications the entire network must have to the ability to operate unattended in harsh environments. Harsh environments, refers to in which pure human access and monitoring cannot be easily scheduled or efficiently managed or it's even not feasible at all. Based on this critical expectation, in many significant wireless sensor network (WSN) applications, the sensor nodes are often deployed randomly in the area of interest by relatively uncontrolled means. [1]

In wireless sensor network, sensor nodes are making group naturally and cluster is formed. Clustering forms hierarchical network structure. Each cluster has a leader, which is called as Cluster head (CH) and it always perform special tasks. The several common sensor node is called as member node (MN).In this cluster head form higher level and cluster member node form lower level. Cluster head (CH) nodes aggregate the data and transmit them to the base station (BS) either directly or through the intermediate communication with other CH nodes. However, because the nodes send all the time data to higher distance than member nodes, they naturally spend energy at higher rates. Therefore some issues like Energy consumption and network lifetime comes into picture. The power consumed due to various kind of data is transmitted from the node to the sink i.e. BS which limits the network lifetime. The battery of the node is difficult to change. Hence it become important to consideration of number of cluster, cluster head as well as distance between cluster head and other sensor node for minimizing energy consumption and maximize network lifetime. [2]

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijircce.com*

**Vol. 5, Issue 4, April 2017**

Thus energy efficient protocols for wireless sensor network come into existence.

## II. RELATED WORK

W. Heinzelman, A. Chandrakasan, and H. Balakrishanan discussed the Low Energy Adaptive Clustering Hierarchy (LEACH**)** in which sensors are organized into clusters and one node in each cluster acting as CH takes the responsibility to collect data, aggregate them, and finally transmit them to the distant BS. They showed that the network is optimal in the sense of energy dissipation when around 5 percent of the total nodes act as CHs[1]. Author gives the operation of LEACH is divided into rounds, where a round begins with set-up phase followed by steady-state phase. During the setup phase each node decides whether it becomes the CH or not. After that, the CH broadcasts an advertisement message to the rest of the nodes. Depending on the received signal strengths, each node decides the CH to which it wants to belong for that round. Each CH then creates a TDMA schedule for all the member nodes in its cluster and sends it to them. During the steady state phase, the member nodes start sensing and transmitting data to the CHs according to the TDMA schedule, and the fused information by the CH is sent to the BS. At the end of a given round, a new set of nodes become CHs for the subsequent round and the process repeats [7]. Harneet Kour and Ajay K. Sharma, 2010 discuss about the H-HEED protocol. This protocol is basically used in heterogeneous wireless sensor network. H-HEED protocol is employed to extend the network life . The impact of heterogeneity in terms of node energy in wireless sensor network has been stated. H-HEED (Heterogeneous Hybrid Energy Efficient Distributed) is the revised version of the HEED protocol in terms of non- homogeneity [5].A. E. Tumer and M. Gunduz, author have discussed a EELP (Energy Efficient LEACH Protocol) routing protocol based on Low Energy Adaptive Clustering Hierarchy (LEACH) . In EELP, all nodes are organized sequentially in the rooms of the apartments of a multi-story building. In this protocol, cluster head (CH) selection is determined as the highest energy by the base station[8].A. Ray and D. De author have discussed the Efficient Clustering Head Selection (EECHS) adjusts the threshold value of the stochastic CH selection algorithm of Low Energy Adaptive Clustering Hierarchy (LEACH). It considers residual energy of the nodes, distance between the nodes and the BS, and the number of consecutive rounds in which a node has not been a CH in CH selection [6],[9].

## III . CLUSTERING PROTOCOLS

### . 1] LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH):

In the Low Energy Adaptive Clustering Hierarchy (LEACH) protocol, sensor nodes of the network will be organizing themselves into local clusters, with one of the nodes of them acting as the cluster head (CH).The operation of LEACH is carried out into multiple rounds, where each round is categorize into two phases,

(i) Set-up phase
(ii) Steady-state phase.

***(i) Set-up phase***

In Set-up phase each node considers itself as CH for the current round but it is decides based on the predefined percentage of CHs and how many times the node has been a CH in previous rounds. The decision is taken by the node choosing a random value from 0 and 1. The node will consider as a CH if the value is less than the given threshold value for current round.

$$T(n)=\begin{cases} \dfrac{p}{1-p\,(r \bmod (1/p))} & \text{if } n \,\varepsilon\, G \\ 0 & \text{Otherwise} \end{cases} \qquad \text{..................(1)}$$

Where,
r = current round number
G =set of nodes that have not become cluster head within the last 1/p rounds.

***( ii) Steady state phase***

In steady state phase, the member nodes start sensing and transmitting data to the CHs according to the TDMA schedule, and the fused information by the CH is sent to the BS. At the end of a given round, a new set of nodes become CHs for the subsequent round and the process repeats.[3]

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
(An ISO 3297: 2007 Certified Organization)
Website: www.ijircce.com
Vol. 5, Issue 4, April 2017

LEACH has advantage that node that select as a CH in particular round will not selected at the CH next round, so all nodes can equally share the load in the network and TDMA avoids unnecessary collision of CHs. [4]

**2] Energy Efficient Clustering Head Selection (EECHS):**

Another Protocol is Energy Efficient Clustering Head Selection (EECHS) protocol. It adjusts the threshold value of the stochastic cluster head selection algorithm of Low Energy Adaptive Clustering Hierarchy (LEACH). It considers Residual energy of the nodes, distance between the nodes and the BS and the number of consecutive rounds in which a node has not been a CH in cluster head [5].

To ensure an even energy load distribution over the whole network, additional parameters should be considered to optimize the process of cluster-head selection. So in this paper cluster head selection algorithm is improved by adjusting the threshold *T(n)*, relative to the nodes remaining energy, distance of the nodes from the base station and the number of consecutive rounds in which a node has not been a cluster head.

***(i)Residual energy factor***:

Here residual energy factor is

$$E(i)=(E_{residual}(i)/E_{initial}) \quad ..................(2)$$

Where, E residual is the remaining amount of energy and E initial is the initial energy of node before transmission .Variable i indicates the serial number of nodes.

***(ii) Distance from Base station factor:***

Base station (BS) sends its location (<X BS,YBS>) and serial numbers of nodes to all the sensor nodes in WSN. Serial numbers are only sent at the first round .All the nodes will compute their respective distances to BS immediately as soon as receive the information from the BS. For example, the distance from point i to BS is

$$d_{iB}= \sqrt{(X_i-X_{BS})^2+(Y_i-Y_{BS})^2} \quad .................(3)$$

also consider the distance of the farthest(d Farthest) node from the BS .

$$\text{Distance factor } D(i)= d_{iB}/ d_{Farthest} \quad .............(4)$$

D(i) is saved into node(i)'s RAM, and do not need to compute again, because all the nodes are static. The smaller D the node owns, the nearer to BS the node is, and vice versa. D is one of the main factors in electing CHs.

***(iii) Whether or not the node was recently a cluster head:***

Also it considers the factor that whether or not the node was recently a cluster-head. For example, suppose s is the number of consecutive rounds in which a node has not been a cluster head and *r* is the number of the current round. Then higher the (s div r) value, higher the chance of selecting as a Cluster head.

Considering all three factors the modified T(n)Becomes,

$$T(n)=\left\{ \frac{p}{1-p\,(r \bmod (1/p))} \times[E(i) + (1- D(i)) +(s \text{ div } r)] \quad \text{if } n \in G \right.$$
$$T(n)=0 \quad ............(5)$$

Where *P* is the cluster-head probability, *r* is the number of the current round and *G* is the set of nodes that have not been cluster-heads in the last 1/P rounds. In order to select cluster-heads each node *n* determines a random number between 0 and 1. If the number is less than the threshold *T(n)*, the node becomes a cluster-head for the current round. Using this threshold, each node will get a chance to be a cluster head that have not been cluster-heads in the last 1/P rounds. So here the value of s is always much less than the value of current round r. member nodes.

After the cluster-heads are determined, the cluster head nodes advertise clustering message towards surroundings and the normal nodes determine which cluster-head node they will join, in according to the strength of the message. The cluster heads generate TDMA schedule for every member node in order to make the member nodes transmit data in their own schedule.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
(An ISO 3297: 2007 Certified Organization)
Website: www.ijircce.com
Vol. 5, Issue 4, April 2017

The energy-driven adaptive clustering hierarchy (EDACH) approach that Puts more number of cluster-heads in the region relatively far from the base station .

## IV.PROPOSED PROTOCOL

### Energy Driven Adaptive Clustering Hierarchy (EDACH):

In EDACH, Each round of communication in the proposed scheme begins with the set-up phase where the clusters are organized, followed by the self-organized data collection and transmission phase where data transfer to the base station occurs. The second phase also includes the proxy node selection process and Indicator Control Message (ICM) advertisement process[6].

### *(i) The Set-Up Phase*

In this phase partition the entire area of the sensor network into three segments as near, medium, and far segment . The values of $P$ for the nodes belonging to different segments differ from each other. That is, the $P$ value for the nodes in the near, medium, and far segment is $(1-x)P$, $P$, and $(1+x)P$, respectively, where $0 < x < 1$. With this arrangement the nodes relatively close to the base station will have smaller threshold value and thus smaller chance to become a cluster-head.

When a node is selected as a cluster-head, it generates a cluster-head token. Then, the selected cluster-head advertises its token by CSMA/CA MAC protocol to all its neighbours. After the remaining nodes receive the advertisements, they compare the strengths of the received signals. It keeps only the token with the strongest signal in every comparison, and broadcasts the topology reply packet by CSMA/CA MAC protocol back to the cluster-head. In the reply packet the node's position (NP) and remaining energy (RE) level are included. When the cluster-heads receive the reply packets, they set up a schedule for the nodes in their cluster. Based on the number of nodes in the cluster, the cluster-head creates a TDMA schedule indicating when each node in the cluster can transmit.

### *(ii)The Self-organized Data Collection and Transmission Phase*

After the set-up phase, the self-organized data collection and transmission phase starts.

Every sensor node collects the data and then sends a packet to the cluster-head in its scheduled transmission time. The radio of a node is turned off when it is outside its scheduled time slot in order to save the energy. Each cluster-head keeps its receiver on to collect data from the nodes in its cluster and continuously updates the table listing the energy of the nodes based on the received packets. When the data from all the nodes have been received, the cluster-head executes the function for data fusion to aggregate the received data into one packet. After the data fusion, the cluster-head sends it to the base station. As a cluster-head needs to receive many packets and consume large power for long range transmission, its energy is used up more quickly than other nodes in the cluster. Therefore, a cluster-head can cause a failure because of energy deficiency. If a failure occurs at a cluster-head, the network has to be re-clustered and a new schedule needs to be transmitted to the sensors. This will significantly reduce the network lifetime. In order to solve this problem, a proxy node is selected if the battery power of the cluster-head becomes smaller than the threshold explained next.

### Calculation of the Threshold Value:

The threshold value, $E_{TH}$, plays a very important role in the data transmission phase. It is calculated when a cluster-head is selected. If the energy of the cluster-head drops below the threshold, the proxy node selection process begins. We assume that all sensors are identical and produce data at the same rate. The following equations are used to compute the threshold value.

$$k_j = M_{bit} \sum_{i=1}^{[n/k]-1} k_{ij} \qquad \text{.........(6)}$$

$$E_{CH(j)} = E_{ele} \times k_j + \varepsilon_{amp} \times k_j \times d_{CH(j)}^2 \qquad \text{.........(7)}$$

$$E_{TH} = 1/k \sum_{j=1}^{[n/k]-1} E_{CH(j)} \qquad \text{.........(8)}$$

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 4, April 2017

Here $k_j$ is the length of the aggregated message in the cluster-head and $d_{CH}$ is the distance between the cluster-head and base station. Since $E_{TH}$ changes with time, it is recalculated in every self-organized data collection and transmission phase. When the energy level of the cluster-head falls below the threshold, a proxy node is selected using the RE and NP value of the reply packets received in the set-up phase. After a node is selected as a proxy node, the cluster-head broadcasts an indicator control message (ICM) containing the address of the proxy node and a new TDMA schedule for the member nodes. The member nodes receiving the ICM send a confirmation message to the proxy node. When the proxy node receives the confirmation message, it keeps the node IDs of the member nodes. After the message exchanges are over, the member nodes resume data transmission.

## IV .NETWORK MODEL

There are two types of network on the basis of energy; homogeneous and heterogeneous. Informer type of network, nodes having same energy levels are deployed, whereas, in lateral type, nodes possess different initial energy levels[11].The heterogeneous network is considered in our work. We divide network into two energy levels of nodes. The nodes with higher energy level are called advanced nodes and the nodes with low energy level are called normal nodes. The percentage of advanced nodes is m. Each advanced node posses α times more energy than a normal node[12].

Energy of Normal node is,

$$E=E0 \qquad ...........(9)$$

Energy of Advanced node is,

$$E=E0\,(1+\alpha) \qquad ..........(10)$$

Where, E0=Energy of a normal node

## V.SIMULATION PARAMETERS

In this work, the sensor network with 100 Sensor nodes which are randomly distributed over the 100×100 $m^2$area. The sink or base station is located at central and boundary condition. The packet size that the nodes send to their cluster heads as well as the aggregated packet size that a cluster head sends to the sink is set to 4000 bits. The initial energy of each normal node is set to 1J. The proposed approach has been implemented in MATLAB R2012a .All the parameter values including the first order radio model characteristic parameters are mentioned in the table1.

**Table 1**: Various parameters and their values

| Parameter | Value |
|---|---|
| Number of nodes | 100 |
| Network Size | 100 ×100 $m^2$ |
| Location of BS | (100,100) |
| Cluster head probability | 0.05 |
| Data Packet Size | 4000bits |
| Initial Energy of node | 1J |
| Unit Energy consumed by the electronics toprocess one bit data (Eelec) | 50 nJ/bit |
| Energy for Data Aggregation EDA | 5 nJ/bit/Signal |
| Amplifier factor for free space ( $\varepsilon fs$) | 10 pJ/bit/$m^2$ |
| Amplifier factor for multipath model ($\varepsilon mp$) | 0.0013 pJ/bit/$m^2$ |

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
*(An ISO 3297: 2007 Certified Organization)*
*Website: www.ijircce.com*
**Vol. 5, Issue 4, April 2017**

### VI. SIMULATION RESULTS

The Simulation result gives comparison of Energy efficient EDACH protocol with LEACH and EECHS based on following parameters:
i) Packet rate
ii) Network Lifetime
iii) Death rate
iv)Number of cluster heads per round
v) Energy Consumption Rate

**i] Packet rate**
Figure 1 shows number of packet sent to base station per round .The amount of data received by the base station describes the rate of the accuracy of the nodes. The more data received means high accuracy .The EDACH uses proxy node in case of cluster head failure occurred. Therefore EDACH sent more number of packets as compares to LEACH and EECHS as shown in figure 1.

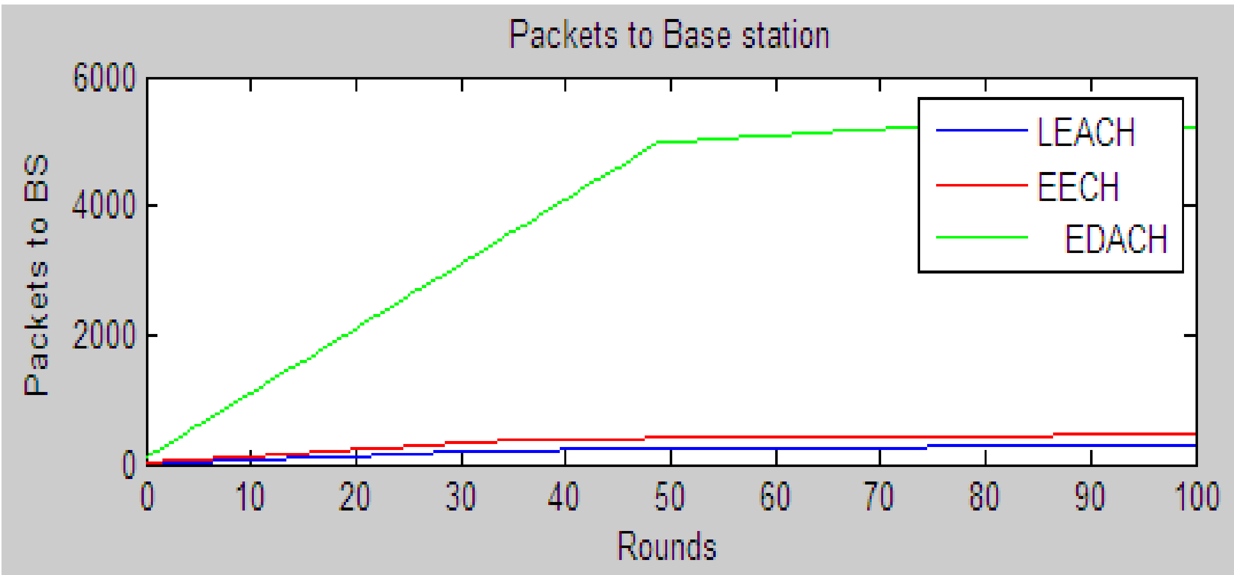


**Figure 1**.Packet sent to base station

**II] Network Lifetime**
Figure 2 shows number of alive nodes per round with base station at central position .The network lifetime of the sensor network is the lifetime of the network from the starting of the network to the end of the network. It means the time from where the network starts its operation till the phase network has completed its operation. The operation is measured in terms of the rounds .The network lifetime is measured in terms of number of alive nodes. Figure 2 shows that, for EDACH all nodes alive up to 31 round and for LEACH it is a up to 5round and for EECHS it is up to 9 round then goes to becoming dead, also EDACH contains more number of alive node as compares with LEACH and EECHS.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

**International Journal of Innovative Research in Computer and Communication Engineering**

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijircce.com*

**Vol. 5, Issue 4, April 2017**

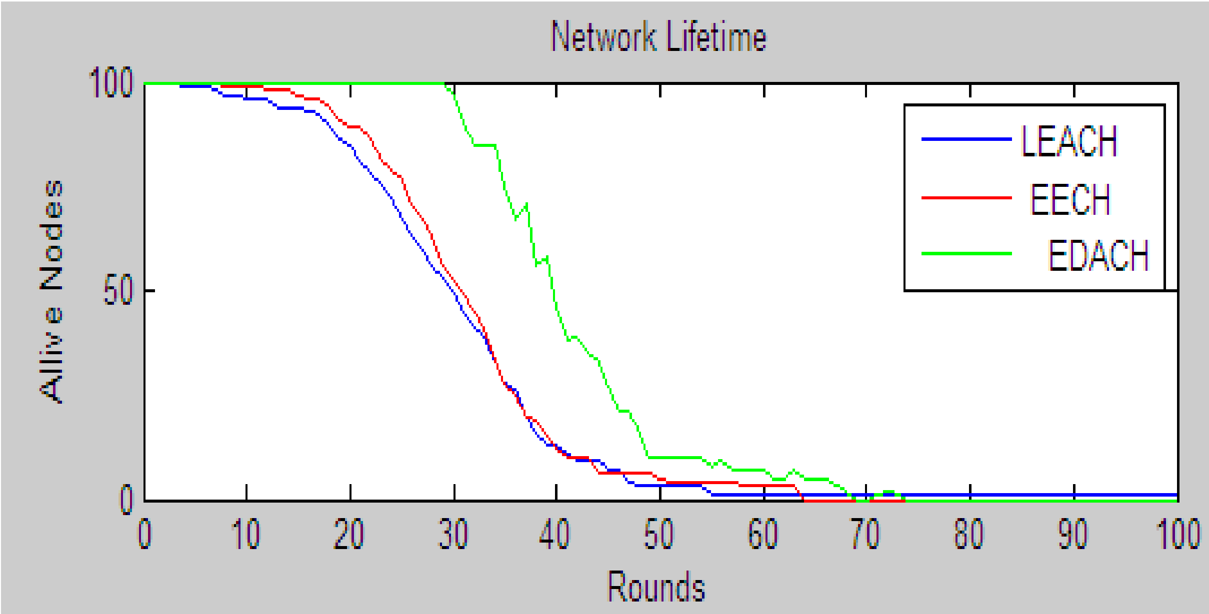


**Figure 2.**Network Lifetime

**III] Death Rate**

Figure 3 shows number of dead nodes per rounds .It is seen that for EDACH node start to becoming dead after 31 round and for LEACH it start after 5 round and for EECHS it is after 9 round.

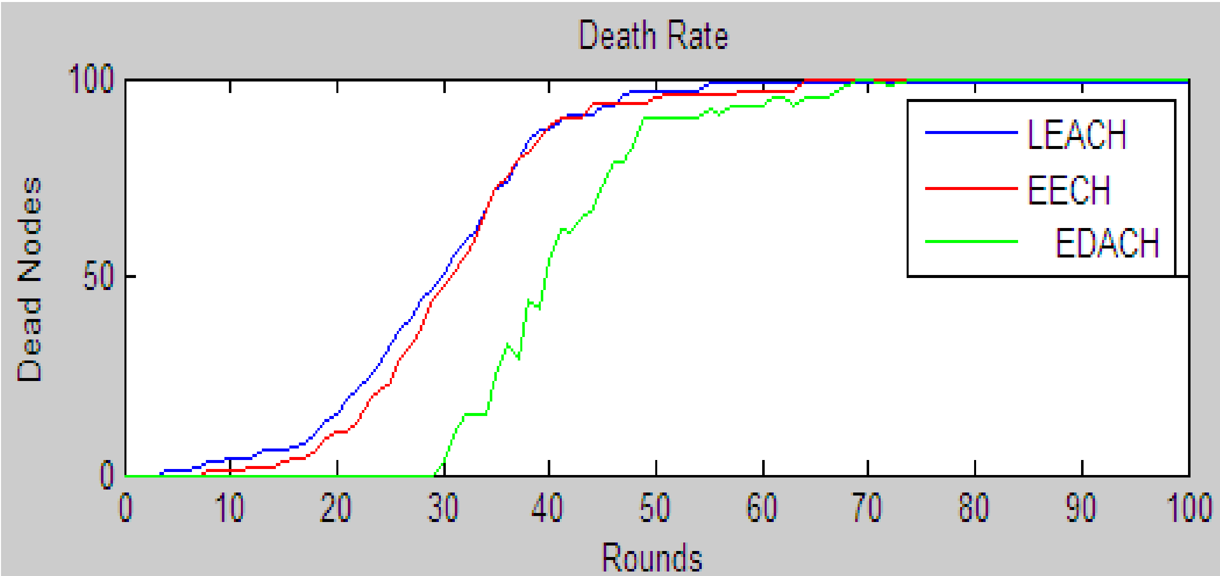


**Figure 3.**Death Rate

**IV] Number of cluster heads per round**

Figure 4 shows number of cluster heads per round. It gives instantaneous measure reflects the total number of nodes which would sent directly to the base station, information aggregated from their cluster member. It is seen that EDACH contains more number of cluster heads per round as compares with LEACH and EECHS.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

**International Journal of Innovative Research in Computer and Communication Engineering**

*(An ISO 3297: 2007 Certified Organization)*

*Website: [www.ijircce.com](http://www.ijircce.com)*

**Vol. 5, Issue 4, April 2017**

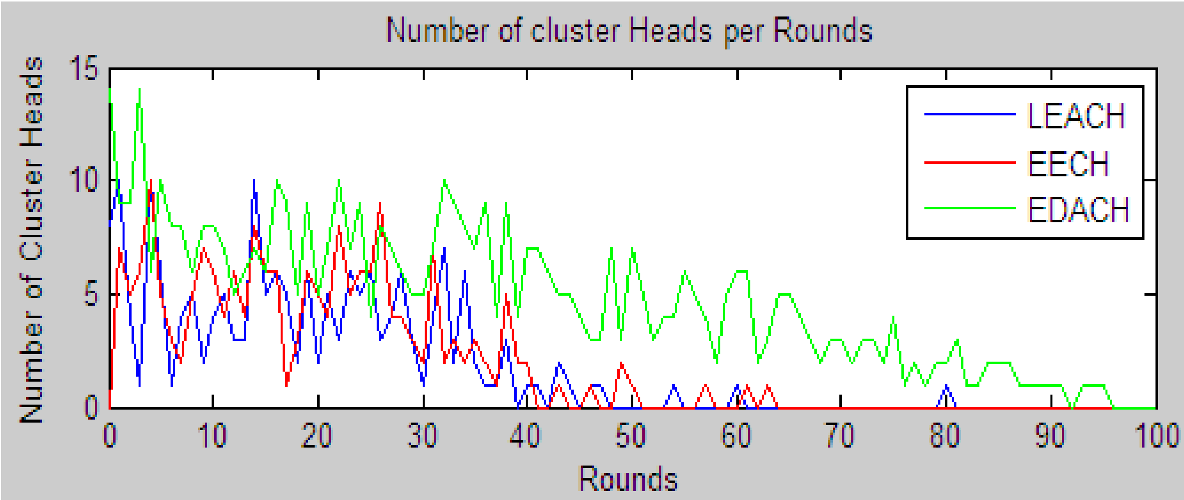


**Figure 4**.Number of cluster Heads per round

**V] Energy Consumption Rate**

Fig 5 shows that energy consumed per round. It is seen that LEACH consume more energy from 0 to 40 round about 230 J.EECHS consume 110 J energy from 0 to 100 round .EDACH consume 54 J energy from0 to 50 round. It is seen that EDACH consume minimum energy than EECHS and LEACH.

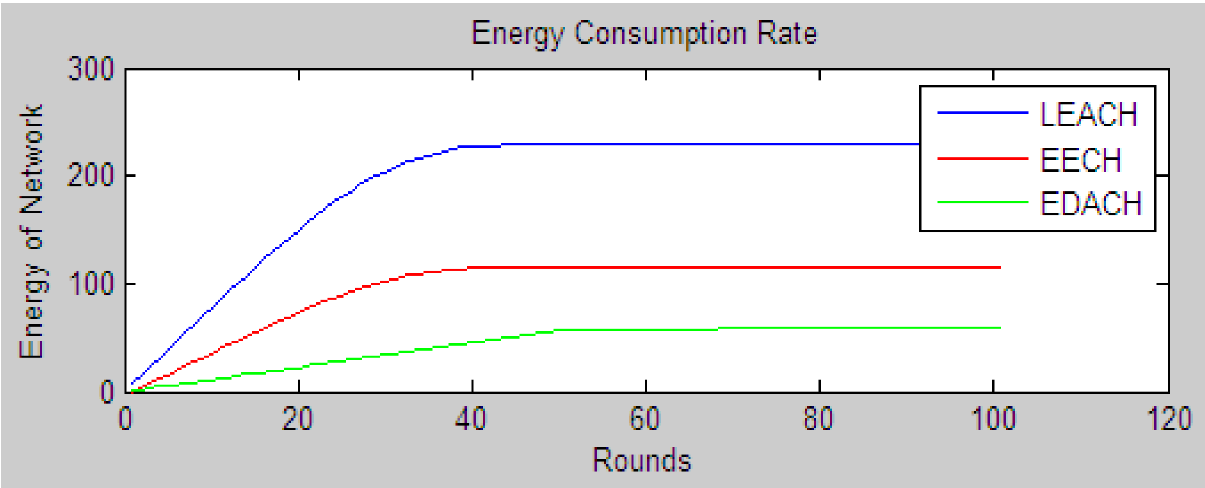


**Figure 5**.Number of cluster Heads per round

**Table 2**.Values of packet to base station, number of cluster head, first node die.

| Parameter | LEACH | EECHS | EDACH |
|---|---|---|---|
| Packet to BS | 294 | 461 | 5221 |
| Number of cluster heads | 9 | 11 | 14 |
| First node dead after(round) | 5 | 9 | 31 |

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering
(An ISO 3297: 2007 Certified Organization)
Website: www.ijircce.com
Vol. 5, Issue 4, April 2017

Table 2 gives comparison between LEACH, EECHS, EDACH. EDACH contains more number of packets i.e 5221 than LEACH and EECHS. Also EDACH have more number of cluster heads and it dead after 31 round. It is seen that EDACH ultimately increases network lifetime than EECHS and EDACH.

## VII. Conclusion

This paper gives performance analysis of Energy Driven Adaptive Clustering Hierarchy (EDACH) with Low Energy Adaptive Clustering Hierarchy (LEACH*)* and Energy Efficient Clustering Head Selection Protocol (EECHS) . EDACH use proxy node in case of cluster head failure and data transmission is occurred successively. From the result it can be concluded that EDACH increases network lifetime with minimum energy consumption than LEACH and EECHS . Also EDACH increases packet rate and number of cluster than LEACH and EECHS.

## References

[1] W. Heinzelman, A. Chandrakasan, and H. Balakrishanan,"Energy–Efficient Communication Protocol For Wireless Microsensor Networks", Proceedings the 33rd Annual Hawaii .International .Conference on System Sciences. Maui, IEEE Computer Society 2000, pp.3005-3014.

[2] B. Mamalis ,D. Gavalas, C. Konstantopoulos and G. Pantsiou, " Clustering in Wireless sensor Networks", Zhang/RFID and Sensor Network AU7777_C012, pp.323-353,2009.

[3] K. Kim, M. Kim, J.Choi, H.Youn,"An Energy Efficient and Optimal Randomized Clustering for Wireless Sensor Networks ", Sungkyunkwan University Suwon440-746, pp. IEEE Jun 2015.

[4] Alakesh Braman, Umapathi G. R, "A Comparative Study on Advances in LEACH Routing Protocol for Wireless Sensor Networks :A survey", International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 2, February 2014..

[5] Harneet Kour and Ajay K. Sharma, "Hybrid Energy Efficient Distributed Protocol for Heterogeneous Wireless SensorNetwork", International Journal of Computer Applications (0975 – 8887) Volume 4 – No.6, July 2010.

[6] A. Ray and D. De,"Energy Efficient Clustering Hierarchy Protocol for Wireless Sensor Network", in Proceedings ICCIA, pp.1-4, Dec.2011.

[7] Meghashree Kamath, Nandini Maninarayana, "Cluster Head Selection Algorithm to Minimize Energy Consumption in Wireless Sensor Network", International Journal of Innovative Research in Computer and Communication Engineering (An ISO 3297: 2007 Certified Organization) Vol.2, Special Issue 2, May 2014.

[8] A. E. Tumer and M. Gunduz,"An improved leach protocol for indoor wireless sensor networks", in Proceedings SPIN, pp. 432–437, Feb. 2014.

[9] Kaushik N. Gotefode, Dr. Kishor R. Kolhe, "A Survey on Energy Efficient Hierarchical Routing Protocol in Wireless Sensor Network", International Journal of Allied Practice, Research and Review ,ISSN 2350-1294.

[10] Kyung Tae Kim and Hee Yong Youn, "Energy-Driven Adaptive Cluster Hierarchy (EDACH)for Wireless Sensor Networks",Autonomic Computing and Network Project,21st Century Frontier,EUC Workshops 2005, LNCS 3823, pp. 1098–1107, 2005.

[11] Nikita Sehgal,Gurwinder Kaur,"Improved Cluster Head Selection Using Enhanced LEACH Protocol",International Journal of Engineering and Innovative Technology(IJEIT),Vol3,(September2013).

[12] A. Iqbal, M. Akbar, N. Javaid, S. H. Bouk, M. Ilahi, R. D. Khan, " Advanced LEACH: A Static Clustering-based Heteroneous Routing Protocol for WSNs", COMSATS Institute of IT, Islamabad, *Iqbal et al.*,2013.

## BIOGRAPHY

1] Priyanka Patil is a PG student of the Electronics and telecommunication Department, D.Y.Patil college of Engineering & Technology, Shivaji University Maharashtra ,India. She received Bachelor in Engineering degree in 2014 from JJMCOE, Shivaji Univesity India. Her research interests are wireless sensor network.

2] .Dr.A.N.Jadhav is Professor guide & Head of Department of the Electronics and telecommunication Department, D.Y.Patil college of Engineering & Technology, Shivaji University Maharashtra, India. He received Bachelor in Engineering degree from Shivaji Univesity India and Ph D degree in 2017. His research interests are wireless sensor network, digital communication ,Ad hoc network.