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Equalized Cluster Head Election Routing Protocol for WSNs

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Abstract—*In recent years, the growing interest in the WIRELESS SENSOR NETWORK (WISENET) is increases. Wireless Sensor Network is an emerging technology that promises a wide range of potential applications in both civilian and military areas. A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. Every sensor node is equipped with a Sensing Unit, Data Processing Unit, transceiver and power source. The development of WSNs largely depends on the availability of low-cost and low-power hardware and software platforms for sensor networks. Equalized Cluster Head Election Routing Protocol (ECHERP), pursues energy conservation through balanced clustering for Energy Efficiency.*

Keywords— Data Accuracy, Energy Efficiency, Network lifetime, Wireless Sensor Networks (WSN).

I. INTRODUCTION

In general routing protocols are classified based on topological structure of network mainly in Flat based Routing, Hierarchical routing and location based routing. Hierarchical routing protocol (ECHERP) [2] are used to reduce energy consumption by localizing communication within the cluster and aggregate the data to reduce transmission to the BS. The sensing electronics measure the ambient conditions related to the atmosphere surrounding the sensors and convert them into an electrical signal.

A wireless sensor network (WISENET) consists of computing, data processing, and communicating components with battery-operated sensor devices. In a WSN, the sensor nodes can be deployed in prohibited environments, such as factories, hospitals battlefield, civilian area, military area etc. environmental monitoring, military command and control, battlefield monitoring, etc.). Energy consumption is one of the major design issue in WSN to increase the network lifetime. Equalized Cluster Head Election Routing Protocol (ECHERP), pursues energy conservation through balanced clustering. ECHERP calculates the combinations of nodes that can be chosen as cluster heads in order to extend the network lifetime. The objective of this project is to simulate and analyses performance of routing protocol by using various metrics like energy usage in terms of network load, throughput, energy efficiency and delay and end-to-end performance characteristics of algorithms.

II. MOTIVATION

Sensors in WSN [6] are very delicate to energy consumption because they require energy during many phases like environment sensing, data processing and communication phases. If one node or some percentage of nodes dies in network then entire network can become non-functional. So limited energy consumption is a critical issue while designing routing protocol for WSN to increase the network lifetime. For this reason many of the data routing protocol has been proposed for data transmission in WSN. Most of the protocol like LEACH uses cluster in order to reduce energy consumption and to increase the network lifetime.

In Low Energy Adaptive Clustering Hierarchy (LEACH), hierarchical protocol in which most nodes transmit to cluster heads, is presented. The operation of LEACH consists of two phases:

- **The Setup Phase**: It consist of clusters are organized and the cluster heads are selected. In each time, a stochastic algorithm is used by each node to determine whether it will become a cluster head. If a node becomes a cluster head one time, it cannot become a cluster head again for P rounds, where P is the desired percentage of cluster heads.
- **The Steady State Phase**: In the steady state phase, the data is sent to the base station. The period of the steady state phase is longer than the period of the setup phase in order to reduce overhead.

LEACH is a protocol that have a tendency to lessen energy consumption in a WSN. However, LEACH uses single-hop routing in which respectively sensor node transmits information directly to the cluster-head or the sink. Therefore, it is not suggested for networks that are deployed in huge areas.

III. ECHERP

The ECHERP [2] (Equalized Cluster Head Election Routing Protocol), with the purpose of growth of the network lifespan elects a node as cluster head that reduces the total energy intake in the cluster and not the node with the higher energy. ECHERP also accepts multi hops routing system to transfer data to base station. In ECHERP, the BS is predictable to have unlimited energy residues and communication power. It is also supposed that the BS is located at a fixed position, either inside or away from the sensor field. The longer the distance between the BS and the center of the sensor field, the higher the energy expenditure for every single node transmitting to the BS.

Entirely the network nodes, which are presumed to be located within the sensor field, are energetically grouped into clusters. One of the nodes within each cluster is chosen to be the cluster head of this cluster. Therefore, the number of cluster heads is equal to the number of clusters. The cluster heads, which are located close enough to the network base station, are mentioned to as the first level cluster heads. These cluster heads are capable of direct transmission to the base station with sensible energy expenditure. The cluster heads that are situated at large coverage positions from the base station are considered as second-, third-, etc. level cluster heads. These cluster heads pass on data to the upper level cluster heads. Moreover, in order to succeed balanced energy consumption and extend the network's lifespan, the election of the cluster heads is performed in turns.

The main distinctive of ECHERP is the cluster head selection process. In this protocol, in order to designate a cluster head, the routing data and the energy consumed in the network are conveyed as a linear system, the solution of which is computed using the Gaussian elimination algorithm. Therefore, cluster heads are nominated as the nodes that minimize the total energy consumption in the cluster.

3.1 Algorithm of ECHERP

In ECHERP [7] Algorithm the steps in order to structure clusters and then choose cluster heads are the following:

1. The BS (Base Station) creates a Time Division Multiple Access (TDMA) timetable and appeals the nodes to broadcast themselves, a process similar to that of other protocols.
2. Individual node broadcasts a message to advertise its energy level and location to its neighbors. Based on this exchanged information, each node arrange up a neighbor information table that registers the energy level and the locations of its neighbors nodes and sends this table along with its equivalent information to its neighbors nodes. This step is repeated until the information of all the nodes in the network is sent to the BS, allowing the BS to have a global knowledge of the network. At this step, all the nodes are cluster head applicants, and each node has a unique ID that is also counted in the exchanged table.
3. Once the node advertisement is completed, the BS start the Gaussian elimination algorithm and calculates the number of rounds at which every node can be a cluster head, trying to maximize the network lifespan. In the first step of the cluster head selection, the BS elects the nodes nearby to itself to be the high level cluster heads. Moreover, around of the nodes from which the BS has not received any direct advertisement message are considered to be low energy level cluster heads.
4. The BS broadcasts the unique IDs of the newly nominated cluster heads, and their cluster members and the nodes use this information to form and enter a cluster. Therefore, each node has the information of the number of times that it can be a cluster head and the number of times that it cannot. The BS runs the Gaussian elimination algorithm and figures the appropriate number of rounds that the nodes can be cluster heads and sends this data to the nodes.
5. The lower level cluster heads do not transfer directly to the BS. They route the upper level cluster heads as middle rep eaters of their data to the BS.
6. Each cluster head creates a TDMA schedule and broadcasts this schedule to the nodes in its cluster, in order to inform each node of the timeslot that it can transmit. Moreover, the radio component of each node is allowed to be turned off at all time periods. Therefore, the energy dissipation of every individual sensor is greatly reduced.
7. After, the data communication starts. The nodes, based on the allocated transmission time, pass on the data relating to the sensed events to their cluster head. The transmission power of every node is adjusted to the minimum necessary to reach its next hop neighbor. In this way, both the intrusion with other transmissions and the energy dissipation are condensed.
8. Then each lower level cluster head aggregates the data and then transmits the compressed data to the upper level cluster heads until the data reaches the base station. A round of data transmission has been completed, and the protocol continues from step 4 for the next round.
9. In case that there is a change in the network topology, due to either a change in a node position or in the total dissipation of a node residual energy, the BS uses again the Gaussian elimination algorithm to determine the appropriate cluster head election.
10. The execution of the protocol is terminated as soon as all the nodes in the network run out of energy.

The pseudo-code of the Gaussian elimination algorithm used in ECHERP algorithm as used in the proposed protocol is presented as follows:

```
for (k = 1; k < m + 1; K++)
        i_max: argmax (i = k ... m, abs(A[i, k]));
if (A[i_max, k] = 0)
        error "Matrix is singular!";
swap rows (k, i_max);
for (i = k + 1; i < m + 1; i++)
        for (j = k + 1; j < n + 1; j++)
                A[i, j]: = A[i, j] − A[k, j] x (A[i, k]/ A[k, k]);
```

The proposed protocol performs clustering only once, at the initial stage. Hence, the protocol can avoid the time and energy consumed for re-clustering. The energy spent by the nodes in the network is modeled as a linear system, and the BS uses the Gaussian elimination algorithm in order to compute the energy consumed by a node if it becomes a cluster head at the very next round by taking into consideration all possible combinations. Therefore, a combination that minimizes the overall energy consumption and prolongs the network is selected.

Let us assume that a cluster consists of **k** nodes; matrix **A** represent the energy consumption of every node in the cluster and **k** the number of nodes in a cluster. **aij** Denotes the energy consumed by node **i** if node **j** is the cluster head. Additionally, **bi** denotes the residual energy of node **i**, while **xi** expresses the times that node **i** can become a cluster head. In this way, matrices **B** and **X** are formed, so that A·X = B, as shown in Equation (1).

$$\begin{pmatrix} a_{11} \; a_{12} \ldots a_{1k} \\ a_{21} \; a_{22} \ldots a_{2k} \\ . \quad . \quad . \quad . \\ . \quad . \quad \ldots \\ a_{31} \; a_{32} \ldots a_{3k} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ . \\ . \\ x_k \end{pmatrix} = \begin{pmatrix} b_1 \\ b_2 \\ . \\ . \\ b_k \end{pmatrix} \qquad (1)$$

This algorithms propose a great solution, since they select the node with the higher residual energy in the cluster as the cluster head for the next round. Though, this does not assure the maximum prolongation of the overall network lifetime. Therefore, if the node with the highest residual energy is a node located at the side of the cluster, this can lead other nodes to spend considerable amounts of energy to reach that node, which cannot be energy efficient for the entire network. This is the reason we propose a protocol that elects as cluster heads nodes that minimize the total energy consumption in a cluster.

All the network nodes, which are assumed to be located within the sensor field, are dynamically grouped into clusters. One of the nodes within every cluster is elected to be the cluster head of this cluster. Therefore, the number of cluster heads is equal to the number of clusters. The cluster heads, which are located close enough to the network base station, are referred to as the first level cluster heads. These cluster heads are capable of direct transmission to the base station with reasonable energy expenditure.

ECHERP chooses cluster heads in the network using a model, as most of the previously proposed protocols. However, the main difference with other protocols is that this one uses a supplementary effective tool to select a node as the cluster head. This is completed by considering the current and the estimated future residual energy of the nodes, along with the number of rounds that they can be cluster heads, in order to maximize the network lifetime. ECHERP models the network and the energy spent by the nodes as a linear system and, using the Gaussian elimination algorithm, selects the cluster heads of the network.

3.2 Flow Chart of ECHERP

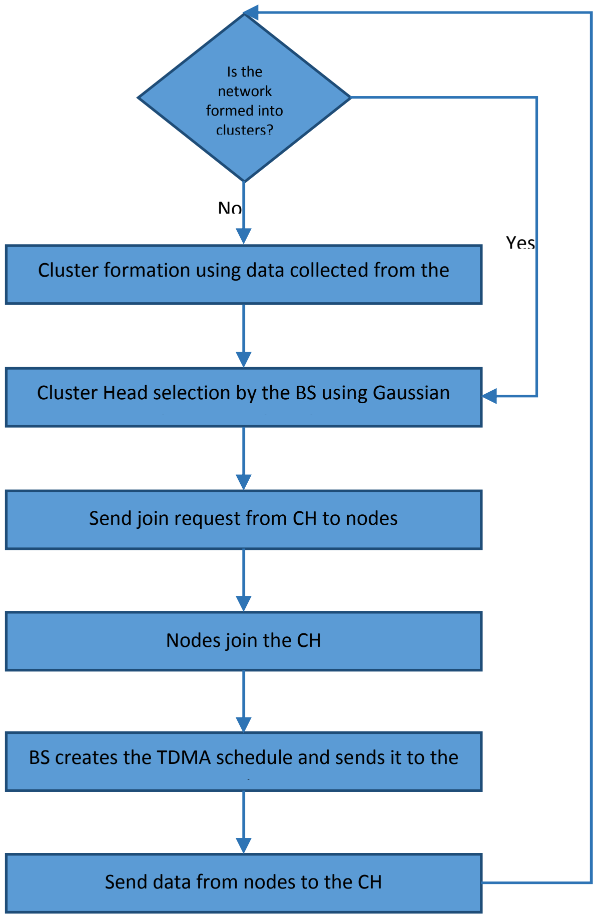

Fig.1: Cluster formation in ECHERP

IV. SIMULATION ENVIRONMENT

We performed simulation in network simulation (NS-2). Simulation Configuration is conducted within the Network Simulator NS2.34 environment on a platform Ubuntu 10.04. The system is running on a laptop with Intel(R) Core(TM) i7-4510U CPU and 8-GB RAM. In NS2.34, the configuration specifies 50 and 100 nodes in a flat space with a size of 200m × 200m with single source and destination with possible of multiple routes. Both the physical layer and the 802.11 MAC layer are included in the wireless extension of NS2. The moving speed of mobile node is limited to 10ms. User Datagram Protocol traffic with constant bit rate is implemented with a packet size of 512 B. The packets are routed using Ad hoc On-demand distance vector routing protocol and the acknowledgments Packets are authenticated using RSA and AES algorithm.

Network Simulator (Version 2), widely known as NS2, is simply an event-driven simulation tool that has proved useful in studying the dynamic nature of communication networks. Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2. In general, NS2 provides users with a way of specifying such network protocols and simulating their corresponding behaviors. After simulation, NS2 outputs either text-based simulation results. To interpret these results graphically and interactively, tools such as NAM (Network AniMator) and XGraph are used. To analyze a particular behavior of the network, users can extract a relevant subset of text-based data and transform it to a more conceivable presentation. The supporting tools that come with the NS2 installation, which help set up environment and run simulations. NAM (Network AniMator): NAM is a TCL-based animation tool for viewing network simulation traces and real traces of packet data.

V. SIMULATOIN RESULTS

We evaluate mainly in following metrics using cutting-edge tools in algorithm of ECHERP. As per simulation environment worked on different metrics like Packet Delivery Ratio (PDR), Control Overhead, Normalized Routing Overhead, Delay, Throughputs and Dropping Ratio.

In figure (2) shows PDR of ECHERP protocol performed in very balance condition, so the ratio in between 55 to 71 which is good for network having constant after 55. The cluster formation algorithm must ensure minimum overhead, in terms of time and energy with the aim of rotating cluster-head nodes and associated clusters. In figure (3) shows control overhead of data transmission increases smallest with respect to time in seconds. Next in figure (4) which is normalized routing overhead initially it behave in bad manner but in few seconds the graph value increases. This algorithm also minimizes the energy and latency for cluster formation, in order to minimize overhead to the protocol. In figure (5) Delay increases initially but after few seconds it becomes constant. In our simulation protocol gives throughput as shown in figure (6). Let's observed figure (7) dropping ratio which is increases initially but immediately constant. Now figure (8) is showing Average energy of ECHERP.

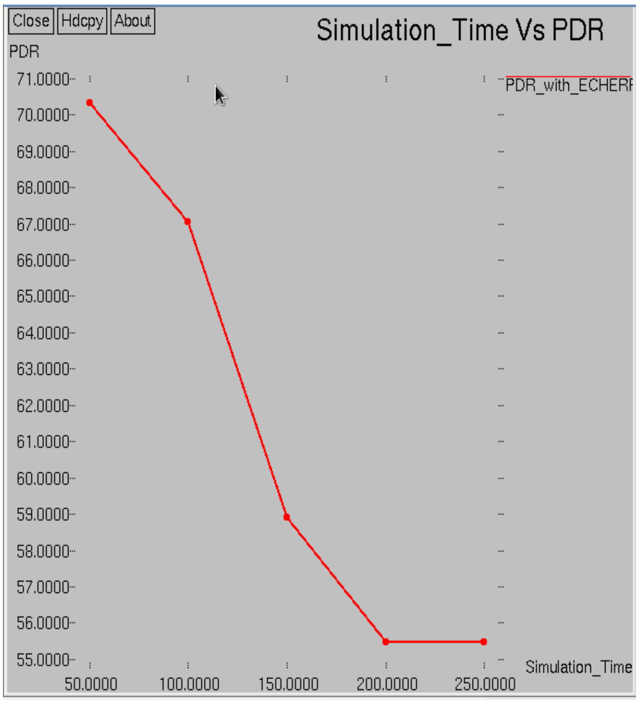

Fig.2: Packet delivery ratio (PDR) of ECHERP

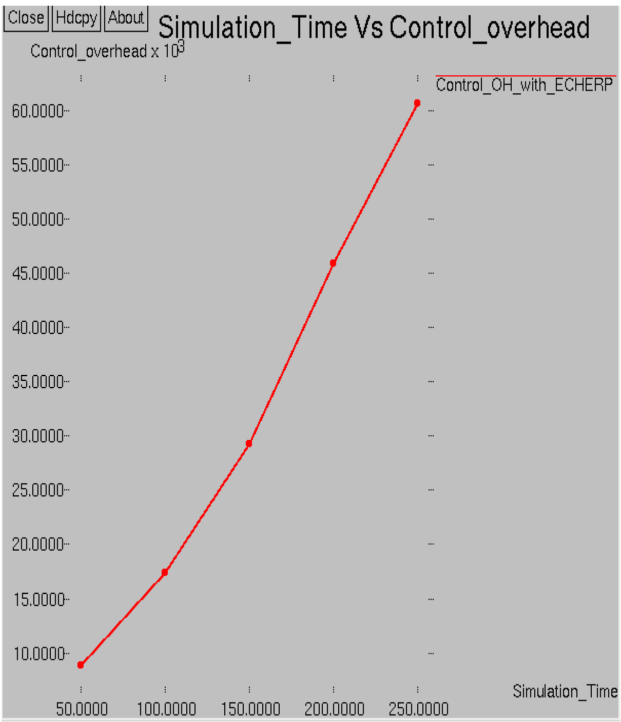

Fig.3: Control overhead of ECHERP

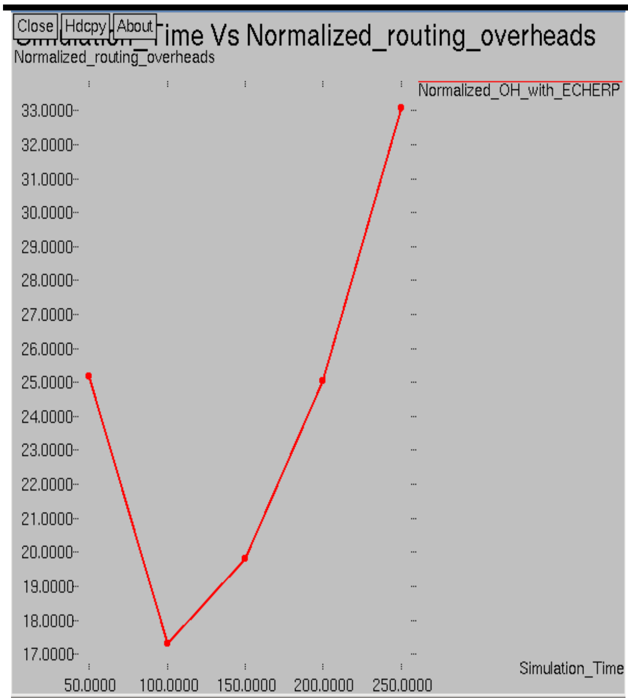

Fig.4: Normalized routing overhead of ECHERP

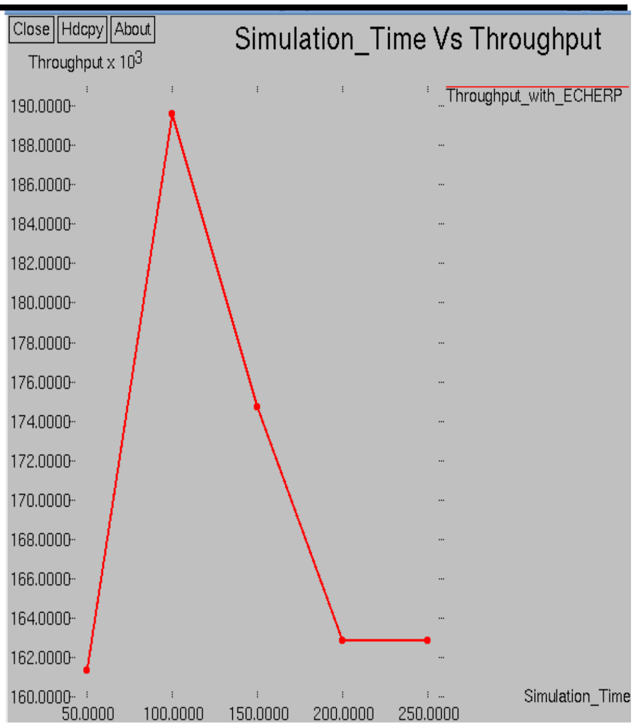

Fig.6: Throughput of ECHERP

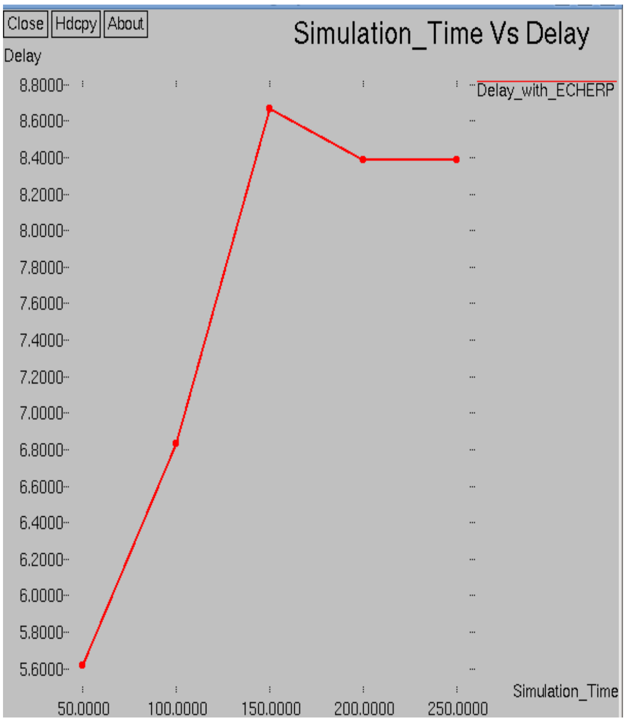

Fig.5: Delay of ECHERP

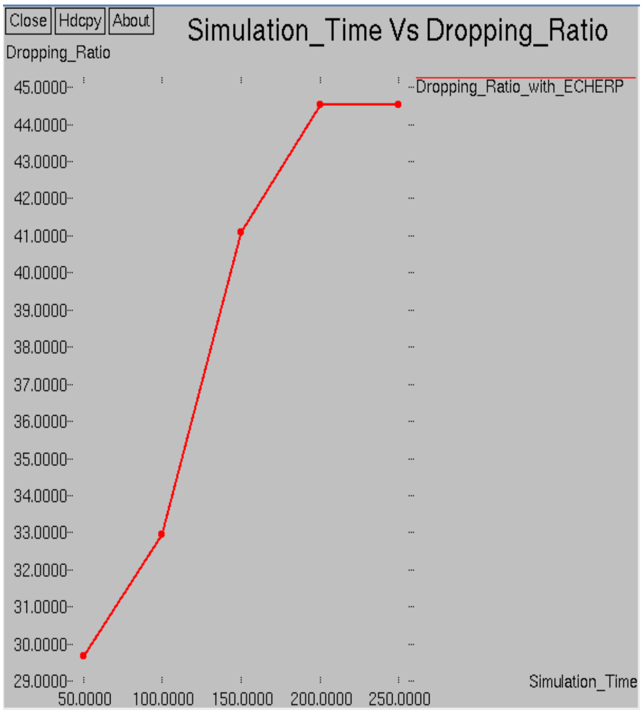

Fig.7: Dropping ratio of ECHERP

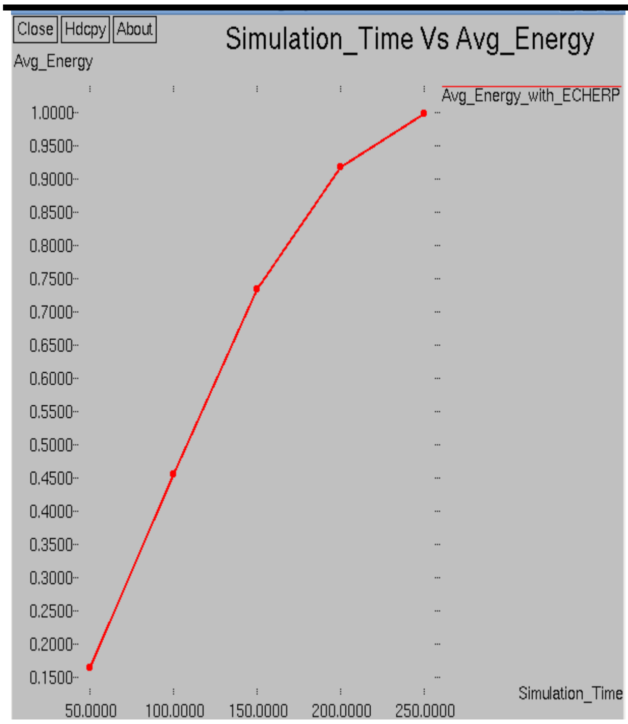

Fig.8: Average Energy of ECHERP

VI. CONCLUSION AND FUTURE WORK

In this type of protocol our main objective to elect cluster head with higher energy for better network life span using Gaussian algorithm. As per simulation results we observed that each metric shows better performance. By election process of cluster head we achieved our goals. We hope that the simulation results presented by us will be useful to other researchers to analyses. In future we will compare ECHERP protocol with PDCH protocol for WSN. PDCH (PEGASIS with Double Cluster Head) is a chain based double cluster head protocol that is near optimal data transmission algorithm in sensor network. This protocol distribute the work load among two cluster heads, nodes were selected in suitable ways to transmit the data to BS to balance the energy depletion in the network and preserve robustness of the sensor web as node dies at random location.

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