AN ENERGY SAVING ADAPTIVE CLUSTERING FOR WIRELESS SENSOR NETWORK (ESAC)

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ABSTRACT

Routing in Wireless Sensor Networks is different from routing in AD-HOC networks as nodes are randomly deployed. There are three types of routing in the WSNs: Flat, Hierarchical and Location Based Routing. The paper discusses the problem in one of the existing routing protocol in Hierarchical routing and suggests an improvement to deal with the problem. This paper work proposes a hierarchical routing protocol ESAC which shows energy efficiency. Our technique selects cluster head with highest residual energy in each communication round of transmission and the shortest distance to the base station(or next cluster head) from the cluster heads. And we also focus on position of the base station as well as the equal area of each cluster in the network.

Keywords - Sensor networks, hierarchical routing, spin etc.

I. INTRODUCTION

Wireless sensor networks consist of small nodes with sensing, computation, and wireless communications capabilities. WSN [1], [2] contains the sensor nodes and each node is randomly deployed in the regions. Wireless sensor networks are a rapidly growing area for research and commercial development. [3] These types of networks are used to monitor a given field of interest for changes in the environment. They are very useful for military, environmental and scientific applications, distributed computing, detecting ambient conditions such as temperature, movement, sound, light etc to name a few.

Cluster-based approaches are suitable for continuous monitoring applications [4]. Among the available hierarchical routing protocols, LEACH (low-energy adaptive clustering hierarchy) [5] shows significant performance [6] improvements in terms of network lifetime [7] and throughput [8]. Already there has been a lot of research work based upon LEACH to make this protocol more reasonable and efficient, such as LEACH-C [9], LEACH-H [10], ACHTH-LEACH [11], and ESCAL-LEACH [12].

In this paper, by modifying the set-up and steady phase of LEACH, the proposed scheme improves the selection of CH nodes as well as information is also processed and other working of LEACH we consider the same.

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II. DESCRIPTION OF CURRENT LEACH PROTOCOL

A. LEACH Architecture

LEACH is completely distributed, requiring no control information from the base station, and nodes do not require knowledge of the global network. It runs with many rounds. Each round begins with a set-up phase when the clusters are organized, followed by a steady-state phase when data are transferred from the nodes to the cluster head and on to the BS, as shown in Fig. 1.

The steady-state phase duration is usually much longer than set-up phase duration. However, the first phase is more important, in which sensor nodes are allowed to elect themselves as cluster-heads randomly, and then divided into clusters. Each node that becomes the cluster head (CH) will create a TDMA schedule for the sensor nodes within the cluster. That allows the radio components of each non-CH-node to be turned off all times except during their transmit time. Fig. 2 shows the cluster formation algorithm of LEACH.

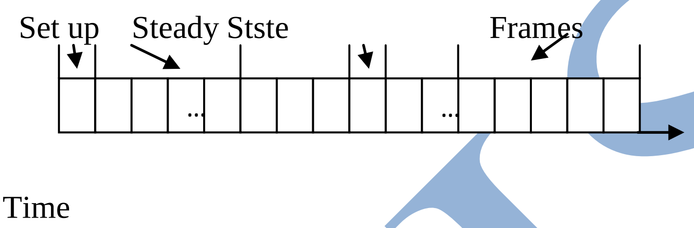

Fig.1 Timeline Showing Operation of LEACH

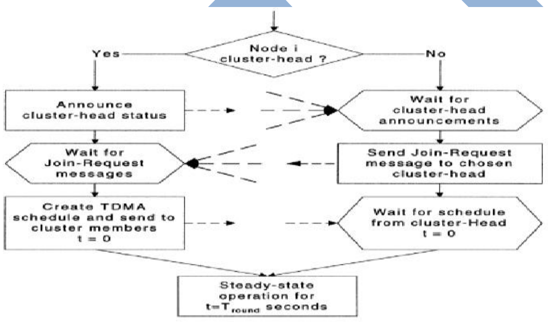

Fig. 2 Cluster Formation of LEACH Protocol

B. Drawbacks of LEACH Protocol

1). Cluster heads are selected randomly in LEACH; it is possible that nodes with less energy would be chosen, which could lead to these nodes die too fast.

2). In addition, because in LEACH protocol cluster heads communicate with base stations in single-hop manner, it is energy consuming and its expandability is limited so that it could not adapt to large network.

3).The Dynamic nature of the routing techniques also create overhead in the LEACH protocol.

III . ESAC PROTOCOL

Our proposed hierarchical routing protocol is based on the principle of clustering algorithm. With data transmission at the network layer being the core area of interest, we have modified the LEACH protocol in terms of hierarchical data

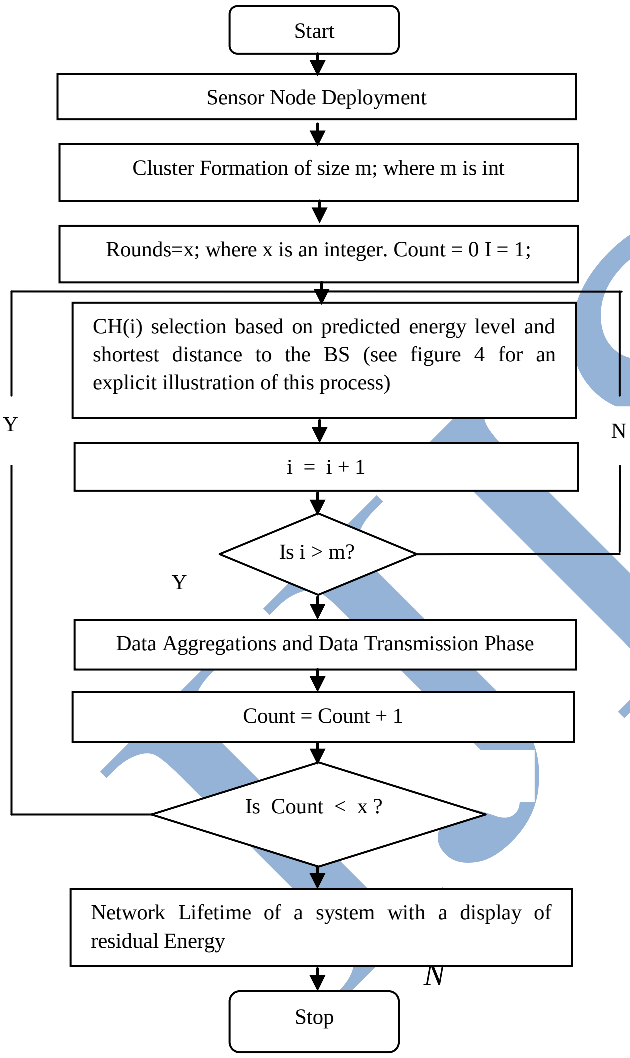

Fig 3 Flowchart of the Proposed Hierarchical Technique

transfer with the employment of energy balancing technique for selection of CH via any shortest path to the BS. In the proposed model, clusters are formed geographically. Geographical formation of

cluster sizes is based on equal segmentation of area space, depending on the case being considered. Apart from the one cluster formation which makes use of the entire sensors area space, other formation such as two clusters or three clusters formation involves equal separation of area space. The two & three clusters formation are known as first level and four & five cluster formation known as second level hierarchy respectively.
The CH election phase proceeds after the cluster formation phase. The selection of CH(s) within each cluster formed is carried out by electing a node that having highest residual energy and minimum distance (to BS or to the next hop CH nearer to the BS) for a particular transmission round. Due to draining activities being constraint on a cluster head during data aggregation and transfer phase, the cluster head is rotated among the sensor nodes of each cluster at every transmission round. A completely new residual energy is carried out at the beginning of every transmission round to elect a new CH for the cluster and thereby energy wastage is being reduce to its minimum, and utilization of each nodes energy is being maximized to ensure a prolong network lifetime. Fig 3 and Fig 4 illustrates the proposed hierarchical routing technique and the cluster head selection of the protocol respectively.

The algorithm in Fig 3 consists of four main stages

i. Geographical formation of cluster.

ii. Selection of cluster heads in each cluster formed.

iii. Data aggregation phase which involves the gathering of collected data by the cluster head from the sensor nodes within its cluster.

iv. Data transmission phase which involves the transfer of all data from the nearest cluster head(s) to the BS.

Also, the Fig. 4 illustrates the CH selection in the proposed hierarchical routing technique. The CH selection flowchart can be explained also in four main stages:-

i. The initial energy or residual energy $E_{in}(n)$ of node is measured.

ii. The maximum energy after the subsequent transmission round for each node is estimated using the formula: max $(E_{in}(n)- E_{amp}*k*d^2$.

iii. Also the distance $d(n)$ from each node to the base station or to the corresponding higher level cluster head is measured.

iv. On behalf of 2nd and 3rd step, the CH selection is carried out, the next cluster head selection will take place after the current round is completed.

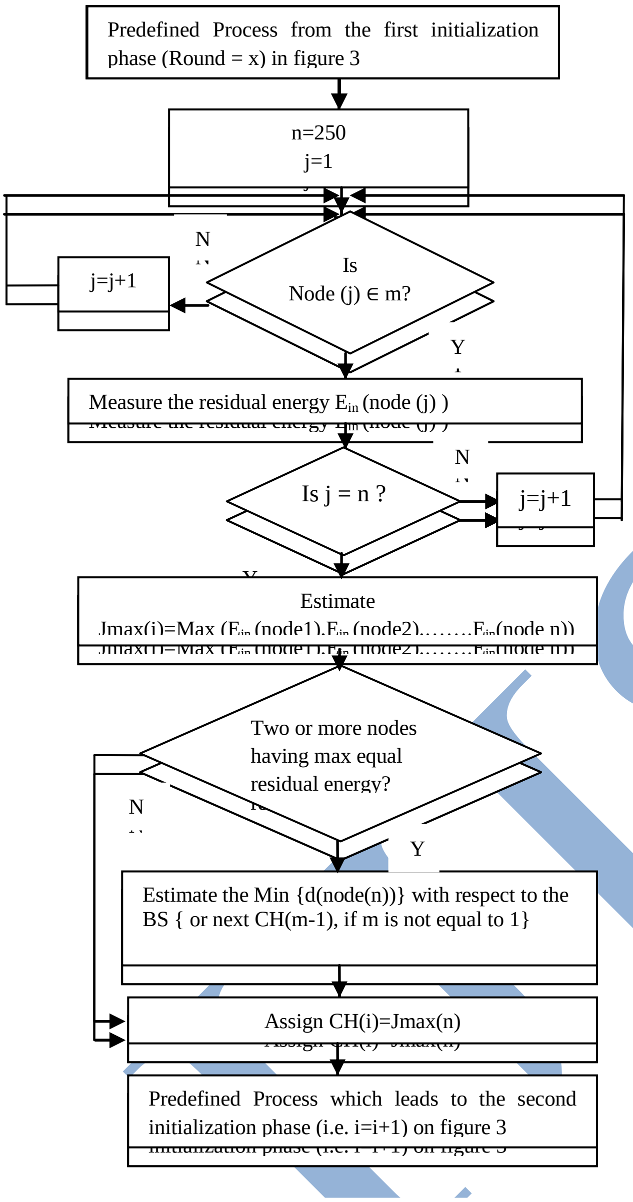

Fig 4 Flow Chart of Cluster Head Selection

IV. SIMULATION SETUP AND SCENARIOS

In this simulation, a total number of 200 nodes were randomly deployed within a space region on 300 m x 300 m. The figure 4 illustrates the simulated environment of the 200 nodes we deployed. The coordinates of *X* and *Y* are measured in meters.

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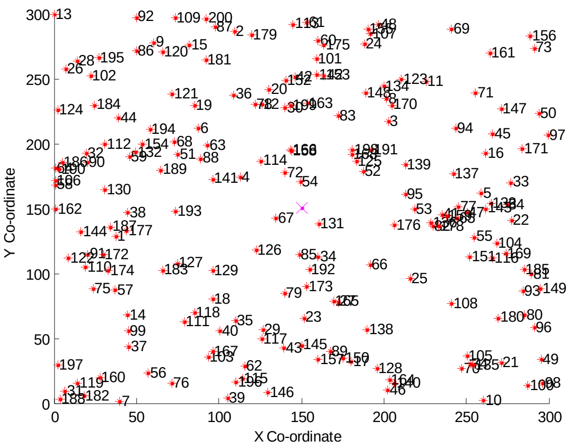

Fig 5: Non Hierarchical formations of 200 nodes deployed randomly in a geographical location of *X* and *Y* coordinates measured in meters

With the nodes being deployed, some assumptions were made concerning the node features and these are as follows:

- All nodes are homogeneous in nature;
- All nodes starts with the same initial energy;
- The base station is situated at the centre of the area space;
- Clusters and nodes are static;
- Normal nodes transmit directly to their respective cluster heads within a particular cluster;
- Cluster heads use multi-hop routing to relay data to the data sink;

The parameters used in the simulation are listed in Table 1

TABLE 1

Parameter	**Quantity**
Total number of nodes, (N)	200
Initial energy of each node (Joules), *(Ein(n))*	250
Packet size (*k*) in bytes	100
Energy circuitry cost at transmission and reception of a bit of data *(Eelec*) in nano Joule per byte	50
Amplifier coefficient*(Eamp*) in pico Joule per bit	100
Coordinate of base station	(150,150)

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The sensor nodes in the network are formed into clusters of different sizes of one, two, three, four and five. One indicates a non-hierarchy formation of cluster, two & three indicate two level of hierarchy and four & five indicate three level of hierarchy for data transmission. Figure 5 indicates the non-hierarchical structure of our routing technique. Likewise, Figure 6, 7, 8 and 9 shows the simulation result of the cluster formation in the proposed technique.

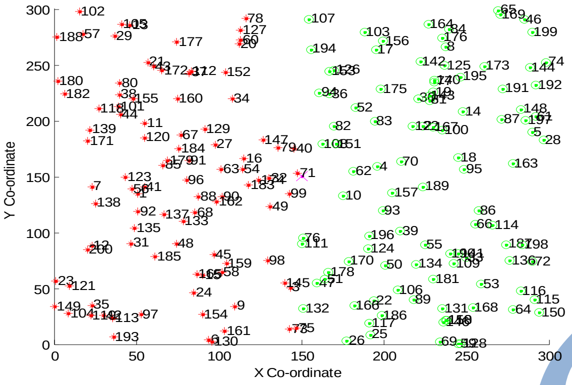

Fig 6: First level hierarchical formation with differentiated colours indicating difference in two clusters.

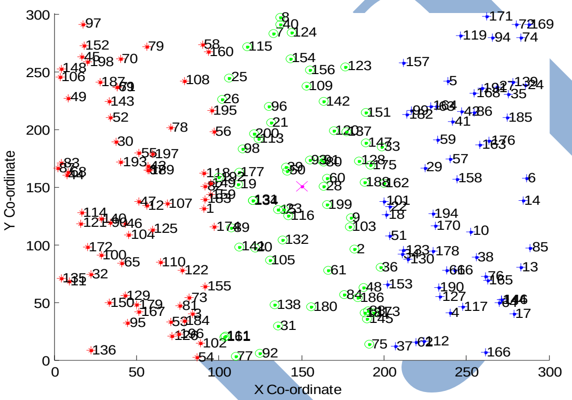

Fig 7: First level hierarchical formation with differentiated colours indicating difference in three clusters.

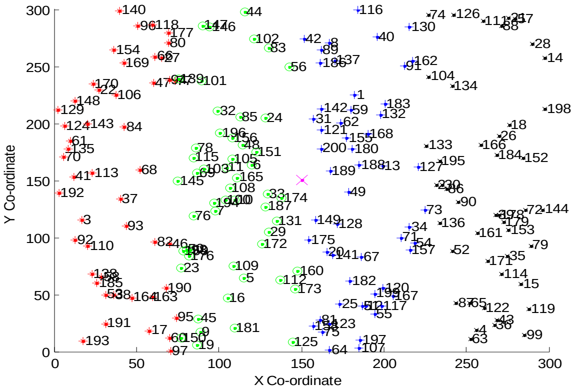

Fig 8: Second level hierarchical formation with differentiated colours indicating difference in four clusters

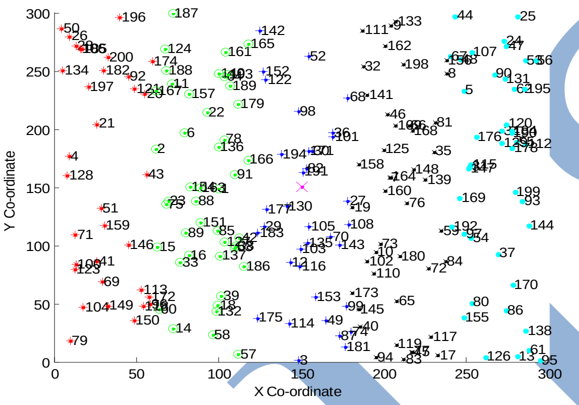

Fig 9: Second level hierarchical formation with differentiated colours indicating difference in five clusters.

Using MATLAB, all 200 nodes were randomly distributed as shown in Fig. 5 with the BS whose location is (150,150) was situated. With the initial energy level of all nodes being set at 250 J, E_{elec} set to 50 nJ/bit, E_{amp} set to 100 pJ/bit/m2, and the size of the sensor data set to 1024 bits, we used the radio model equation to evaluate residual energy level for cluster head selection, data aggregation and transmission phase for 400 rounds for non hierarchical formation scenario, first level hierarchical formation scenario and second level hierarchical formation scenario. The cluster head(s) of *m*-th cluster formed aggregates the data received from other sensor nodes with its own data and transmits it to the next hop cluster head closer to the base station or to the base station depending on the cluster formation and the shortest distance between the cluster head and the BS. At every transmission or reception made, energy reduction occurs for every node, thereby cluster head rotation was utilized to help prolong the lifetime of the WSN.

V. SIMULATION RESULTS

We observed that the first node dies faster in the non-hierarchical formation since all nodes tend to send captured data via one randomly selected cluster head per round to the base station. The constrained load on the elected cluster heads during the 400 round of simulation drastically reduced the CHs' energy over a short period. Unlike the non-hierarchical formation, the proposed hierarchical routing technique in which cluster hierarchy takes precedence in cluster formation and evaluate the residual energy for selection of cluster head, we observed that this technique offers a better life span for individual nodes and even the entire network. With optimization in energy usage, we observed that the lifetime in our proposed hierarchical technique extends to an impressive range when compared to non-hierarchical technique. The impressive increment in life span of the network from our proposed hierarchical technique is seen as a result of efficient routing decision and optimization of energy in cluster head selection of each cluster formed. Since the sensor nodes in each cluster send data to the cluster head within its cluster range and then the aggregated data is sent to the cluster head closer to the base station, which further aggregates data of its own cluster and that of the incoming data, from cluster head whose distance is farther to the BS, before sending the data to the base station. Thus, a considerable amount of energy is saved which indicate improved network lifetime in the case of first level hierarchy when compared to non hierarchical technique. From Fig. 10, we observed that the Non-hierarchical technique had an estimated lifetime of 20 rounds, First level had an estimated lifetime of 30 rounds and Second level had an estimated lifetime of 40 rounds. The progressive increase of network lifetime employed by our proposed technique offers efficient energy usage for each node in the entire network

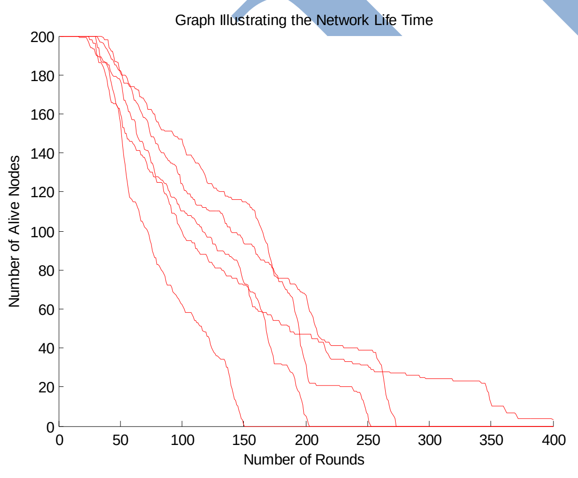

Fig 10 : Network lifetime graph (number of alive nodes for a particular round of simulation) in non-hierarchical, one level & two level hierarchical technique

The progressive increase of network lifetime employed by our proposed technique offers efficient energy usage for each node in the entire network. Also, it was observed that the Non-hierarchical technique network completely stopped functioning at an earlier simulation rounds compared to our proposed technique. We saw that the functional capacity for Non-hierarchical network lasted till an estimated value of 150 rounds of simulation, while the functional capacity of the First level Hierarchical approach and Second level hierarchical approach lasted till an estimated value of 250 rounds and 400 rounds of simulation as shown in fig. 10.

Our proposed protocol is also proved by evaluating the residual energy in each node for particular rounds of simulation. The results in Figure 11 to 15 shows that the mean residual energy value of all the sensor nodes of our proposed method is higher than the non hierarchical method which is a further indication of an improved network lifetime when our proposed technique is being implemented.

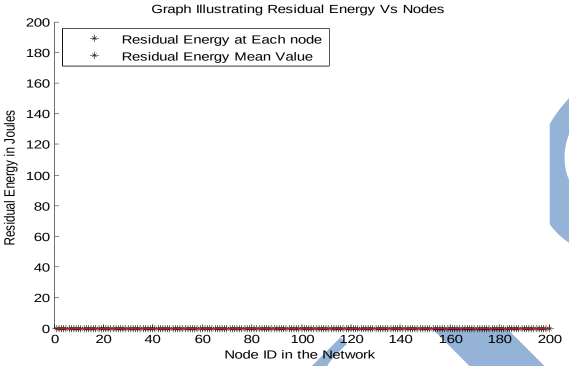

Fig 11: Nodes energy residue in non hierarchical technique after 400 round simulations.

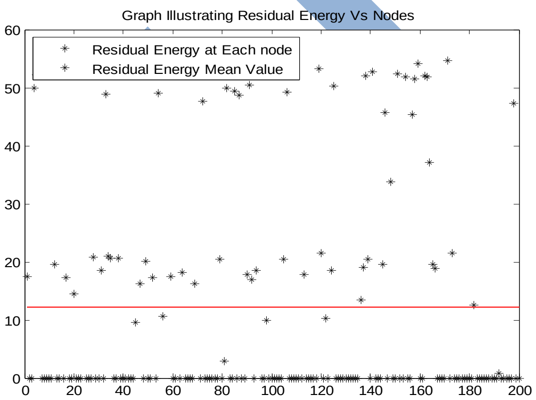

Fig 12: Nodes energy residue in first level hierarchical technique for two cluster after 400 round simulation

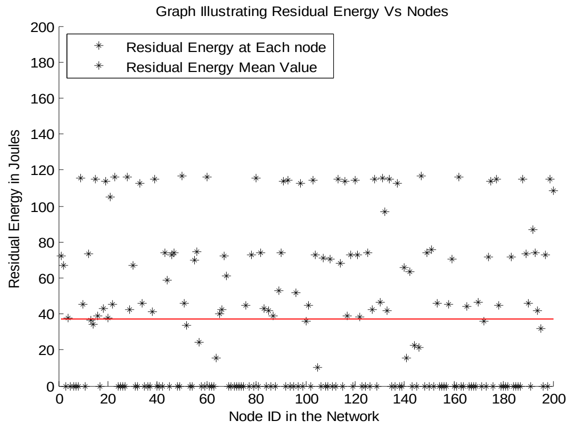

Fig 13: Nodes energy residue in first level hierarchical technique for three cluster after 400 round simulation

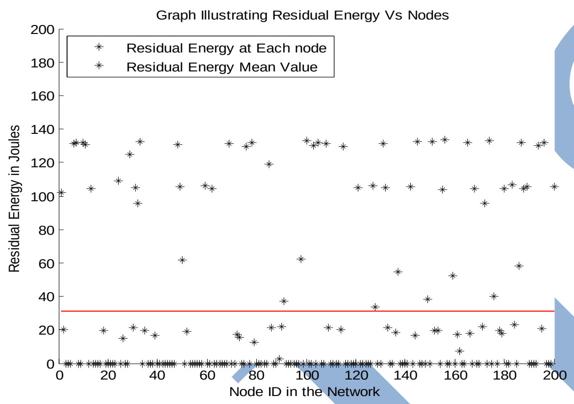

Fig 14: Nodes energy residue in second level hierarchical technique for four clusters after 400 round simulation

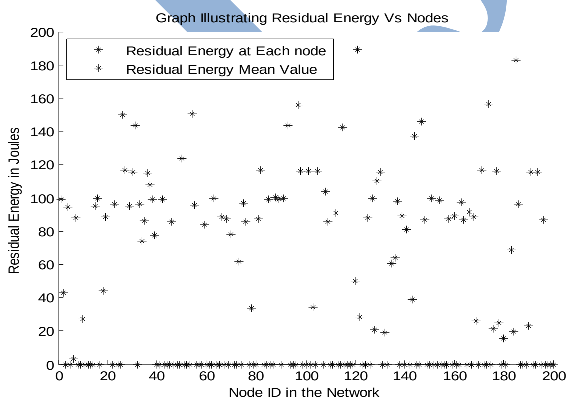

Fig 15: Nodes energy residue in second level hierarchical technique for five clusters after 400 round simulations.

TABLE 2

Technique	**Mean Residual Energy (J)**	**Var. Residual Energy (J)**
Non Hierarchical Technique	0	0
First Level Hierarchy with Two Cluster	16.0084	30.0750
First Level Hierarchy with Three Cluster	22.0498	35.9922
Second Level Hierarchy with Four Cluster	31.4974	49.0736
Second Level Hierarchy with Five Cluster	47.7699	58.5772

Table 2 shows Mean value and variance value of the residual energy in Figure 11 to 15 after 400 rounds

It is also observed in the Table 2 that non-hierarchical technique has the lowest variance and the second level hierarchy has highest standard variance value. The highest value implies the residual energy values after those rounds of simulation are spread out over a large range. Likewise, a lower variance value indicates that the residual energy of each node after the entire simulation rounds tends to the mean residual energy value. It is also observed that a larger variance value indicate how dispersed the residual energy of all node is from the mean value after the entire simulation rounds. It is also noticed that as the value of the variance gets closer to the mean value, it implies a better performance of network since most of the node will die almost at the same time in the end of the simulation.

VI. ANALYSIS

It is proved that the proposed hierarchical routing technique offers when compared to the non-hierarchical routing. We investigated the advantage of the proposed technique by comparing the time in which the first node dies during the 400 rounds of simulation (network lifetime) to that of the non-hierarchical routing technique.

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