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ENHANCING THE NETWORK PERFORMANCE AND PREDICTION OF PROBABLE DEAD NODES USING HYBRID DEC TECHNIQUE

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ABSTRACT

The Network Lifetime of a Wireless Sensor Network is regarded as the Length of Time for Which the Network Is Perfectly Functioning. An Imperative Aspect Which Impacts the Network from Functioning Correctly is the Number of Dead Nodes. It is challenging to predict the Potential Dead Nodes, Which Will Lead to an Impending Network Collapse. Attributed to the Type of the Network, Protocols and Applications, the Networks May Perhaps be Dissimilar. Besides, for Ensuring a Perfectly Functional Network, it is Significant to Ascertain the Nodes that are going to die after a Certain Amount of Time. This Research Aims to Devise a System that Collectively Utilizes Kohonen Self-Organizing Map (KSOM) Techniques, Probability Distribution Function (PDF) Along with Artificial Neural Networks (ANN) for Determining the Classification of Nodes And Enhance the Network Performance. The PDF is deployed for the Detection of Half Dead Nodes. The Simulation of the Proposed Research Method is evaluated in MATLAB tool. The Simulation Results Show the Efficacy of the Proposed Method.

Key word: Artificial Neural Networks, Half-dead nodes, Kohonen self-organizing map (KSOM), Probability Distribution Function (PDF), Wireless Sensor Networks (WSN).

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1. INTRODUCTION

Ascribed to the development and rise of newer technologies, wireless communication has paved a way for substantial and unremitting advancement. Wireless Sensor Networks (WSN) have extensively captivated numerous amount of attention enroute for myriad applications including weather recorders, industrial monitors, earth sensors, surveillance systems, disaster warning systems, healthcare systems and so on. WSNs are principally embedded networks that encompass electronic nodes, each of which comprises of high-level sensors and chips. The key responsibility of WSN is to amass data with the help of sensor nodes and transmits this data wirelessly to the base station. Each sensor is equipped with a transducer, microcomputer, transceiver and a power source (Figure 1). The transducer produces electrical signals that are contingent on the perceived large functions and occurrences. The microcomputer amasses and processes the sensor findings. The transceiver will get directions from the processor for data transmission which will additionally transmit that data to the network. In order to supply power, a battery having a dc-dc converter is employed. The nodes entail an ad-hoc communication system to set up and over see the WSN. Sensor nodes furthermore have a navigation system such as Global Positioning System (GPS) and a mobilizer for travelling across the network area.

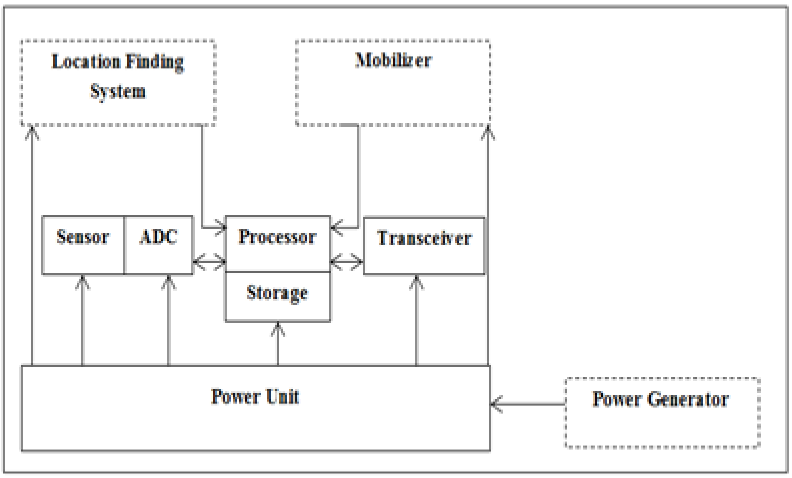

Figure 1 Components of a sensor node

The sensor nodes amass different data from the atmosphere such as humidity, temperature, vibrations, sound, pressure and the like. A single node is able to carry out the functions of data gathering, data aggregation and data communication or transmission [1]. Subsequently WSN nodes are frequently demanded to function for long periods. Because they are battery-driven, the battery gets drained, and the node becomes non-functional thereby degrading the network performance [2] [3] [4]. Hence the sensor nodes have limitations of limited energy resources, limited memory storage and low processing speed. The sensor nodes are installed in an environment where human intrusion is considerably less. The sensor nodes assemble the data that they are required to sense from the relevant surroundings and forward this data to the base station for further processing [2]. Energy conservation has always been an indisputable research focus in WSN [5] [6]. Therefore energy efficiency is the foremost matter in designing a WSN and it has a high impact on the network efficiency [7]. The constriction of energy is the most prominent shortcoming of WSN as the dead nodes are inept of operating and could lead to the failure of the entire application. The various applications demand a constant and persistent monitoring of the surroundings, even in harsh environments, as a consequence demanding functional nodes for a large amount of time.

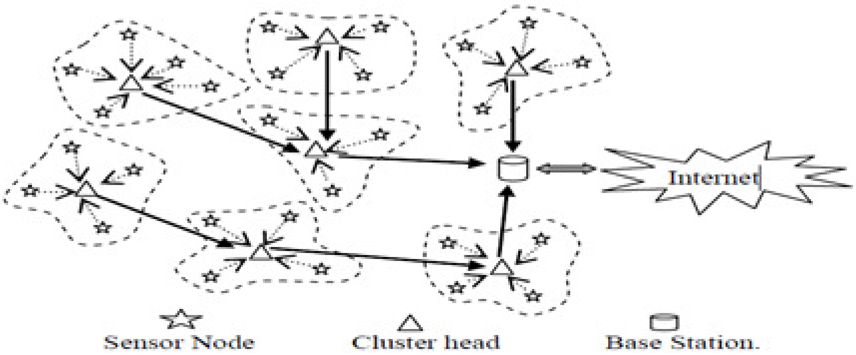

Figure 2 A cluster-based WSN

A cluster-based WSN (Figure 2) has been deemed to bring down the energy consumption of the network by separating the WSN into clusters that encompass several individual nodes. Further a cluster has a cluster head (CH) which is picked out to carry out the dependable tasks such as gathering data from all the nodes within the respective cluster and then transmitting it to the base station. This mechanism saves energy because of the CH aggregating data from all the nodes and transmitting to the base station rather than each node transmitting to the base station. The CH performs this functionality for a limited duration subsequent to which a new CH is elected [8] [9]. The other nodes are only required to sense the data and transmit it via a single-hop or multi-hop transmission to the concerned cluster head.

2. RELATED STUDIES

As reported by Li et al [10], an Energy-Efficient Unequal Clustering (EEUC) mechanism for periodical data gathering in WSNs was incorporated. The protocol partitions the nodes into clusters of unequal sizes. Here the clusters that are closer to the base station have smaller sizes than those farther away from the base station. Thus cluster heads closer to the base station will preserve some energy for the inter-cluster data forwarding. Also, energy-aware multi-hop routing protocol for the inter-cluster communication was developed by the authors. Simulation results show that unequal clustering mechanism balances the energy consumption well among all sensor nodes and achieves an obvious improvement on the network lifetime.

The Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol was proposed by Heinzelman et al [11]. It is one of the basic clustering and routing protocols in WSNs and is used by many subsequent clustering and routing protocols. The main idea of LEACH is to select cluster heads by rotation and the high energy consumption for communicating with the BS spreads among all the nodes. The operation of LEACH consists of rounds, and every round consists of two phases; the set-up phase and the steady-state phase. In the set-up phase the clusters are formed and in the steady-state phase data is delivered to the BS. In the set-up phase, each node takes a call on becoming the CH for the current round. The decision is based on the suggested percentage of CHs for the network and the times of being CH so far. LEACH is efficient to dispense energy dissipation uniformly during the course of the sensors, amplifying the valuable network lifetime.

The Topology-Controlled Adaptive Clustering (TCAC) protocol was proposed by Dahnil et al [12]. In this protocol all clustering steps are carried out in a way that assumes the transmission energy of the nodes that are variable. This protocol comprises of three phases; the first is a periodic update that cuts the energy overhead and delay time, the second phase having the CH election, and the third phase, wherein the CHs filters the nodes that have more signal strength when it sends a packet and each node that receives the packet acknowledges with another. This protocol is centered on the scalability of the network.

Another study [13] for extending the network lifetime was devised on the basis of the Improved Particle Swarm Optimization algorithm. This algorithm is essentially employed for selecting the target nodes. The research considered energy efficiency and transmission distance. The relay nodes were employed for improving the unnecessary consumption of power particularly in the case of the cluster heads. This system provided an enhancement of the distributed sensors and a proportionate clustering system which improved the network's lifetime.

Further, the HEED protocol [14] employs the selection of cluster heads on the basis of the residual energy of the nodes. Also, another factor i.e. the proximity of the nodes to its neighbors was considered for this protocol. The cluster heads are required to transmit the data to the base station through multi-hop communications. In this system, it is made sure that one CH in a specific range will attain an even CH distribution throughout the network. Consequently, in this system, the cluster heads expend more energy, that resulted in the rapid exhaustion of energy.

3. PROBLEM FORMULATIONS

Cluster-based WSNs reduce energy consumption drastically, conserve communication bandwidth and improve the overall scalability of networks [15]. On the contrary, sensor nodes carry inadequate and usually irreplaceable power sources and transmission capacity that cannot match the transmission of large data that has to be collected. For data collection, sensors periodically sense the environment and transmit data to the base station, which analyzes the data to draw some conclusions about the activity in the area [10]. After a sensor node runs out of energy, the network is considered dead because some areas cannot be monitored any more. Therefore, energy consumption must be notably reduced in order to maximize the network lifetime. Periodical data gathering applications in large scale sensor networks appeal the design of scalable, energy efficient clustering algorithms. Also, the nodes that will potentially become dead lead to degradation of the network performance after certain iterations, necessitating a system that can predict the half-dead nodes efficiently, keeping energy efficiency as the priority.

4. METHODOLOGY

The novel idea of the proposed methodology of the current research work is to optimize the energy consumption and overall performance of the network with the aid of Kohonen Self-Organizing Map (KSOM) techniques, Deterministic Energy-efficient Clustering (DEC) protocol along with Artificial Neural Networks (ANN). The KSOM technique is used to map the nodes in the network. The ANN is used for classification of the nodes. The classification of nodes depends on the availability of the nodes and the routing process is executed as per the availability of nodes. The proposed methodology aims of detecting the dead nodes and the half dead nodes thereby enhancing the network efficiency. The primary step in this research is allocation and localization of nodes. In allocation and localization of nodes the following processes are done.

a. Scaling of Network

The boundary formation of network is formed. The regions are assigned around the network and sensor nodes are placed on the areas occupied. The manipulation of framework is done that helps to set the boundary for the particular manipulations to be carried on.

b. Random allocation of Nodes

Depending on the availability of the nodes the classification and the routing process is done. The proposed methodology depends on number of rounds and with each round the cluster of the nodes is formulated. Random clustering based formulation of clustering is carried out. The cluster head is elected among the clusters made of several nodes and the cluster head occupies a fixed position in the network. The cluster head changes according to the availability of nodes and also with the energy efficiency.

c. Initiation of the Clusters

The information from the local and the nearest nodes is sent to the base station by means of cluster head. Hence it is essential and inexpensive for grouping of sensors into clusters as the information is being sent to the sink through these sensor nodes. The cluster head sent the information to the base station using high energy transmission and data aggregation increasing the network lifetime and minimizes the energy consumption. The cluster aggregates the information sent by the nodes and determines the topology of network with the requirement of application.

KSOM mapping technique

KSOM Self Organisation Mapping

The Kohonen Self organising Map (KSOM) has the input and the output layer that is connected in a two dimensional grids. The required input parameters are extracted from the sensor nodes. The input number is given by as,

\V\ = mXn

Where,

M and n are the binary bits taken by the parameters. Hence the output layer shares the organized relationship with the input such that they are themselves classified by the output layer. They structure themselves from a random starting point and exhibit a natural relationship between the patterns organizing a topological map. The output layer is selected according to the input patterns found. Let the input layer be,

$I = (I_1, I_2 \ldots I_{\backslash V \backslash})$ (1)

Let the output layer be,

$O = (O_1, O_2 \ldots O_q)$ (2)

Let D_j be the Euclidean distance value of a sensor node in the outer layer when the communication of the data takes place from the network's input cluster arrangement. The Euclidean distance D_j is given as,

$$D_j = \sqrt{\sum_{i=1}^{|V|}(I_i - W_{ji})^2} \quad (3)$$

By depending on the value of the lower Euclidean distance measurement that depends upon the consumption of energy from the node through this Euclidean the mapping of network from the output takes place.

a. Random Allocation of Clusters

The KSOM is an excellent component for clustering of WSN as it has the capability to diminish multi dimensional input data dimension and view the clusters into map. For the relocation of clusters the energy consumption of the nodes has to be estimated first. This information is assisted in cluster formulation and it provides effective routing mechanism to transmit the collected data from nodes to Cluster Head (CH). The KSOM mapping technique ensures the preservation of the structure of nodes while protecting the data carried by nodes along with the determination of number of clusters in the network.

b. Classification Phase using Artificial Neural Network

The classification of the nodes requires ANN technique. The ANN consists of one hidden node and k output nodes. It is a three layered classifier.

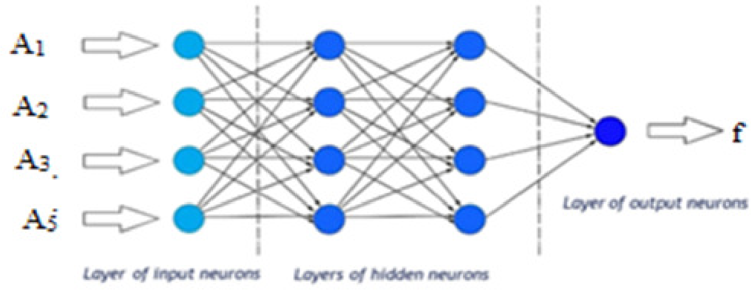

Figure 3 Neural Network hidden layer

1) The weight of every neuron is set separately from the input layer's neuron.
2) The ANN is produced with the help of the attributes that are extracted: the input unit $\{A_1, A_2, A_3, A_4, A_5\}$, the hidden units HU_a and the output unit as age *f*.
3) The proposed Bias function for the input layer is given as follows,

$$X = \beta + \sum_{n'=0}^{H_{NH}-1} w_{(n')} A_1(n') + w_{(n')} A_2(n') + w_{(n')} A_3(n') + \ldots + w_{(n')} A_5(n') \tag{4}$$

By the following equation the calculation of the activation function of the output layer takes place:

$$Active\ (X) = \frac{1}{1 + e^{-X}} \tag{5}$$

The identification of the learning error is given below:

$$LE = \frac{1}{H_{NH}} \sum_{n'=0}^{N_{NH}-1} Y_{n'} - Z_{n'} \tag{6}$$

Where, LE - learning rate of ANN

$Y_{n'}$ - Desired outputs

$Z_{n'}$ - Actual outputs

Data Fusion Algorithm

The data fusion technique used to collect the data obtained from all the nodes and then residue energy on the nodes is calculated and extracted. For the computation of the residue energy left with the available nodes (non-dead nodes) after time T, the following equation is used:

$$P^A(e,T) = E(E_0 - e,T) \quad (7)$$

Here, the net consumed energy is E Here, the net consumed energy is E (e, T) and the initial energy at node is Eo. With this information, routing of data is done in such a way that the node with higher energy in a cluster passes on the data to the cluster head of the network. The same is repeated for the succeeding rounds and by calculating the energy consumption on each node and determining the number of dead nodes. The total energy consumption (Eelec) is calculated by:

$$Eelec = E_{tx} + E_{rx} \quad (8)$$

Where,

E_{tx} is the transmission power and

E_{rx} is the receiving cost

The total energy on all the nodes and thus network energy is determined, which is efficient through this mechanism as the nodes are able to sustain their energy for a longer range of time. After the detection of dead nodes the half dead nodes are detected by using probability distribution function given by as follows,

$$\Pr(X_1,\ldots,X_n \in D) = \int_D f_{X_1,\ldots,X_n}(x_1,\ldots,x_n)\,dx_1\ldots dx_n \quad (9)$$

The Flowchart of the current research is given below in Figure 4.

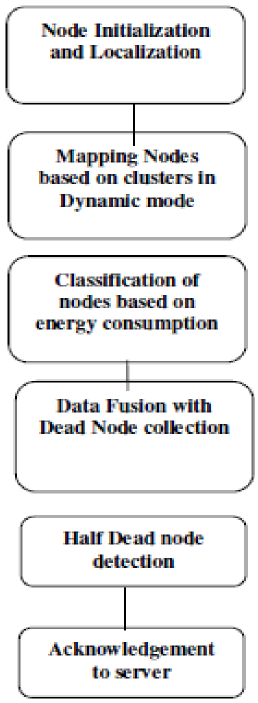

Figure 4 Flowchart of the proposed method

5. SIMULATION RESULTS

The present research uses the MATLAB tool to implement the proposed methodology, such that KSOM and ANN are used for energy efficiency in wireless sensor networks. MATLAB is a model-based design environment for simulating mathematical models and systems.

The following are the input and the output value parameter of the current research method.

The number of nodes to be considered is 100.

The network with energy efficient node is 79.

The network with energy efficient nodes has dead nodes of 1.3518.

The cluster head value of a network with energy efficient node is 11.

At first the random clustering is done such as the different clusters are formed randomly and a cluster head is fixed. The Figure 5 shows the structure of wireless sensor network with 100 nodes and an area of (100, 100).

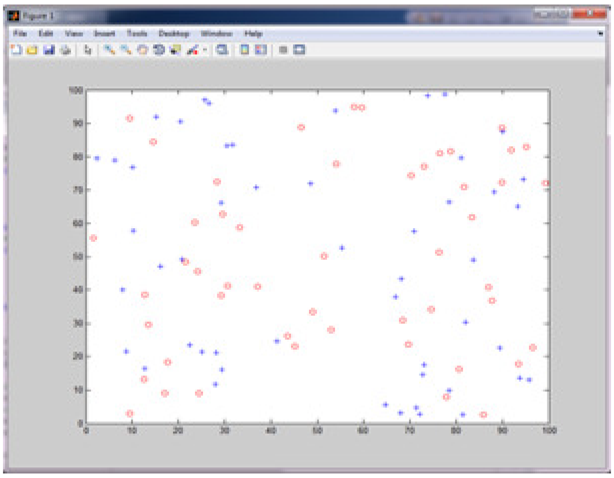

Figure 5 Structure of the wireless sensor network with 100 nodes in an area of (100, 100)

The network topology after the iteration and the cluster formation is represented. The mapping of the node is done such that the nodes will be changing as per the iteration count. The network topology without any dead nodes detected is given below in Figure 6.

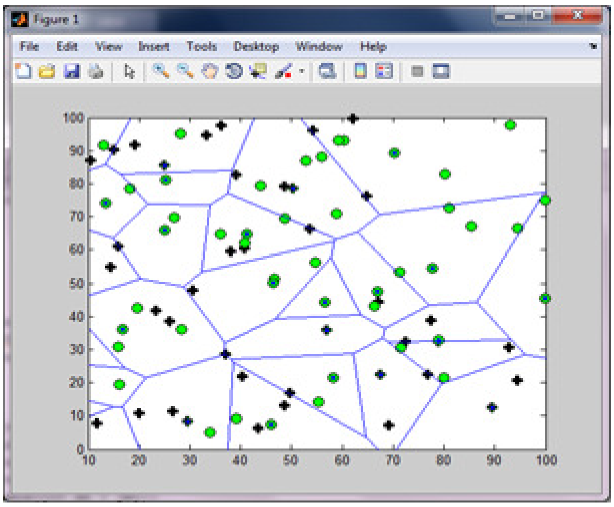

Figure 6 Network topology without dead nodes

The network topology with minimum number of dead nodes detected is shown in Figure 7.

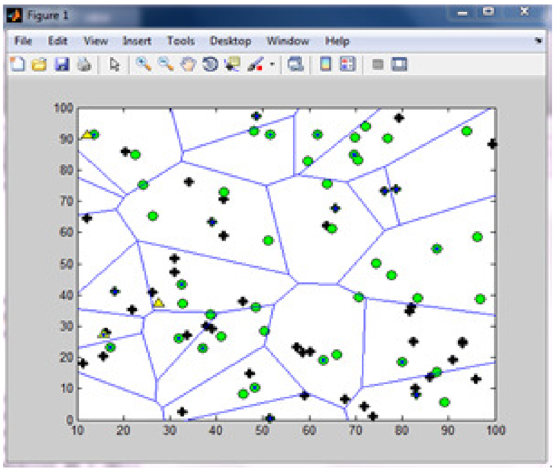

Figure 7 Network topology with minimum number of dead nodes detected

The network topology with the maximum number of dead nodes detected is shown in Figure 8.

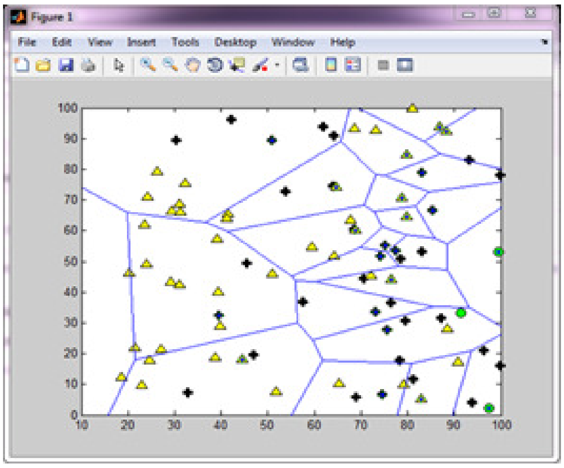

Figure 8 Network topology after iteration and cluster formulation (maximum number of dead nodes detected)

In the final network the total dead nodes and half nodes detected is represented in Figure 9.

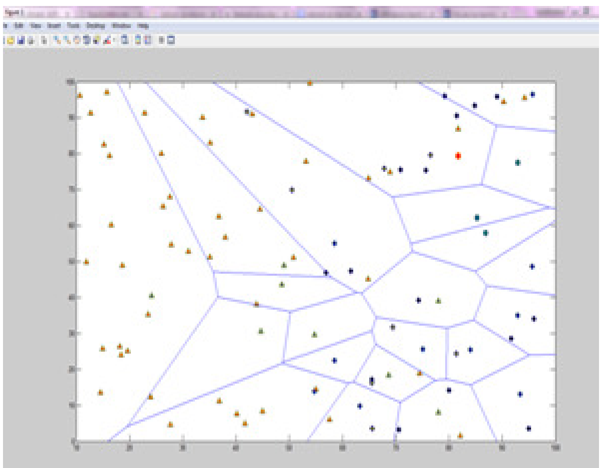

Figure 9 Dead nodes and half dead nodes detection

The energy consumption and the residue energy of each node are calculated for each iteration in order to determine the dead nodes and half dead nodes. This is utilized for the reformulation of the clusters. The Figure 10, 11, 12 and 13 represents the average energy of the nodes or the energy depletion of the nodes at different number of iterations.

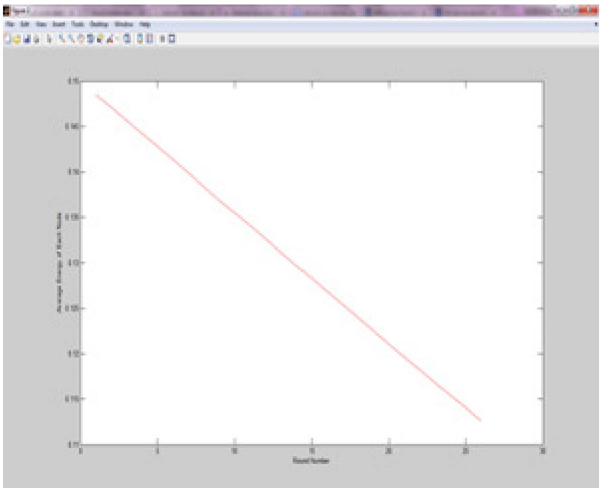

Figure 10 Average energy of each node in a round number 30

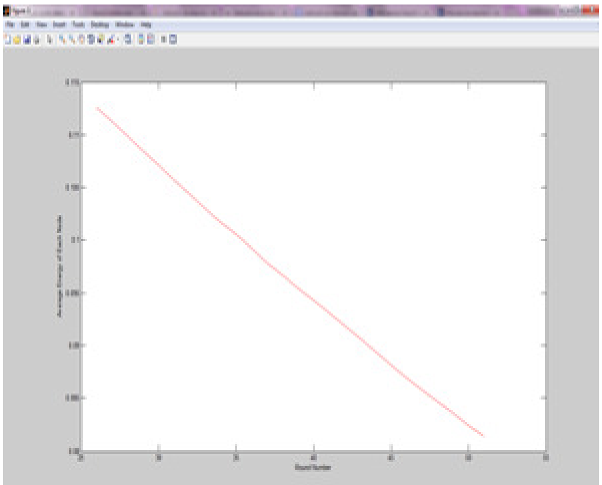

Figure 11 Average energy of each node in a round number 55

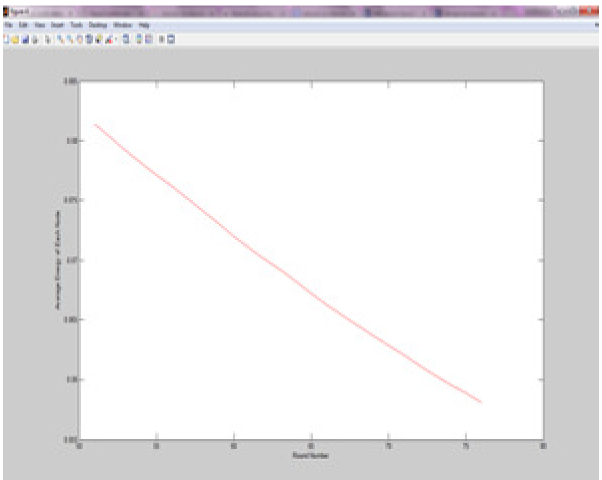

Figure 12 Average energy of each node in a round number 80

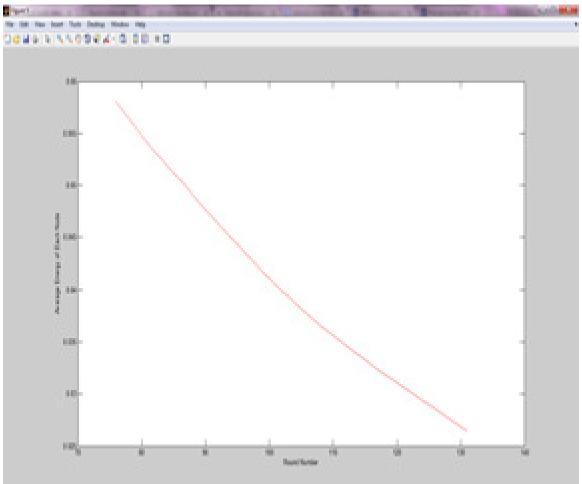

Figure 13 Average energy of each node in a round number 140

6. CONCLUSION

This research presents an advanced approach for optimizing energy efficiency in wireless sensor network by adopting the integration of Kohonen Self Organizing Map (KSOM) and Artificial Neural Networks (ANN). KSOM does effective relocation of clusters in a network with efficient mapping. The ANN does the classification and evaluation of energy consumption parameters. The Probability Distribution Function (PDF) is deployed for detection of the half dead nodes. After the detection of dead nodes and half dead nodes the intimation to the server is acknowledged by means of some embedded alarm signal. The simulation is executed in MATLAB tool. The results obtained showed the effectiveness of the proposed research method by the detection of the dead nodes and the half dead nodes. The Future work can be enhanced by emphasizing the increased network lifetime with better data aggregation techniques.

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