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OPTIMIZED PROTOCOL FOR IMPROVING ENERGY EFFICIENCY IN WIRELESS SENSOR NETWORKS

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***Abstract*— Energy efficiency is a key issue in the networks of wireless sensors because sensor nodes' limited energy capacity. During transferring the packet to the base station several efforts have been undertaken to reduce energy consumption and several clustered protocols improve network life. A new technique for reducing energy consumption was proposed in this research paper. The algorithm was developed via MATLAB and compared with the existing protocols LEACH and SEP. Results from the number of dead, number of live nodes, transmission and packets show that the proposed protocol is effective in comparing the two other protocols. The current research work also proposes a protocol based on energy efficiency optimization. A regular LEACH clustering scheme is implemented to send your data packets to the cluster heads to the Base Station. The algorithm was successfully used in the MATLAB software tool with some basic parameters in various previous research methodologies. The results were much better compared to LEACH. The number of dead nodes is smaller compared to the LEACH and SEP protocol, and so this is more effective and reduces the network's total time period.**

***Index Terms*— Wireless Sensor Networks, SEP protocol, LEACH clustering scheme, MATLAB software tool.**

I. INTRODUCTION

Due to its extensive potential to connect the physical world with the virtual world, wireless based network of sensor nodes has been an attractive area for the researchers. There are potential applications in a range of fields for these large wireless networks, including medical monitoring, monitoring of the environment, home safety and machinery monitoring, military operations. It is expected in the coming decades, there is going to be an increased usage of sensor based networks, around us. These sensor nodes provide effective environment data and monitoring to the end user round the clock. As progress on integrated circuits technology allows the sensor nodes production cost to decrease continuously, the Wireless Sensor Networks be both cost effective but also extensively prevalent.

Wireless Sensor Network:

Wireless Sensor networks are considered as the future of newly developed computer technologies, moving closer to the widespread feasibility with the recent developments in Micro electro-mechanical systems technology,radio frequency architecture and less energy digital electronics. Different useful and varied sensor network application usually involve information collection in rough and uninhibited settings, such as climate tracking, the detectment of chemical hazards to agents and safety tracking. Cheap and intelligent sensors linked through wireless Internet communication have remarkable aims for environmental control and tracking, houses, health care, the military, etc.This includes the use of different devices such asacoustics, infraroads and seismic instruments and sensors that calculate various physical values. In a variety of different situations, for example in military environments, a network of smart sensors can be deployed to detect various threats.

The standard cluster-based Wireless Sensor Network architecture is shown in Figure 1.1. They detect the information by means of a node named cluster head node and transmit it to the base station. The clusterhead adds the files, compresses them to the base station, then transmits them. The base station serves as an entrance to the other network to transfer the info. The base station data base provides the means for updating and retrieving the information on request.

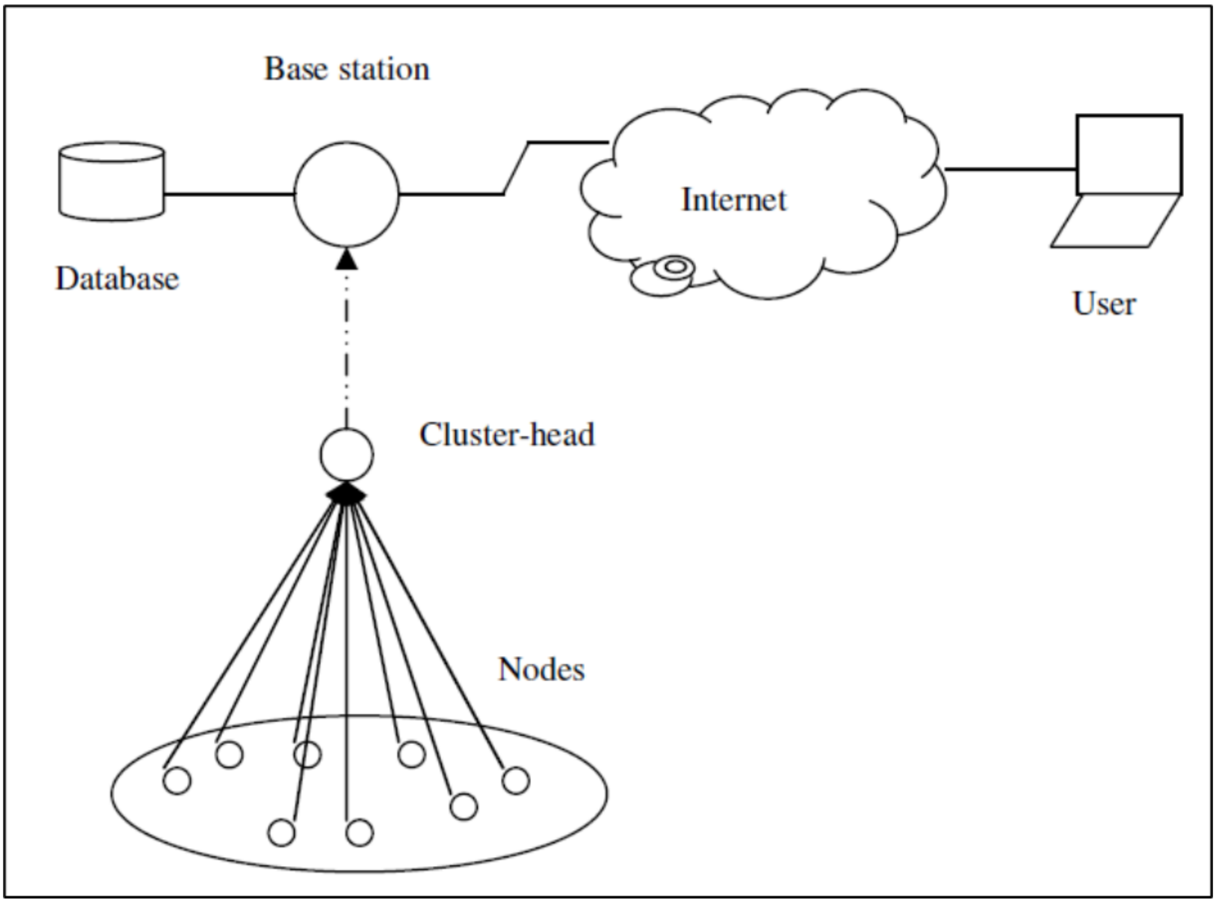

Figure 1.1: Wireless Sensor Network architecture

Design Considerations:

Designing protocols Wireless Sensor Network is a daunting task. There are a few factors to consider.

- Network Lifetime is an important constraint due to limitation of power supplied to these nodes.
- There is high unreliability in the case of Wireless communication as compared to wired communication.
- WSN required to be self configurable.
- The sensor nodes are fixed i.e. their location is not going to change in their entire working lifetime, so the existing protocols designed keeping in mind adhoc networks cannot beused in WSN
- Another important consideration is the size as it typically consist of thousands of sensor nodes as compared to a few nodes in traditional networks.
- The environmental conditions can vary depending on the usage, sometimes extreme temperature and pressure considerations are required.
- The data packets sent over the network by wireless sensor nodes are very few thus the network layer overhead is essential.
- Wireless sensor nodes need to be co-operative in nature and should work in co-ordination to each other.
- In wireless sensor nodes the routing may follow a number of distinct patterns. These patterns can be classified as given below:
  (1) Many to one: A number of individual nodes may send their sensed data packets to one node which aggregates and sends it to base station.
  (2) One to many: distinct control and association signals to sensor nodes from the base station or cluster head multicasts (or broadcasts).
  (3) Local communication: in some topologies, nodes should be discovered and coordinated in the form of communication.

Wireless Sensor Networks Routing:

The basic architecture of a typical wireless sensor node has been discussed in the previous section. Figure 1.1 shows the operation of sensor nodes. The data collected by the sensor nodes has to be transmitted to the base station which is called the sink node as well. The rules and protocols which define this movement of data packet from sensor nodes to base station constitute is the termed as "Routing". Routing is an important terminology when we are in the process of designing any WSN.

There are several ways in which data packets can be sent from the source i.e. sensor nodes to the sink i.e. the base station. The following diagram in figure 1.3 shows a broad classification of the routing algorithms.

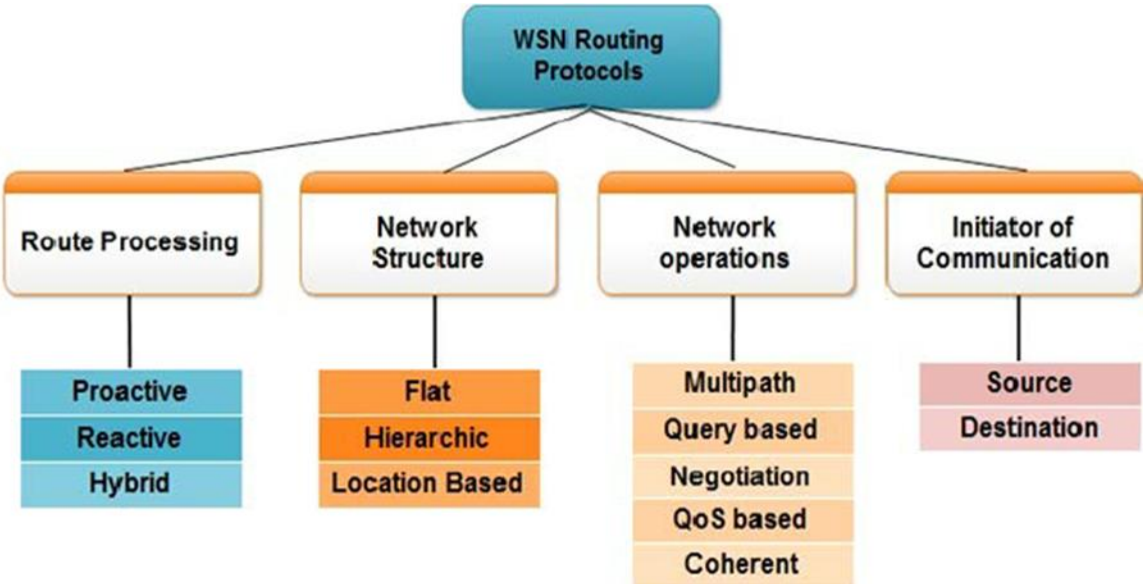

Figure 1.3: Routing Techniques in Wireless Sensor Network

Objective of the Research:

The research is aimed at wireless sensor network energy saving. As has been mentioned, the wireless sensor nodes depend on a fixed energy source in most cases thus effective usage is very important. Thus, the primary objective of this research work is to delve into the area of energy conservation thus improving the network lifetime. The key objectives are as mentioned below:

1. To study the various low energy-based routing protocols suggested by earlier researches.
2. To implement a novel protocol for wireless sensor network routing, which will be based on LEACH protocol.
3. To compare the designed protocol with the existing routing protocols in terms of network lifetime, alive nodes, dead nodes etc.

II. SYSTEM ARCHITECTURE

The concept of network lifetime is one of the most important area of interest for the research in wireless sensor networks. Sensors nodes are located ina big network area having sensing capabilities. One of the big tasks in the wireless sensor networks is to increase the network lifespan to optimize energy usage. After successfully installing the sensors,the cluster heads send their data as well as associate nodes data, in a multi-hop manner and individual sensors cannot execute manually after the deployment. Within the nearness of the base station the sensor nodes absorb more energy than the base station node and die faster. In turn, when 90% of nodes are alive with ample resources unused, the network will disconnect. In this research we investigate and seek to eradicate the question of energy vacuum. It is required to analyze the energy imbalance in these protocols, and attention has been given to the information about the existing sleep and wake processes of nodes in order to boost the network 's lifespan.

All the nodes are not having data which to be transmitted to the base station. As such unnecessarily energy is dissipated in establishing the radio link with the cluster head for sending essentially no data packets. If this scenario is taken into consideration, it is possible to reduce the energy dissipation and efficient usage of the available battery life of the sensor nodes. In this research work, this inactivity of the sensor nodes has been taken into consideration while designing the network model and while deciding the participation of the nodes in the routing process. In this chapter the various steps taken to implement the proposed method has been discussed.

Free Space Signal Propagation Model:

The distance between transmitter device and receiver device antennas is an important factor to determine the received power of a signal. The electromagnetic wave theory states that the power is an inverse function of this distance. Another important realization is that there is a direct communication between a transmitter device and a receiver device known as the line of sight, as given the Free Space Model devised by Friis. The recipient may not however be in the transmitter's line of sight, always.As a consequence, the signal bounces off the objects in the system and at different times hits the receiver from various directions. The receiver receives the overlay from various paths of these many copies of the transmitted signal. This is regarded as a multi-way fading that can be modeled roughly as a power law function that can be used to separate transmitter and receiver from two-raying model. When each signal travels from the transmitter to the receiver, variations in attenuation, delay and phase shift can occur. The signal energy received at the receiver may be either constructive or destructive, amplified or attenuated.

Let "Pt" is the power delivered by the transmitter antenna in watt. For a moment assuming that the transmitter antenna is omnidirectional, lossless, then the received power density (w/m2) at receiver end at a distance d from the transmitter antenna is-

$$S_r = \frac{Power}{Area} = \frac{P_t}{4\pi d^2} \quad \mathrm{W/m^2} \tag{3.1}$$

But any practical antenna has its own directivity. Here the directive gains of transmitter and receiver antenna are respectively Gt and Gr where both Gt and Gr are less than unity.

The power density received actually because of directive gain of transmitting antenna is

$$S_r' = \mathrm{power\,density} \times \mathrm{Gain} = \frac{P_t}{4\pi\, d^2} \times G_t \tag{3.2}$$

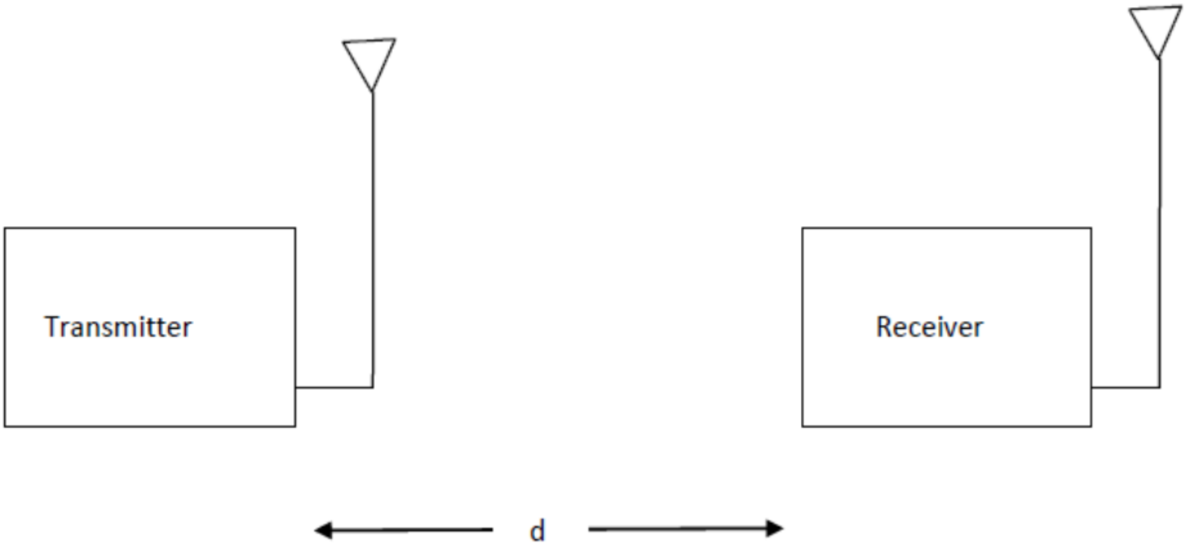

Figure 2.1: Friis Radio model

Friis free space loss and multi-path loss are both dependent on the distance between the nodes and configuration of the transmitter amplifier.

As discussed in the literature review section, the energy varies in proportion of square of the distance for relatively small distances between transmitter and receiver, whereas when the distance becomes relatively large, the energy dissipation varies in proportion to quadratic factor i.e. d4.The cutoff distance which is used to determine the power loss is known as crossover distance and is defined as:

$$d_{crossover} = \sqrt{\frac{\epsilon fs}{\epsilon mp}} \tag{3.3}$$

where ϵfs, is free space loss and ϵmp is the multi path loss.

Clustering Process:

Network lifetime can be increased by collecting data from a group of nodes and sending the aggregated data by cluster head. Network division into decreases traffic and energy usage within the network. As discussed earlier, clustering provides a mechanism for saving the energy of sensor nodes, by effective communication strategies. Research has shown that it increases the overall efficiency of wireless sensor network. There is considerable decrease in the power consumption at nodes since instead of passing data packets to sink directly, its data packets should be sent first to the cluster heads rather than to the sink. Sensors are classified according to their energy, sensed data types, proximity or several other parameters which can be used to determine the selection procedure of cluster head.

In the control of energy consumption, data propagation techniques is also extremely successful. Sending a packet to the sink node can be done in two ways. Firstly sensors can choose to send directly to the sink in one hop mode that demands more energy. Secondlyby choosing one of its neighbors for multi-hop relaying its packets to the sink. When the second solution is used, the power consumption is lower, as the distance between two nodes is smaller.

For the proposed algorithm, a distributed approach is better because the proposed algorithm has been considered to be adaptable to large networks. The nodes also determine whether they will be the group head of clusters or associate themselves to another group head instead on the basis of a large number of criteria coded in the algorithms we are proposing.

Proposed Algorithm

The sensor nodes are placed in the network area in a random fashion. At the beginning of the network all the nodes have equal energy which is given by Eo.For each node the decision to be the cluster-head is done by chosing a value, between 0 and 1. This random number is compared with the threshold value in stochastic algorithm for election of the cluster head. The node regions are divided into clusters and data is aggregated and sent to cluster heads these cluster heads then forward this data to the base station. The selection of Cluster head is done as described:

The base station transmits a starting message packet to all the nodes. This message and all the nodes respond to it. The sensor nodes are required to forward their location, id and energy information to base station over the network. This is followed by base station sending another packet to inquire about the node as to which logical zone, they currently belong to. This packet valuable message for the nodes as their logical positioning depends on this message packet.

Let 'r' be the round number of the head to be the head of the node cluster, analogous to time. Every node elects itself as a cluster head after every "r = 1/p" rounds. In first round every node have equal energy level. Thus all nodes have equal probability of being selected as cluster head. The selection potential is given by the equation 3.4 below:

$$Ps = \frac{p}{1-p\left(r.mod\left(\frac{1}{p}\right)\right)} \quad (3.4)$$

It is required to maintain a significant number of cluster head for each rond, depending on the number of nodes alive. In each round, any node can become a cluster head, though only once.

III. RESULTS & DISCUSSIONS

The implementation of the proposed algorithm has been done in MATLAB software using its various toolboxes, MATLAB graphics functions and basic programming structure of the software. MATLAB is a high end technical programming language which is used extensively in industrial and academic research. It contains an easy to use programming language which is pseudo code or algorithm based. Itmeans that the algorithm or pseudo code easily converts into a workable program. The toolboxes give an added advantage for programmers. The toolbox is a package or collection of built in domain specific functions which are ready to use. There are about more than hundred toolboxes in MATLAB which makes the task of scientists, researchers and students' task easier working in these domains.

The implementation results and simulation are discussed and analyzed in detail. Network software setup requires certain parameters derived from the radio model of a typical Wireless Sensor network architecture as has been described in Chapter 2. The various equations defining the energy dissipation process in the wireless sensor network has been implemented in the software. The various network modelling parameters with their values are shown in the Table 3.1. For this simulation the network area is 200mx200m. The base station is placed at location x=100, y=100 in the network area. The division shows the different cluster formation in the network area. The number of nodes is taken to be 200. The network is simulated for 2500 rounds. The rounds are equivalent to a certain time scale. After every round the energy dissipation factor from different sources is accumulated to calculate the average energy left in each node.

Table 3.1: Simulation Parameters

Parameters	**Values**
Network Area	200m
d0, Crossover distance,	sqrt(E_{fs}/E_{mp})
E_{elec} ,Electronics circuitry energy	50 nJ/bit
E_{fs}Energy consumed for LOS	10 pJ/bit/m$_2$
EmpEnergy loss for multipath,	0.0013 pJ/bit/m$_4$
EDA ,Data Aggregation Energy,	5 nJ/bit/signal
E0, Initial Energy,	0.5 J
Selection Probability	0.1

The selection probability for a node to become a cluster head is taken as 0.1, i.e. out of all the available nodes 10 percent can become cluster heads.

A. Algorithm:

The pseudocode or algorithm for software implementation of this research work is thoroughly explained in this section.

1. Set network parameters as given in table 3.1
   X & Y co-ordinates of the network area: xm=200; ym=200
   Location of Base Station BSx=100, BSy=100;
   Number of nodes for simulation: n = 200;
   Assign selection probability, p=0.1;
2. Set energy Parameters as given in table 3.1
3. Initialise random node positions
4. Assign initial cluster heads =0.
5. Number of nodes "n"and "n+1" taking BS.
6. Initialize Counter for dead nodes, alive nodes, first dead node and packets transmitted by the nodes.
7. Initialise counter for sleep nodes as zero and threshold energy for sleep or inactivity as, th=0.00000000000001. The inactive nodes are checked and counter for inactive nodes is incremented in each loop, as per below:
   if (S(i).E<=th & S(i).E>0)
   s1=s1+1;
   end
8. The remaining nodes are taken as the active nodes and participate in the clustering process, as per the equation given in chapter 2.
9. The cluster heads are selected and the distance is calculated to derive the energy dissipation in each round.
10. The remaining nodes (non cluster heads) are associated with the cluster heads for channelling of data packets by resulting out the minimum distance from each node to the available cluster head in each node.
    for c=1:1:cluster1-1
    temp=min(mindis,sqrt((S(i).xd-C(c).xd)^2 + (S(i).yd C(c).yd)^2));
    if (temp<mindis)
    mindis=temp;
    mindiscluster=c;
    end
    end
11. Calculate the residual energy, packets transmitted and number of dead nodes after each round and update the respective counter variables.
12. Plot the various data graphically.

B. Simulation Results:

The simulation results have been plotted as graphs between various parameters obtained and the number of rounds as shown in below figures.

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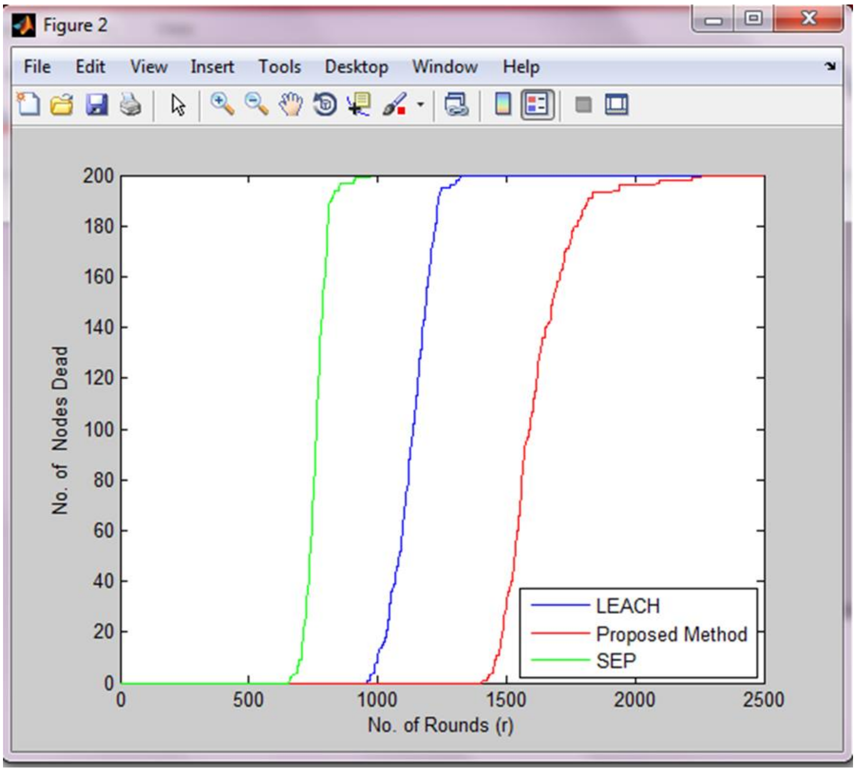

Figure 3.1: Number of Dead nodes vs rounds ((LEACHvsSEPvsProposed)

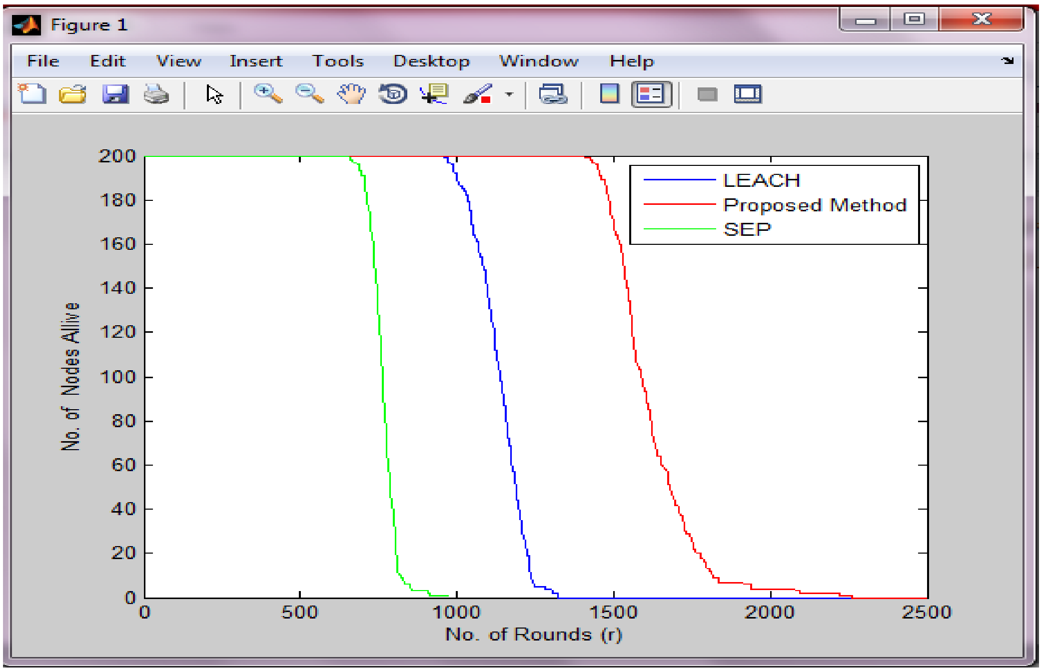

Figure 3.2: Number of Alive nodes vs rounds (LEACHvsSEPvsProposed)

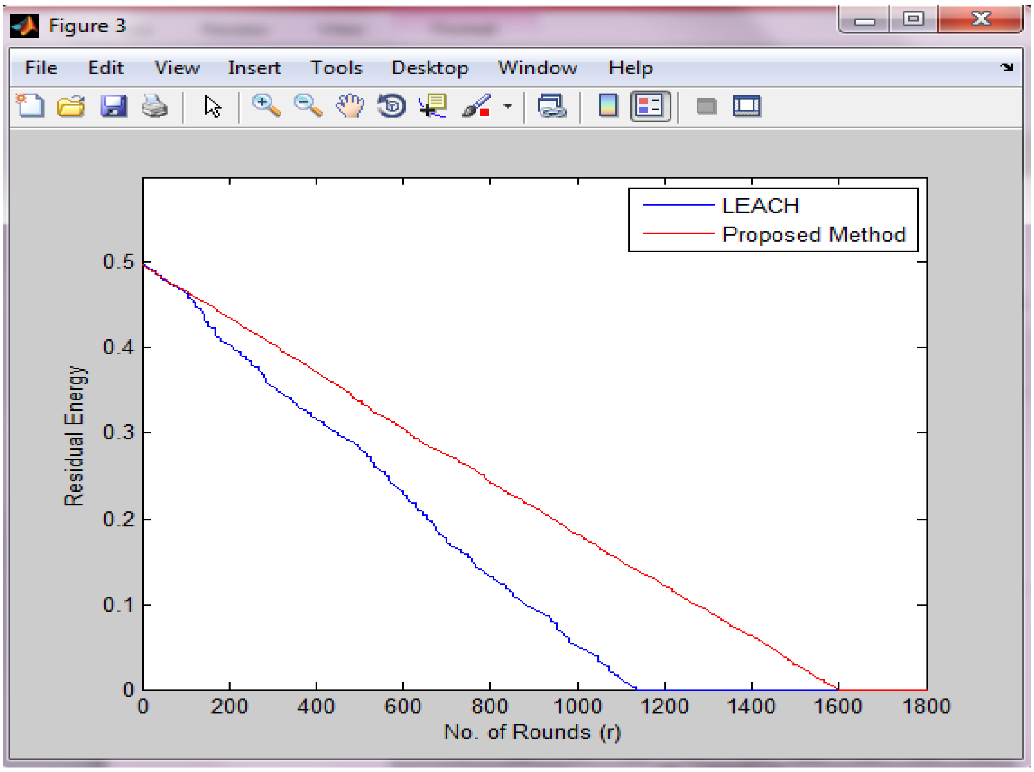

Figure 3.3: Residual Energy vs rounds

The residual energy graph giving a comparison between the LEACH protocol and the proposed protocol is shown in the figure 3.3. As shown in the graph the energy of the networks is increased in the proposed protocol and hence the network lifetime.

Figure 3.4 shows the Cluster heads formed with increasing number of rounds. As can be observed the proposed method have more cluster formation as compared to LEACH.

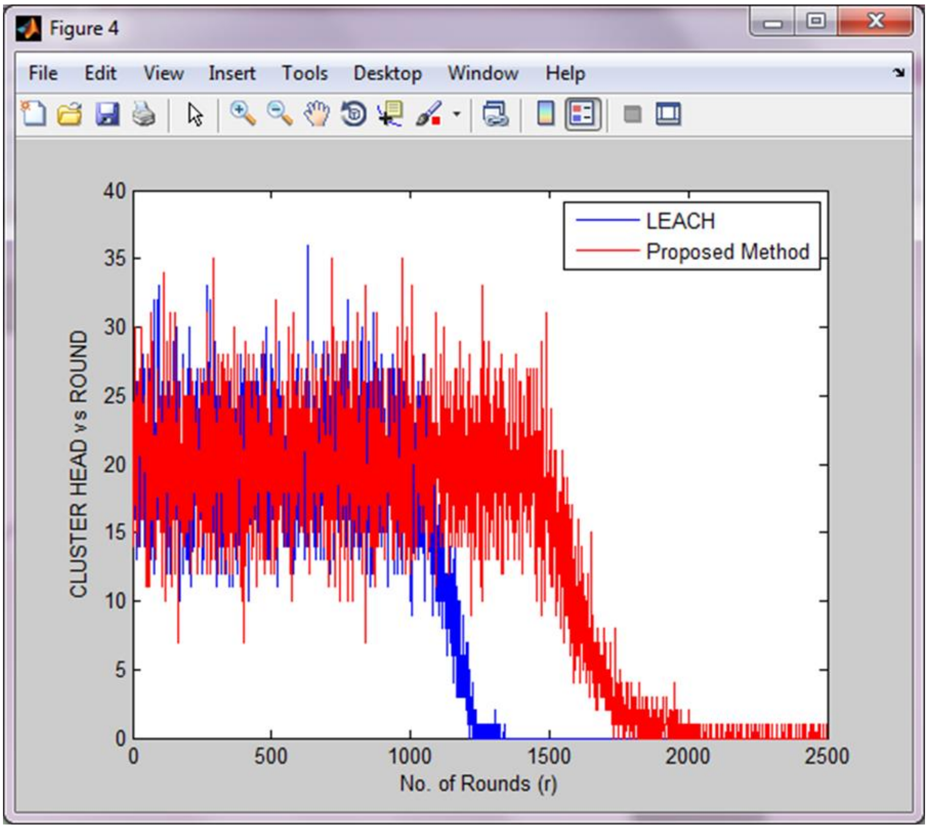

Figure 3.4: Cluster Head vs Rounds

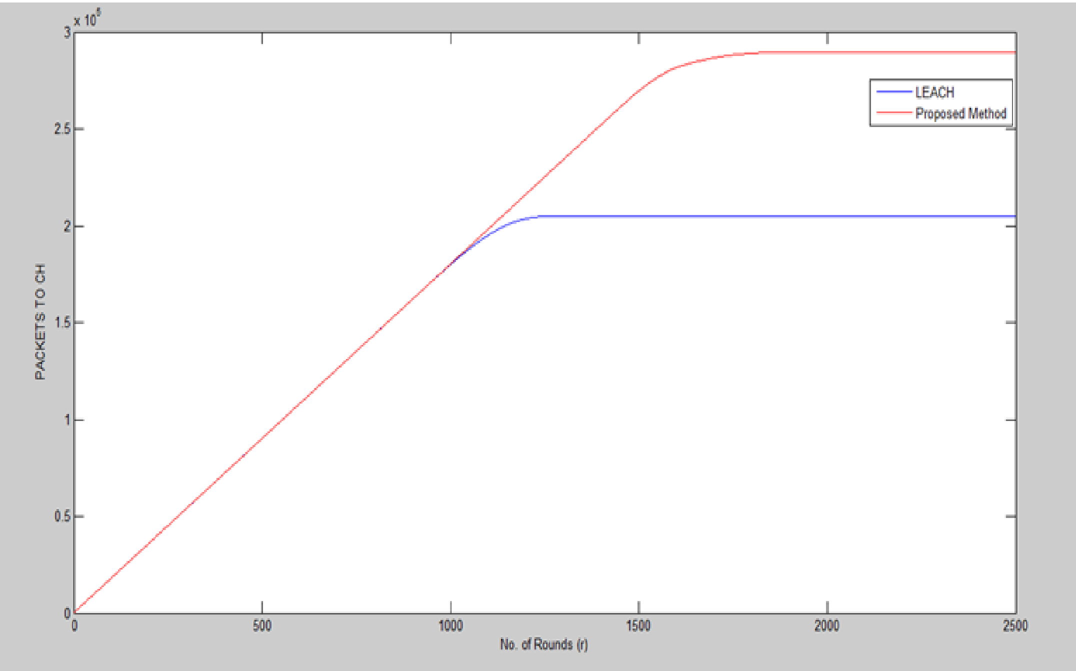

Figure 3.5: Packets to Cluster Head vs Rounds

The number of packets of data(throughput) has been plotted in figure 3.5. The proposed method sends more data packets due to increased lifetime as compared to LEACH protocol.

IV. Conclusion and Future Work

This research work is aimed at studying the Wireless sensor Networks and its various clustering protocols. It also aimed at suggesting novel algorithm for increasing the network lifetime by improving the battery life of the sensors. The below sections describe the key findings of this research work and give a brief summary of the research work.

A. Conclusion

The Wireless Sensor Networks are always constrained with limited power sources and at the same time the power requirements are towards the higher side with a lot of task assigned to the tiny battery powered sensor nodes viz. sensing, collecting data, sending data packets to the base station etc. All these functions are quintessential for any network and consume a lot of battery power. Thus, the design of communication protocols is always focused on saving the energy of sensor nodes to increase the energy efficiency of such networks.

The current research work is also focused on suggesting a protocol, which is based on optimizing the energy utilization. They follow a standard LEACH based clustering to send their data packets to the respective cluster heads which in turn send it to the Base Station.The algorithm was successfully implemented on MATLAB software tool, with some standard parameters as available in various previous research methodologies. The results were compared against the LEACH protocol and has shown a considerable improvement in number of alive nodes after 2500 rounds. The number of dead nodes is less as compared to the LEACH protocol, thus showing that this proposed method is more effective and increases the overall network existence time.

B. Future Work

The Wireless Sensor Network paradigm has always focused developing an efficient routing protocol. One of the approaches can be that to include the geographical information of the nodes in the network formation. Studies can be made further to include this information in between the clusters as well so as to improve the inter-cluster information. The working of the current proposed algorithm can also be studied and verified by other researchers on varying kinds of network structure to check its feasibility of the proposed work.

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