CHAPTER 1

INTRODUCTION

1.1 Objective

Communication is the major cause of energy depletion in the wireless sensor network, so designing of energy efficient routing algorithm is one of the key challenges that need to be addressed for extending life time of network.

The objective of the project is to implement and understand energy efficient wireless sensor network algorithms for grouping the nodes.

One of the main design issues for a sensor network is conservation of the energy available in each sensor node. Increasing network lifetime is important in wireless sensor networks. Many routing algorithms have been developed in this regard. Out of all these, clustering algorithms have gained a lot of importance in increasing the network lifetime thereby the efficiency of the nodes in it. Clustering provides an effective way for prolonging the lifetime of a wireless sensor network. This paper elaborately compares two renowned routing protocols namely, LEACH and EAMMH for several general scenarios, and brief analysis of the simulation results against known metrics with energy and network lifetime being major among them. In this paper will the results and observations made from the analyses of results about these protocols are presented.Routing protocol based on clustering is well known solution for increasing life time in WSN. The basic idea of clustering routing is to use the information aggregation mechanism in the CH to reduce the amount of data transmission, thereby, reduce the energy dissipation in communication and in turn achieve the purpose of saving energy of the sensor nodes. LEACH (low-energy adaptive clustering hierarchy) is well-known clustering based protocol in WSN.

1.2 Overview

Recent advances in the field of communication technologies and the manufacture of cheap wireless devices have led to the deployment of minimum power wireless sensor networks. Due to their ease of deployment and multi-natured functionality of the sensor nodes, wireless sensor networks have been utilized for a range of applications such as ocean waves monitoring, temperature monitoring, etc. Key issue in wireless sensor networks is maximizing the network lifetime and the amount of data transferred successfully during the network lifetime. In sensor networks, the data transport model is such that a base station, typically is located at the boundary of or beyond the field from where the sensors sense/measure data. Researchers have proposed numerous routing protocols to improve performance of different application in a wireless sensor network. Most of the protocols in Wireless Sensor Networks are designed based on single path-routing strategy without considering the various effects of various load traffic intensities. A hop by hop basis data transfer increases the overhead on routing table management and quickly brings down the lifetime of those nodes which are near to the base station as these nodes will be used extensively as relay nodes. Such a network will be non-existent as the energy of the nodes near the base station drains quickly. Many routing protocols have been suggested to overcome such issues. Out of these, clustering algorithms have been of much interest as they well balance several key factors of Wireless Sensor Networks operation simultaneously. Choosing one arbitrary node to act as servicing node for several sensor nodes than each trying to reach Gateway node can extend network lifetime and bring down energy utilization considerably. This process of choosing one node to act as servicing node for several neighbour nodes is known as 'clustering'.

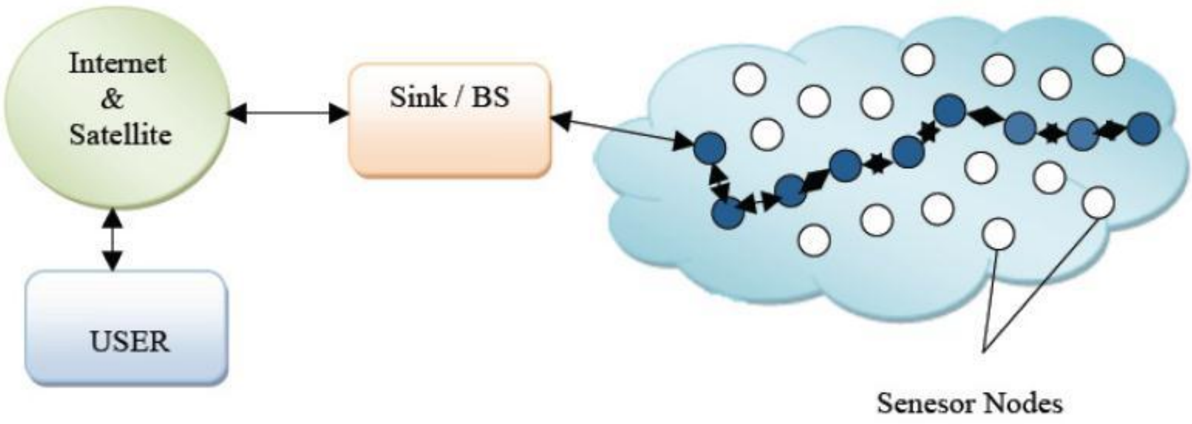

Fig.:1.1*Overview of Wireless Sensor Networks.*

1.3 Motivation

Environmental and bio-process onitoring are some of the fields tht have most benefited from the evolution of sensors, in particular bio-sensors and sensor networks. Replacement of sensor nodes carrying very less power sources is difficult and life time of sensor depends upon power supply. To minimize energy consumption, energy efficient routing protocol is required. So, designing energy efficient routing protocol is a necessity. Many routing protocol are designed for WSNs. Routing in WSNs is a very tedious task due to the inherent property of the WSNs. Some frequent occurred problems are:

1. Coverage problem: It shows how well a sensor monitored or tracked in a wireless network.

2. Position estimation problem: Determining the actual position of nodes in the wireless network is the real problem.

3. Energy Consumption: In WSNs most of the energy is consumed in transferring and receiving of data as compared to sensing and processing of data.

1.4 Problem Statement

With all the talks about global warming, the governments, network device manufacturers, networks service providers and users are more concerned about energy efficiency of the wireless devices than before. The reasons for requiring the more energy efficiency in wireless are various, but most of them are worrying about design problem, the policy of green technology, saving the business cost, and final user satisfaction.

Routing protocols in WSNs have a common objective of efficiently utilizing the limited resources of sensor nodes in order to extend the lifetime of the network. Different routing techniques can be adopted for different applications based on their requirements. Applications can be time critical or requiring periodic updates, they may require accurate data or long lasting, less precise network, they may require continuous flow of data or event driven output. Routing methods can even be enhanced and adapted for specific application.

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1.5 Report Outline

This report discusses about the understanding and implementation of LEACH and EAMMH protocols in wireless senor networks and their comparison. Chapter 1 gives a brief introduction to the topic. Chapter 2 tells about the literature of the topic, Chapter 3 gives a brief implementation of the code while Chapter 4 discussses the Tests and Results. Chapter 5 concludes with an idea about the conclusion and the future scope of the topic.

This section has been taken from references [3], [4], [7], [11].

CHAPTER 2

LITERATURE

Key issue in wireless sensor networks is maximizing the network lifetime and the amount of data transferred successfully during the network lifetime. In sensor networks, the data transport model is such that a base station, typically is located at the boundary of or beyond the field from where the sensors sense/measure data.

2.1 Understanding the protocols

2.1.1 Low-Energy Adaptive Clustering Hierarchy (LEACH)[1]

LEACH is the first and most popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption. In LEACH, the clustering task is rotated among the nodes, based on duration. Direct communication is used by each cluster head (CH) to forward the data to the base station (BS). It uses clusters to prolong the life of the wireless sensor network. LEACH is based on an aggregation (or fusion) technique that combines or aggregates the original data into a smaller size of data that carry only meaningful information to all individual sensors. LEACH divides the a network into several cluster of sensors, which are constructed by using localized coordination and control not only to reduce the amount of data that are transmitted to the sink, but also to make routing and data dissemination more scalable and robust. LEACH uses a randomize rotation of highenergy CH position rather than selecting in static manner, to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor and dying quickly. The operation of LEACH is divided into rounds having two phases each namely

(i) a setup phase to organize the network into clusters, CH advertisement, and transmission schedule creation and

(ii) a steady-state phase for data aggregation, compression, and transmission to the sink. LEACH is completely distributed and requires no global knowledge of network.

It reduces energy consumption by

(a) Minimizing the communication cost between sensors and their cluster heads.

(b) Turning off non-head nodes as much as possible.

LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink. Therefore, it is not applicable to networks deployed in large regions. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption. While LEACH helps the sensors within their cluster dissipate their energy slowly, the CHs consume a larger amount of energy when they are located farther away from the sink. Also, LEACH clustering terminates in a finite number of iterations, but does not guarantee good CH distribution and assumes uniform energy consumption for CHs.

2.1.2 Energy Aware Multi-hop Multi-path Hierarchical (EAMMH) Routing Protocol [2]

EAMMH routing protocol was developed by inducing the features of energy aware routing and multi-hop intra cluster routing. The operation of the EAMMH protocol is broken up into rounds where each round begins with a set-up phase, when the clusters are organized, followed by a steady- state phase, when data transfers to the base station occur. The below flow chart describes the overview of the protocol initially the user has to give the input which is in the form of number of nodes.

For the nodes generated, their positions are randomly assigned and displayed. Once the nodes are deployed, every node uses the neighbor discovery algorithm to discover its neighbor nodes. Using the cluster head selection algorithm cluster heads are selected among the nodes. These cluster heads broadcasts the advertisement message to all its neighboring nodes and thus clusters are formed with a fixed bound size. Each node in the cluster maintains routing table in which routing information of the nodes are updated. DRAND (distributed randomized time slot assignment algorithm) method is used, it allows several nodes to share the same frequency channel by dividing the signal into different time slots. The cluster head aggregates the data from all the nodes in the cluster and this aggregated data is transmitted to the base station.

2.2 Design [5]

In this project, there are three main tasks to be accomplished. Firstly, programming the sensor nodes, then programming the gateway, where all the information is gathered from the sensor nodes, and lastly informing the manager of the greenhouse with the information at the gateway, via both a user friendly web site and sending SMS.

Programming the sensors: It involves periodically measuring the temperature, light and humidity levels and sending these measurements to the gateway. However, this task should be completed in such a way that the sensor nodes use least possible energy. Thus, in this task, we will be implementing power conservative routing algorithms for sensor networks. Programming the Gateway: This task consists of three major operations. Firstly, if there is an error in the data coming from the sensor nodes, fix it. Then, consolidate the data. Lastly, save the data to an SQL database on the computer which the gateway is connected. Develop a web application: This application will provide a user friendly interface to the greenhouse manager, such that the manager will be able to see meaningful information about his/her greenhouse almost instantly. The manager will also be able to see the past information and the comparisons of them with the current information.

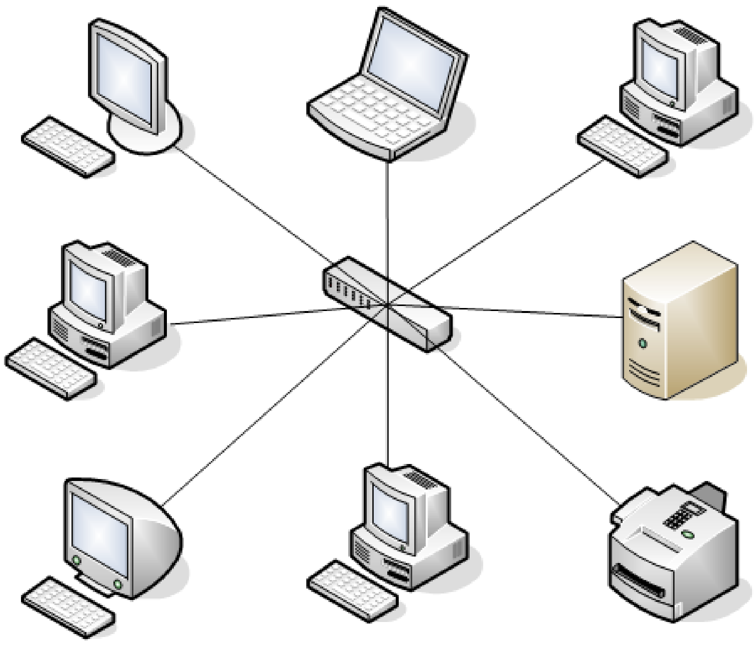

Fig:2.1*Star Topology.*

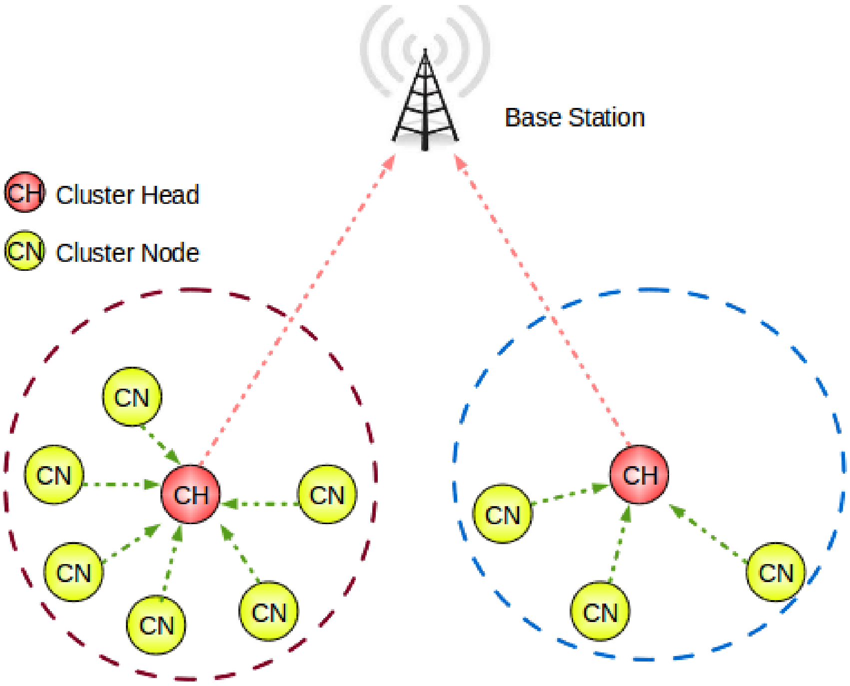

Fig: 2.2 *LEACH Protocol*

2.3 Language Used

2.3.1 MATLAB [9]

MATLAB (matrix laboratory) is a multi-paradigmnumerical computing environment and fourth-generation programming language. A proprietary programming language developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

MATLAB supports object-oriented programming including classes, inheritance, virtual dispatch, packages, pass-by-value semantics, and pass-by-reference semantics.However, the syntax and calling conventions are significantly different from other languages. MATLAB has value classes and reference classes, depending on whether the class has handle as a super-class (for reference classes) or not (for value classes).

CHAPTER 3

IMPLEMENTATION

3.1 Algorithm

Algorithm operation LEACH could be divided into several rounds. Each round starts with a setup phase and finishes with steady state phase. In the setup phase clusters are organized and in steady state information is transmitted to base station. Setup phase First off, each sensor determines whether it wants to be cluster head or not considering its residual energy and number of times it is selected as cluster head. The decision is made based on a random number between zero and one. Afterwards, if selected number is less than threshold that node will be cluster head in a new round. This trust threshold is derived from following equation: Where p is probability for cluster heads (selected by cluster), r is current round and p/1 is a set of nodes which were selected as cluster heads in previous round. At the first stage all nodes might be cluster heads with p probability. When a node is selected as cluster head it cannot be a cluster head for next p/1 rounds. As the probability of being cluster head is lower for some nodes, with this method all nodes could be selected as cluster head. When the cluster head is determined it announces its position by broadcasting advertisement message (ADV). This message includes a small message consisting of node ID and a header as announcement message. All nodes store received messages for next rounds. Each node selects its corresponding cluster head with respect to power of received signal. If at the end of procedure one node does not select its cluster head, one cluster head is randomly selected as its cluster head. Each node transmits a membership request message to its cluster head. In all stages of this phase, radio hardware of cluster heads must be on. Cluster head receives messages of its members. In LEACH algorithm, cluster heads operate as local control centers for coordination of data transfer in their cluster. Based on number of nodes a cluster head designs a schedule using TDMA method and transmits it to member nodes.

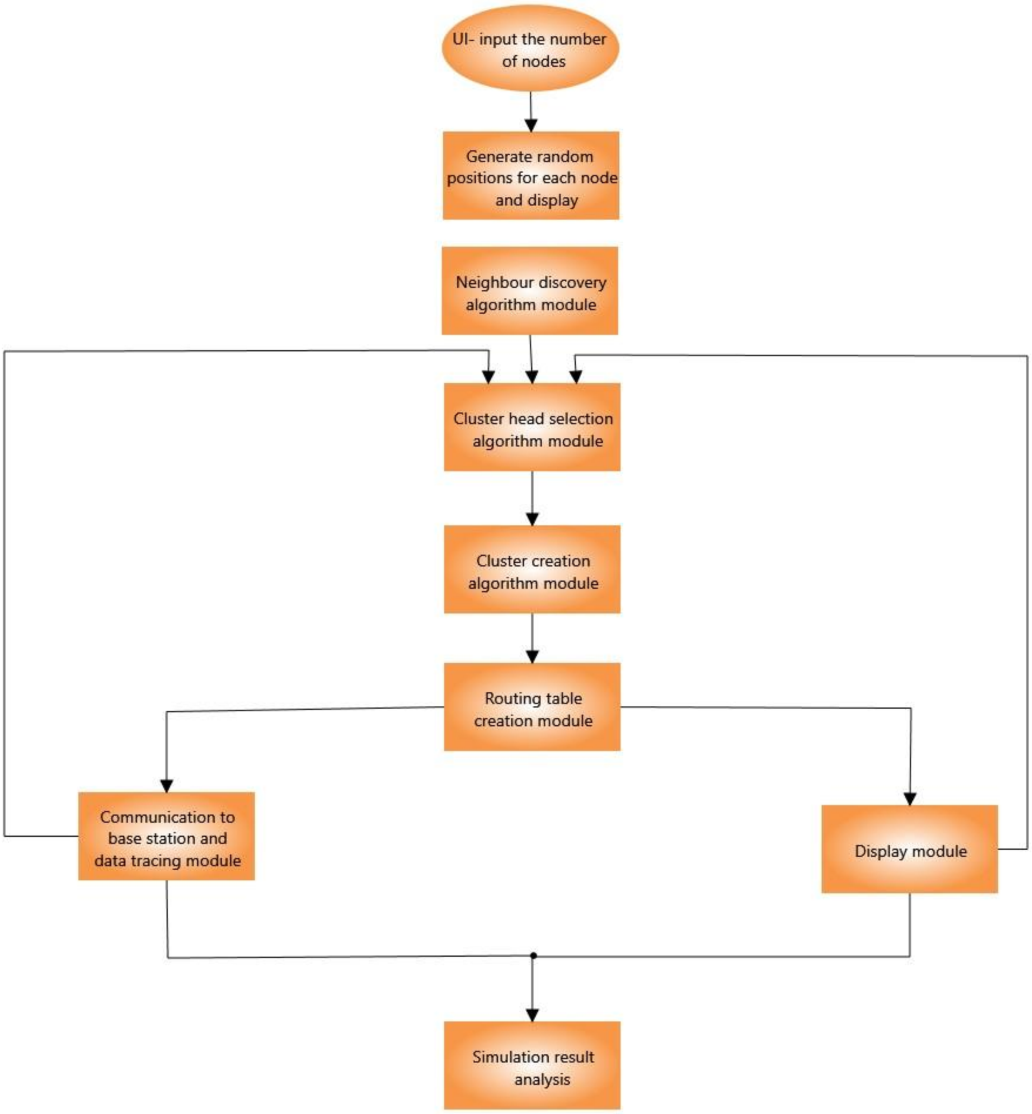

Fig 3.1 *Flow Chart of EAMMH*

3.2 Setup Phase

Initially, after the node deployment the neighbor discovery takes place. This can be done using many methods like: k-of-n approach, ping, beacon messaging. After the neighbor discovery, when cluster are being created, each node decides whether or not to become a cluster-head for the current round. This decision method is similar to the one used in LEACH. The setup phase operates in the following sequence: 1. CH (Cluster Head) Selection 2. Cluster Formation

In LEACH, nodes take autonomous decisions to form clusters by using a distributed algorithm without any centralized control. Here no long-distance communication with the base station is required and distributed cluster formation can be done without knowing the exact location of any of the nodes in the network. In addition, no global communication is needed to set up the clusters. The cluster formation algorithm should be designed such that nodes are cluster-heads approximately the same number of time, assuming all the nodes start with the same amount of energy. Finally, the cluster-head nodes should be spread throughout the network, as this will minimize the distance the non-cluster-head nodes need to send their data. A sensor node chooses a random number, r, between 0 and 1.

Let a threshold value be

$$\mathbf{T(n) : T(n)= p/1\text{-}p \times(r \bmod p\text{-}1) \qquad \ldots\ldots\ldots(1)}$$

If this random number is less than a threshold value, T(n), the node becomes a cluster-head for the current round. The threshold value is calculated based on the above given equation that incorporates the desired percentage to become a cluster-head, the current round, and the set of nodes that have not been selected as a cluster-head in the last (1/P) rounds, p is cluster head probability. After the nodes have elected themselves to be cluster-heads, it broadcasts an advertisement message (ADV). This message is a small message containing the node's ID and a header that distinguishes this message as an announcement message. Each non-cluster-head node determines to which cluster it belongs by choosing the cluster-head that requires the minimum communication energy, based on the received signal strength of the advertisement from each cluster-head. After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits a join-request message back to the chosen cluster-head. The cluster-heads in LEACH act as local control centers to co-ordinate the data transmissions in their cluster . The cluster-head node sets up a TDMA schedule and transmits this schedule to the nodes in the cluster. This ensures that there are no collisions among data messages and also allows the radio components of each non cluster-head node to be turned off at all times except during their transmit time, thus minimizing the energy dissipated by the individual.

3.3 Data Transmission Phase

Once the clusters are created, the sensor nodes are allotted timeslots to send the data. Assuming nodes always have data to send, they transmit it at their allotted time interval. When a node receives data from one its neighbors, it aggregates it with its own data. While forwarding the aggregated data, it has to choose an optimal path from its routing table entries. It uses a heuristic function to make this decision and the heuristic function is given by,

$$\mathbf{h = K\,(Eavg/\,hmin\ *\ t\,)} \quad \text{……..(2)}$$

where K is a constant, Eavg is average energy of the current path, hmin is minimum hop count in current path, t = traffic in the current path. The path with highest heuristic value is chosen. If this path's Emin> threshold, it is chosen. Else the path with the next highest heuristic value is chosen, where

$$\mathbf{Emin = Eavg\,/const} \quad \text{………(3)}$$

The constant may be any integer value like 10. If no node in the routing table has Emin greater than threshold energy, it picks the node with highest minimum energy.

3.4 Periodic Updates

The information about the paths and routing table entries at each node becomes stale after a little while. The heuristic values calculated based on the stale information often leads to wrong decisions. Hence the nodes are to be supplied with fresh information periodically. This will increase the accuracy and timeliness of the heuristic function. During the operation of each round, the necessary information is exchanged at regular intervals. The interval of periodic updates is chosen wisely such that the node does not base its decisions on the stale information and at the same time, the periodic update does not overload the network operation.

CHAPTER 4

RESULT

4.1 Simulation and Analysis of Result

Both LEACH [1] and EAMMH [2] are simulated using MATLAB. The parameters taken into consideration while evaluating EAMMH and LEACH are as follows.

- Round Number vs Number of Dead Nodes (with variation of probability)
- Round Number vs Average Energy of Each node (with variation of probability)
- Round Number vs Number of Dead Nodes (with variation of number of nodes)
- Round Number vs Average Energy of Each node (With variation of number of nodes)

To simplify the simulation of these protocols few assumptions are made. They are as follows:

1. Initial energy of nodes is same.
2. Nodes are static
3. Nodes are assumed to have a limited transmission range after which a another equation for energy dissipation is used
4. Homogeneous distribution of nodes.
5. Nodes always have to send the data.

4.1.1 Simulation of protocols at 0.01 probability

The below set of results represent the simulation of both LEACH and EAMMH protocols at 0.01 probability that is the percentage of total nodes which can become cluster head is 1% of the total number of node

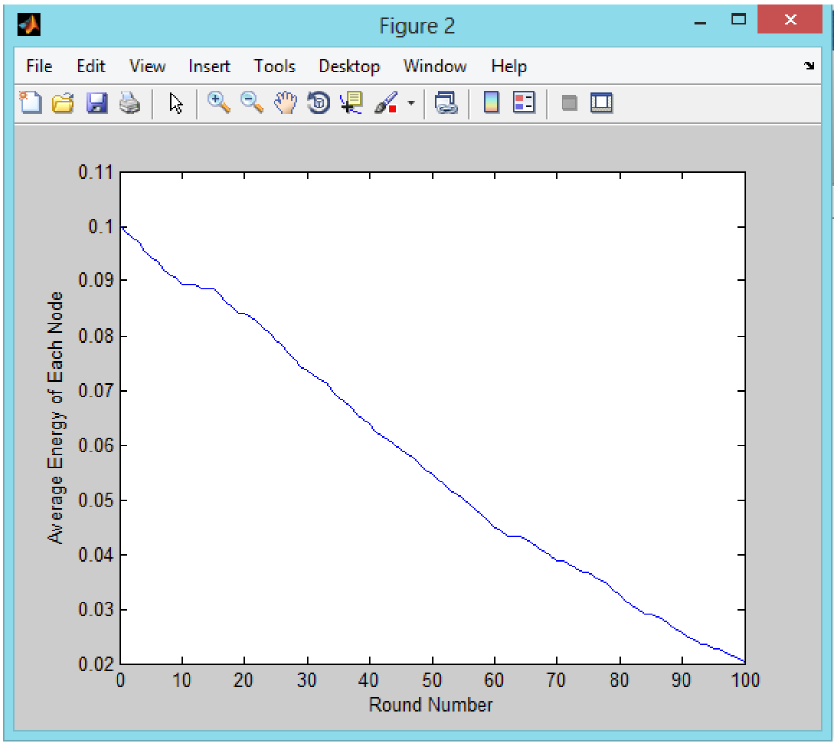

Fig 4.1 *Average energy vs Round no. : EAMMH*

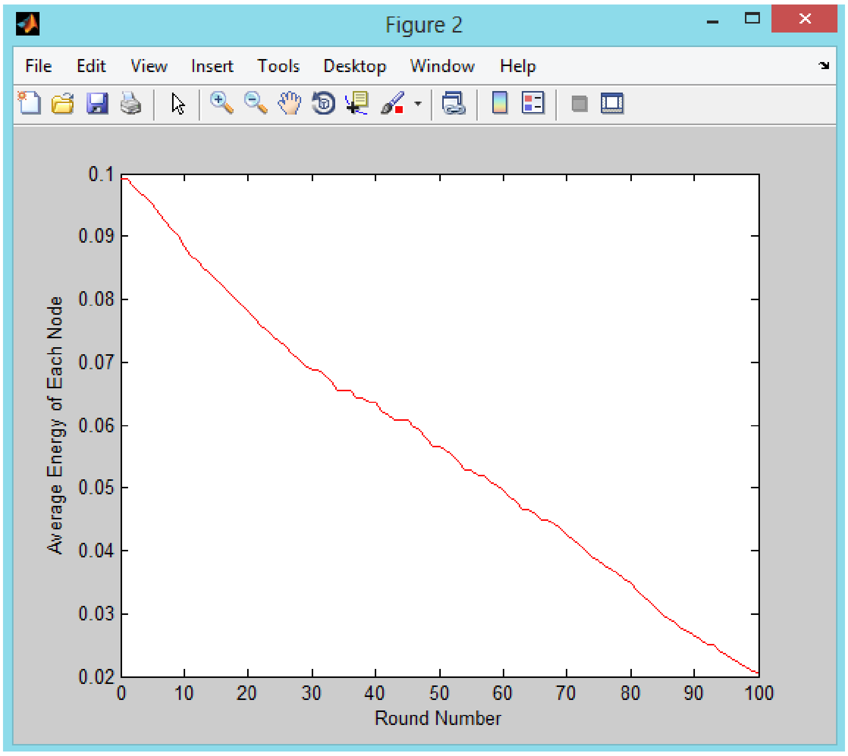

Fig 4.2 *Average energy vs Round No. : Leach*

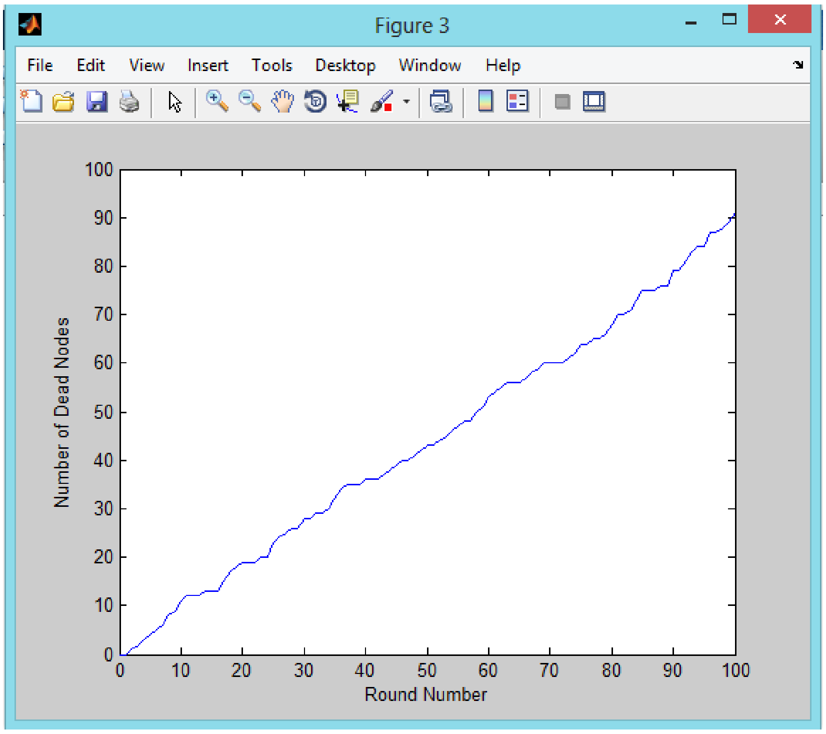

Fig 4.3 No.of dead nodes vs round no.: EAMMH

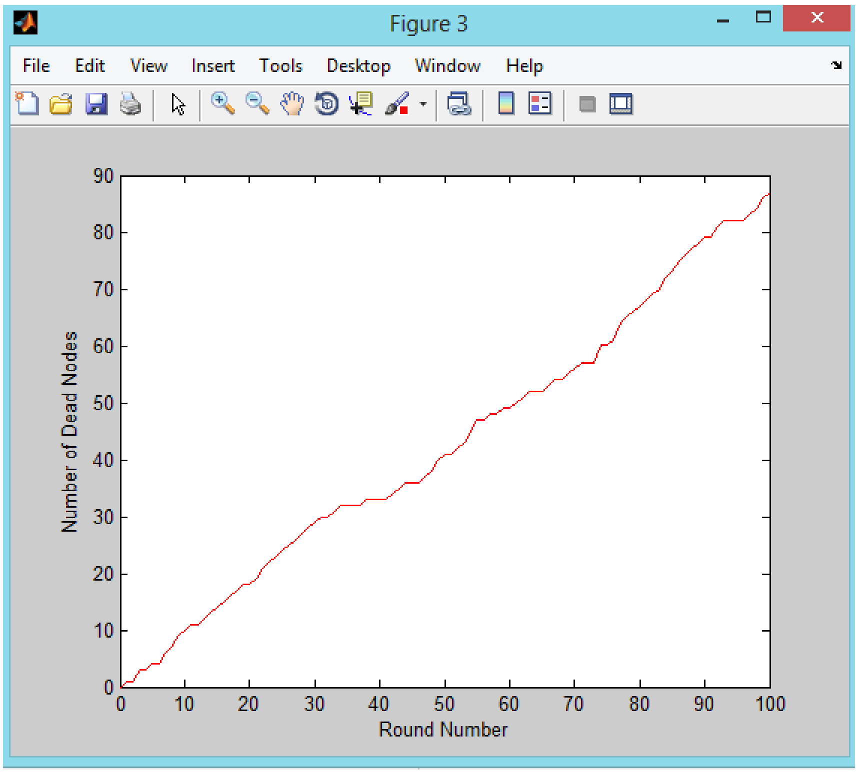

Fig 4.4No.of Dead nodes vs round no. : Leach

4.1.2 Simulation of Protocols at 0.5 probability

The above set of results represent the simulation of both LEACH and EAMMH protocols at 0.5 probability that is the percentage of total nodes which can become cluster head is 50% of the total number of nodes.

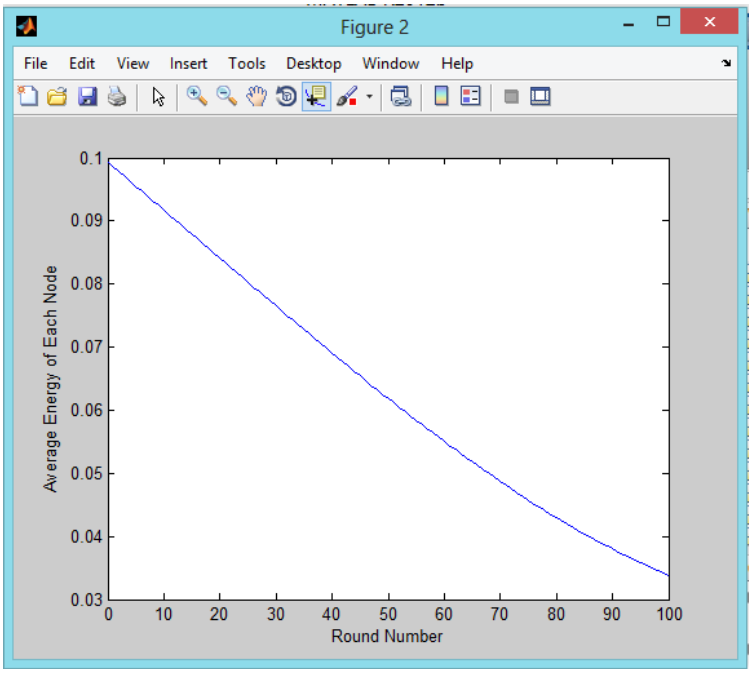

Fig 4.5 *Average energy vs Round no. : EAMMH*

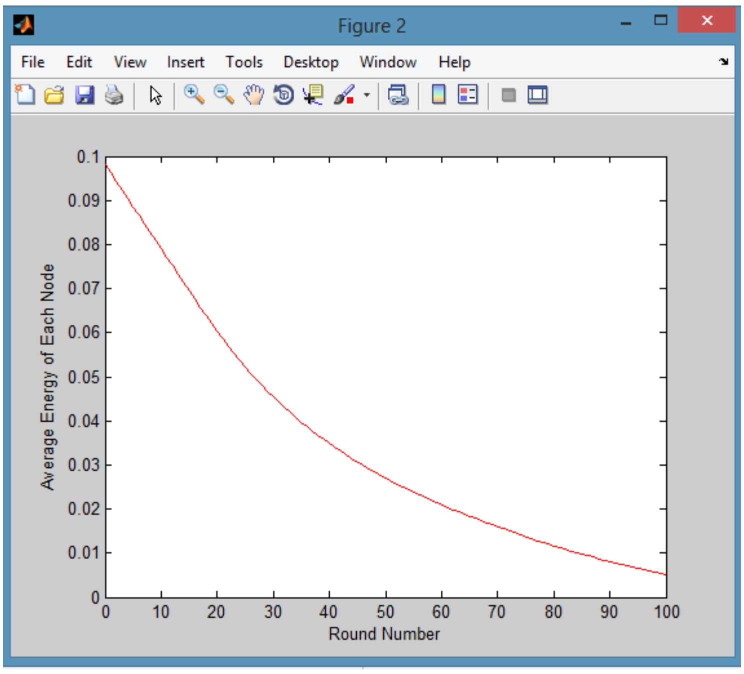

Fig 4.6 *Average energy vs Round No. : Leach*

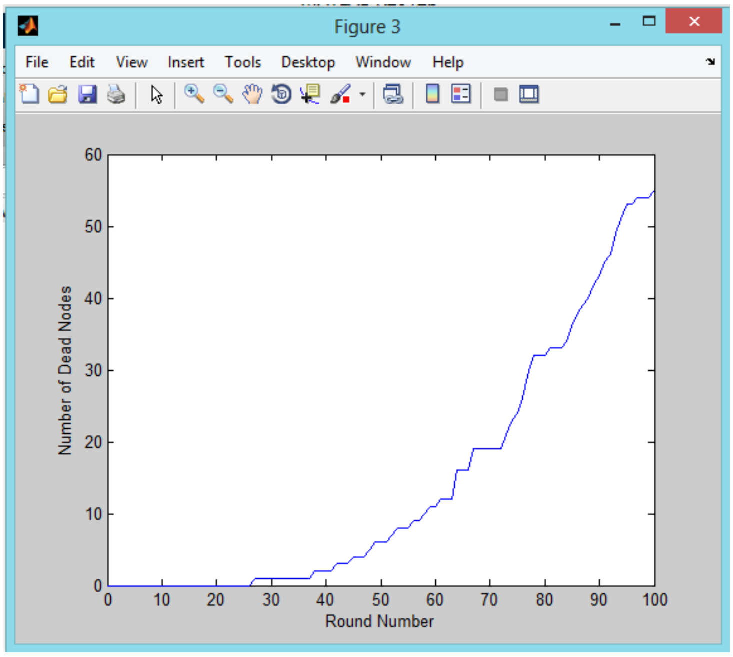

Fig 4.7 *No.of dead nodes vs round no.: EAMMH*

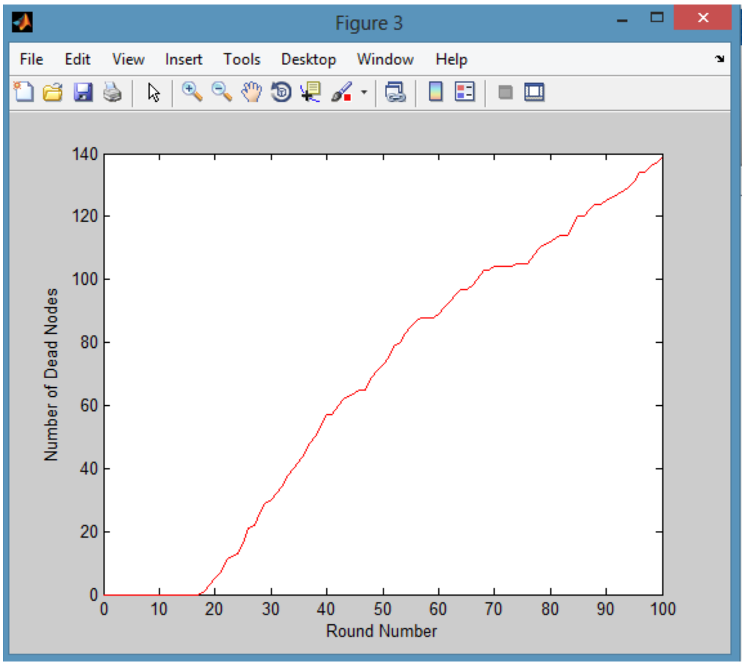

Fig 4.8 *No.of Dead nodes vs round no. : Leach*

4.1.3 Simulation of Protocols at 0.2 probability

The above set of results represent the simulation of both LEACH and EAMMH protocols at 0.2 probability that is the percentage of total nodes which can become cluster head is 20% of the total number of nodes.

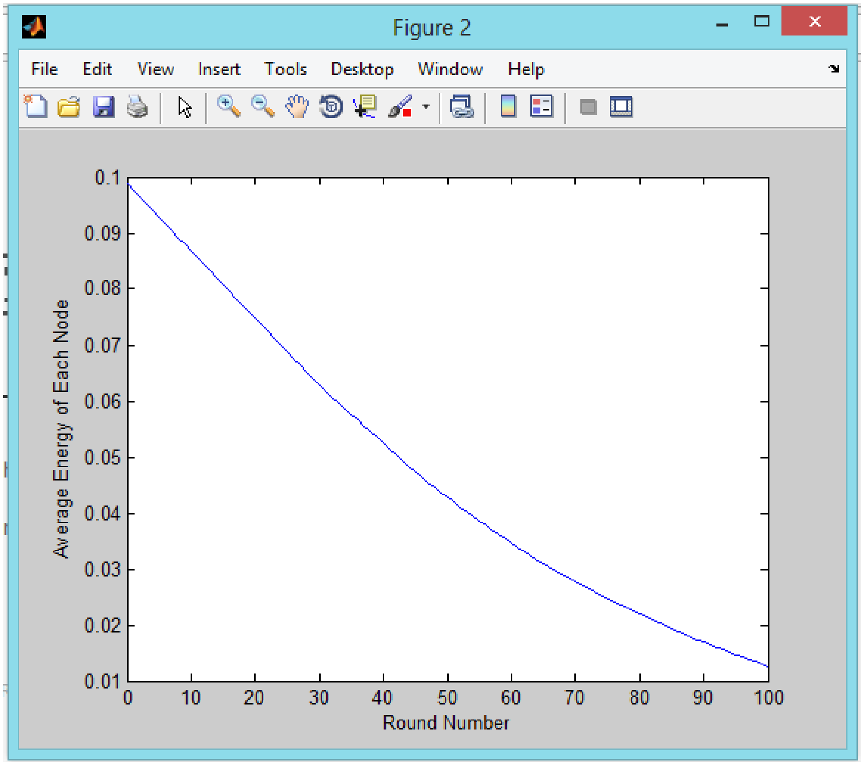

Fig 4.9 *Average energy vs Round no. : EAMMH*

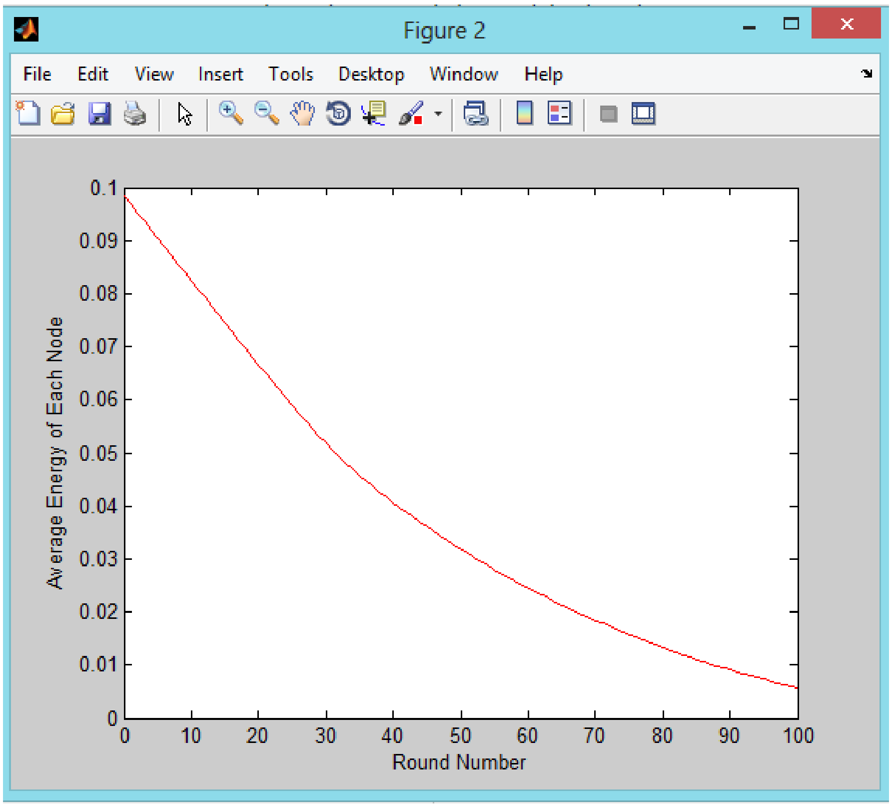

Fig 4.10 *Average energy vs Round No. : Leach*

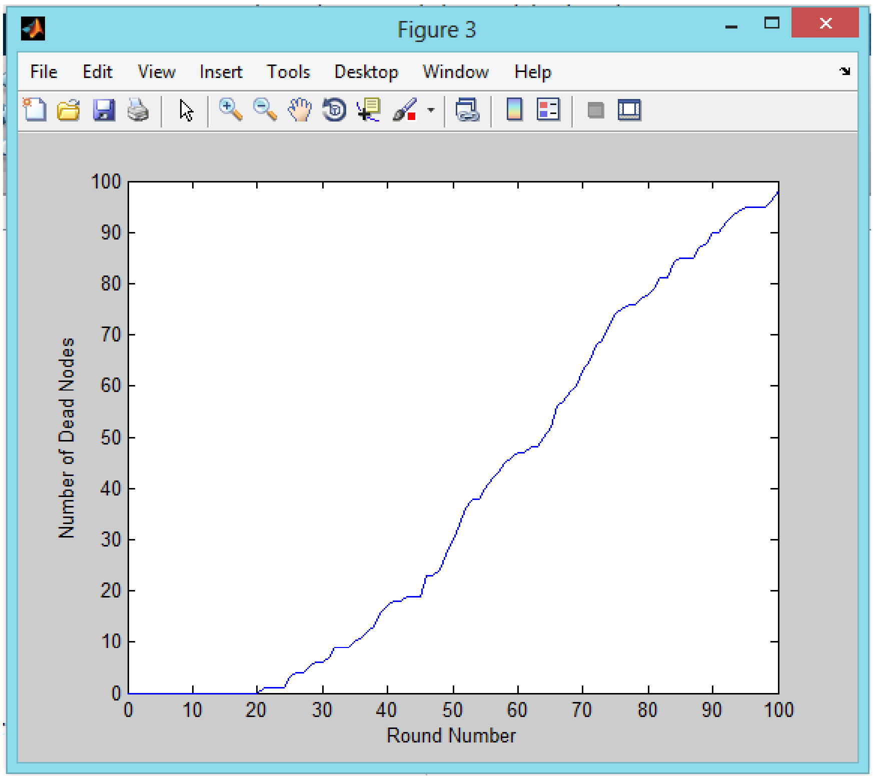

Fig 4.11 *No.of dead nodes vs round no.: EAMMH*

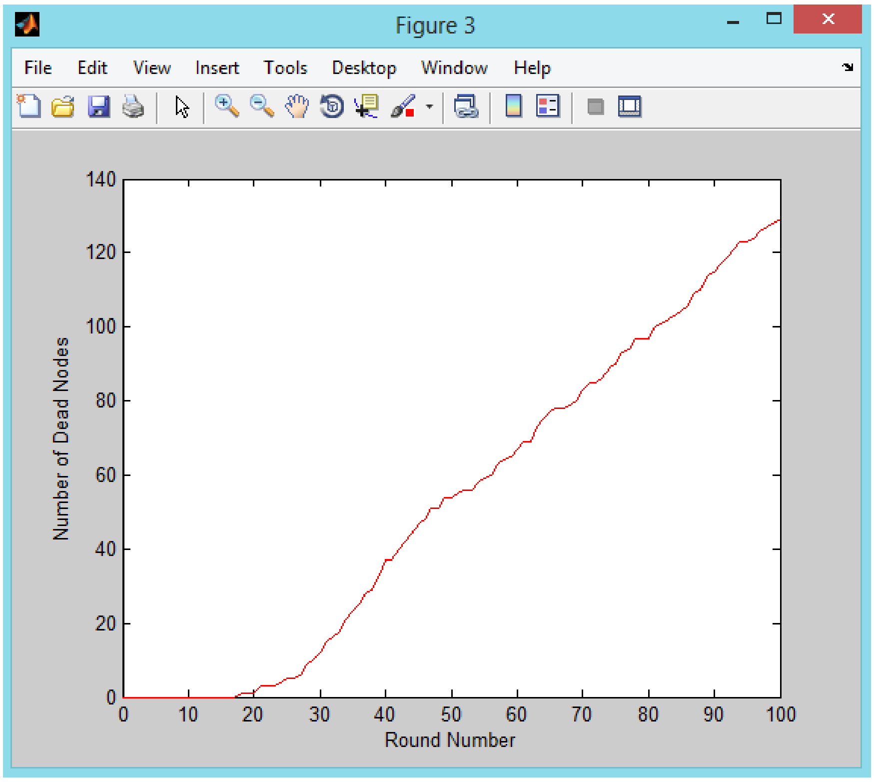

Fig 4.12 *No.of Dead nodes vs round no. : Leach*

4.2 Analysis of Result

It is observed from the figures 4.1 to 4.10 ,that as time progress LEACH and EAMMH both lose energy as the number of round increases. It is also observed that once a node reaches the value of zero it is no longer functional and is deemed as a dead node. From Figures 4.3-4.5 we observe that as the number of nodes increase EAMMH curve for average energy of each node is slightly better. The numbers of dead nodes also get lesser as the number of total nodes increase when compared to LEACH. Therefore for a probability of 0.01 as the number of nodes increases, the better is EAMMH when compared to LEACH. From the Figures 4.1 to 4.10, it is be evident that for each probability level as the number of nodes increase EAMMH is seen to perform better in terms of average energy of each node and the total number of dead nodes. However for a lesser number of total number of nodes, LEACH is found to perform better. From the Figures we observe from most cases that even though EAMMH performs better, the first dead node in most of the operations is by EAMMH. LEACH on the other hand has a delayed time in getting the first dead node but a larger number of nodes run out of energy in a short period of time subsequently. From the Figures, it can also be observed that for a fixed set of nodes, if the probability of election of Cluster Head is increased, then the average energy of each node gap between the curves increases favoring EAMMH. From Figure 4.2,4.5 and 4.9 we observe that LEACH at 0.01 probability is better than EAMMH, while at a probability of 0.5, EAMMH outperforms LEACH by a factor of 25% and at 0.2 probability by a factor of around 45%/. This is due to the fact that the nodes or the Cluster Head which are farther from the Base Station have to dissipate large amounts of energy to send the information as they will have to travel longer distances when compared to the ones which are nearer. The reason why EAMMH performs better than LEACH in majority of the scenarios is for the reason that EAMMH consists of a inter cluster routing mechanism which will help make the network survive for a longer time. LEACH on the other hand has a direct hop communication with the Cluster Head and then to the Base Station. Even though LEACH employs Multi-hop mechanisms, EAMMH with the usage of Multi-path and hierarchical routing parameters and techniques with the inclusion of Multi-hop can perform with much better energy efficiency than LEACH in cases where more number of nodes are involved.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Wireless Sensor Networks are usually spread over large areas are recently finding applications in many fields. In this regard, there is a requirement of methods which can manage the WSN's in a better way. Wireless Sensor Networks are powered by the limited capacity of batteries. The main challenge in the design of protocols for Wireless Sensor Network is energy efficiency due to the limited amount of energy in the sensor nodes. The ultimate motive behind any routing protocol is to be as energy efficient as possible to keep the network running for a longer period of time. In this paper we have presented clustering as a means to overcome this difficulty of energy efficiency. Detailed description about the working of two protocols, namely LEACH and EAMMH are presented. We have also presented the details about the simulation and the results of it. From the brief analyses of the simulation we have come to a conclusion that LEACH can be preferred in cases of smaller networks where the total number of nodes is less than fifty where it performs slightly better than EAMMH and EAMMH can be chosen in larger networks and also when the heuristic probability of Cluster Head selection is more.

Advantages–

1. Outperforms conventional routing protocols
2. LEACH is completely distributed, requiring no control information from the base station
3. No global knowledge of network required.

Besides these advantages LEACH suffers from many drawbacks such as:

1. Extra overhead to do dynamic clustering.
2. Cluster head selection is randomly that doesn't take into account energy consumption
3. LEACH is not able to cover large area.
4. Cluster heads are not uniformly distributed

5.2 Conclusion and Future Research

Designing Efficient Energy Routing Protocol is the fundamental requirement for WSNs, because after some round sensor nodes are dead. The Number of rounds depends upon the power of individual sensor which is measured in joule/node. The value of these rounds is different for every routing protocol which may be around 300 or 500 if we give power of 0.25 or 0.5 joule to node respectively. So, now we have a necessity to design energy efficient routing protocol which helps to keep sensor alive for a long time or for long rounds. In this paper, we have reviewed many research papers which mainly focused on Energy Efficient Routing Protocol for WSNs. We have compared many Routing protocol in several aspects. These papers covered many Energy Efficient Routing Protocols for WSNs but still improvement is required. Further research would be based on many issues which are not covered in existing protocol.

REFERENCES

[1] Rajaravivarma, V.; Yi Yang; Teng Yang; , "An overview of Wireless Sensor Network and applications," System Theory, 2003. Proceedings of the 35th Southeastern Symposium on ,16-18March-2003.

[2] Arampatzis, Th.; Lygeros, J.; Manesis, S.; , "A Survey of Applications of Wireless Sensors and Wireless Sensor Networks," Intelligent Control, 2005. Proceedings of the 2005 IEEE International Symposium on, Mediterrean Conference on Control and Automation", vol.no.pp.719-724,27-29June-2005.

[3] A. P. Azad, A. Chockalingam, Mobile Base Stations Placement and Energy Aware Routing in Wireless Sensor Networks , Department of ECE, Indian Institute of Science, Bangalore 560012, India.

[4] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, Wireless sensor networks: a survey, Computer Networks, Volume 38, Issue 4, 15 March 2002, Pages 393-422, ISSN 1389-1286, 10.1016/S1389-1286(01)00302-4.

[5] Liu X. A survey on clustering routing protocols in wireless sensor networks Sensors (Basel). 2012;12(8):11113-53. Epub 2012.

[6] Liu X. A survey on clustering routing protocols in wireless sensor networks Sensors (Basel).

[7] W.Heinzelman, A.Chandrakasan,and H.Balakrishnan,"Enegy-efficient routing protocols for wireless microsensor networks," in Proc. 33rd Hawaii Int. Conf. SystemSciences(HICSS).

[8] Heinzelman W.B.,Chandrakasan A.P.,BalakrishnanH.,"An application specific protocol architecture for wireless microsensor networks".

[9] Vaibhav Pandey, Amarjeet Kaur and Narottam Chand "A review on data aggregation techniques in wireless sensor network" Journal of Electronic and Electrical Engineering.

[10] Monica R Mundada, V CyrilRaj and T Bhuvaneswari. "Energy Aware Multi-Hop MultiPath Hierarchical (EAMMH) Routing Protocol for Wireless Sensor Networks".

[11] Valerie Galluzzi and Ted Herman "Survey: Discovery inWireless Sensor Networks" International Journal of Distributed Sensor Networks Volume 2012.