Chapter 1

Introduction

1.1 Introduction

A WSN consists of enormous battery operated sensor nodes, which are randomly deployed in an unreachable terrain and harsh environment for sensing and gathering the required information from the surroundings and transmitting the aggregated data to the far located sink. The sensor node has low cost and are randomly deployed due to which it is impossible to recharge their batteries. The energy efficiency and lifetime of the network are the critical problems in wireless sensor networks. Channel fading and interference are the biggest problems for the design of an efficient routing protocol for wireless sensor network especially in military applications.

LEACH is a routing protocol in which the data is delivered to the data sink or base station in a cluster-based approach. There are few factors to be kept in mind such as maximizing network lifetime, minimizing energy consumption and performing data processing at intermediate nodes to reduce the number of transmissions. It is a cluster-based hierarchy in which the entire network is divided into clusters and each cluster has a cluster head assigned to it. Cluster formation is dynamic in each round and the cluster head is responsible for the data collection from all the nodes of that cluster; it processes the data and sends the collected data to the base station. In LEACH, cluster-heads are selected randomly but the energy spent for each round is balanced as all the sensor nodes have a probability to be selected as a cluster-head.

PEGASIS is a routing protocol in which a chain based approach is followed. This protocol follows a greedy algorithm starting from the farthest node and all the sensor nodes form a chain like structure. It works on the principle that each node will transmit to and receive from its close neighbors. There is a leader in the chain which is responsible for transmission of the combined data to the sink node . Nodes take turns being the leader in the network which evenly distributes the energy load amongst the nodes. This even energy distribution and high energy efficiency leads to the extension of the network lifetime. It attempts to reduce the delay that the data acquires on the way to the base station ..

P-LEACH protocol is the hybrid of both the protocols LEACH and PEGASIS. P-LEACH overcomes the shortcomings of LEACH and PEGASIS both. In P-LEACH, we use the cluster formation technique of LEACH in the chain based architecture of PEGASIS. As a result, the system will have higher lifetime, low energy consumption, and unlike PEGASIS, can also deal

with a dynamic system. This protocol uses an energy efficient routing algorithm to achieve the proposed results.

1.2 Important Factors

The protocol focuses on reduction in power consumption of wireless sensor networks with the help of the LEACH protocol. It presents the three metrics – First Node Dies (FND), half of the Nodes Alive (HNA) and the Last Node Dies (LND) that determines the lifetime of a sensor network. However, it is assumed that all nodes in the network are homogenous and energy-constrained and are able to reach the base station, nodes have no location information, and cluster heads perform data compression. Multi-hop routing with the LEACH protocol to prolong lifetime of WSN is implemented based on Received Signal Strength Indicator (RSSI). This reduces energy consumption.

PEGASIS is based on assumption that sensor nodes are static in behavior, and all nodes have global knowledge of the network. This protocol uses a routing tree technique, where the roots of a routing tree technique have been selected by the base station, which then broadcasts this information to all nodes in the network.

1.3 Aim and Objective

The aim of our project is to simulate the energy efficient protocol P-LEACH and compare it with the parent protocols PEGASIS and LEACH

.

1.4 Project outline

Chapter 2: This chapter presents the basic theory of WSNs, including the network specification and the locations of nodes and BS.

Chapter 3: In this chapter the energy consumption, LEACH, PEGASIS and P-LEACH protocols, their phases, flow chart and their workings.

Chapter 4: The simulation result for these protocols has been discussed. Then the performance of the protocols has been studied by comparing distribution, average energy distribution, number of dead and alive nodes.

Chapter 5: This chapter contains conclusion.

Chapter 2

Network Model

2.1 Introduction to Wireless Sensor Networks

A WSN consists of enormous battery operated sensor nodes, which are randomly deployed in an unreachable terrain and harsh environment for sensing and gathering the required information from the surroundings and transmitting the aggregated data to the far located sink. The sensor node has low cost and are randomly deployed due to which it is impossible to recharge their batteries. The energy efficiency and lifetime of the network are the critical problems in wireless sensor networks. Channel fading and interference are the biggest problems for the design of an efficient routing protocol for wireless sensor network especially in military applications .A WSN consists of a number of sensor nodes with limited energy and sink node with adequate energy and computing capability. The sink node is the destination of all data from sensors in the network while sensor network collect data from target environment. Since data transmission takes the most critical part of whole energy consumption for a sensor node, most WSN protocols has incorporated schemes to save energy in data transmission. If sensor nodes transmit data to sink node directly then the farthest node from sink node may consume more energy because larger transmission energy is needed to send farther. This makes those nodes dies earlier than others. To solve this problem clustering algorithm is used .In clustering algorithm whole network is divided into small clusters and each sensor nodes send data to its cluster head which further transmit it to sink node . Data gathering is an efficient method for conserving energy in sensor networks. The major purpose of data gathering is to remove the redundant data and save transmission energy [1-3]. A data-gathering algorithm includes some aggregation methods to minimize the data traffic. It reduces the number of message exchange among the nodes and BS. The performance of data gathering in WSN can be characterized based on the rate at which the sensing information can be gathered and transmitted to the BS (or sink node). In particular, the speculative measure to capture the demerits of collection processing in WSN is the capacity for many-to-one data collection. Data-gathering capacity reflects how efficient the sink can gather sensing data from all sensors under the presence of interference. Performing the data-gathering function over CH still causes significant energy wastage. In case of homogenous sensor networks, CH will soon die and re-clustering needs to be initiated. It causes higher energy consumption. This is done by using LEACH protocol. LEACH is a routing protocol based on clustering, which reduces energy consumption in sensor networks. It offers an energy-efficient routing in WSN based on the effective data ensemble and optimal clustering. In this system, a cluster head is elected for each

clusters to minimize the energy dissipation of the sensor nodes and to optimize the resource utilization. The energy-efficient routing can be obtained by nodes which have the maximum residual energy. Hence, the highest residual energy nodes are selected to forward the data to BS. It helps to provide better packet delivery ratio with lesser energy utilization.

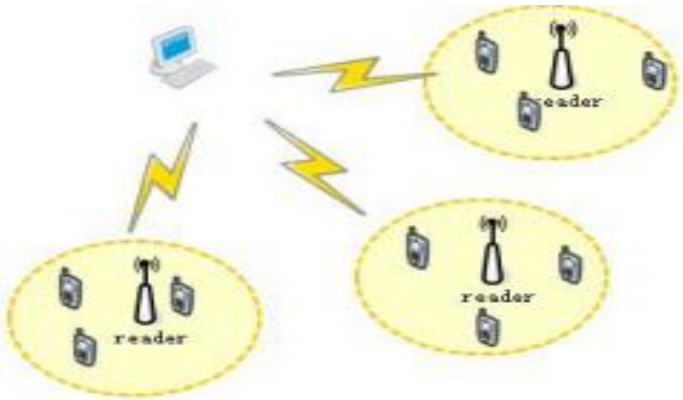


Fig 2.1: Structure of WSN

2.2 Network Specification

Parameter	**Value**
Yard type	Rectangle
Yard length	100
Yard width	100

Table 2.1: Network Specifications

2.3 Location of nodes

2.3.1 Location of sensor nodes

- The x-coordinate and the y-coordinate of the sensor nodes are randomly generated by using a rand function in MATLAB.
- We have stored the location of sensor nodes as a attributes of the node. So, our result of analysis can vary depending on the location of the nodes that are being randomly generated , as energy required for transmission depends on distance.

2.3.2 Coordinates of sensor nodes

- Y-coordinate =(Yard width)/2
- X-coordinate =(Yard length)/2

2.3.3 Location of Base Station

The x-coordinate and y-coordinate of the Base Station are also generated randomly using rand function in MATLAB and stored as the attribute.

Chapter 3

Description of the Protocol

3.1 Model Energy Comsumption in wireless sensor network

In wireless sensor network the energy consumed by a sensor node is essentially due to the following operations: capture, processing and data communication, to maximize the lifetime of the sensor network, it is necessary to think about the strategy that allows the efficient use of energy consumed by each node used in the transmission or reception between all the nodes constituted the wireless sensor networks,in the order, the communication energy represents the largest portion of the energy consumed by a sensor node.

3.1.1 Energy Parameters:

- E_{fs} :-Energy Consumption of free space
- E_{amp} :- Energy Consumption of multipath.
- E_{elec} :- Energy required for 1 bit transmission and reception.
- d :- Transmission distance
- d_0 :- Threshold of transmission distance for amplification circuit .

$$d_0 = \sqrt{E_{fs}/E_{mp}}$$

The energies needed to send $E_{Tx}(s, d)$ and receive $E_{Rx}(s)$ messages are given by:

To send s bit message to a receiver far from distance d, the transmitter consumes:

$$E_{Tx}(s,d) = s \times E_{elec} + s \times E_{amp} \times d^4$$

To receive a bit message, the receiver consumes:

$$E_{Rx}(s,d) = s \times E_{elec}$$

where E_{elec} and E_{amp}: Electronic transmission energy and Amplification energy

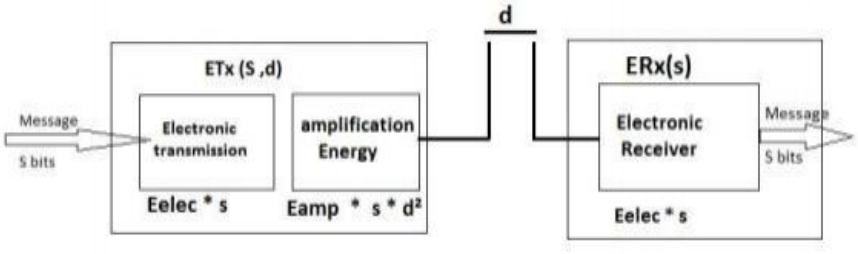


Fig 3.1 Energy Consumption Model in WSN

The Formula distance between each nod and base station is:

$$d_k = \left[(X_{bs}-x_k)^2 + (Y_{bs}-y_k)^2\right]^{1/2}$$

where,

d_k : The distance of each node-k from the base station.

X_{bs} and Y_{bs} : The coordinates of the base station

x_k and y_k : The coordinates of the each k-node

3.2 LEACH Protocol

Wireless sensor networks are assumed to be self organized i.e., there is no centralized control station like base station or access point. Clustering based routing protocols enable the WSNs to exploit some benefits of cellular based wireless networks. Dividing the whole sensor network in number of clusters and selecting a CH for each cluster can localize the coordination and control of the network. LEACH is well known energy efficient clustering based protocol for wireless sensor networks that can achieve as much as a factor of reduction in energy dissipation compared with conventional routing protocols. The LEACH protocol also outperforms classical clustering algorithm by using adaptive clustering and rotating the CH among nodes that randomize the power consumption of the CH. The LEACH protocol operates on a round to round basis and each round has three phases: Advertisement phase, cluster set-up phase, and steady-state phase. LEACH is completely distributed and requires no global knowledge of network. It reduces energy consumption by minimizing the communication cost between sensors and their cluster heads and 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.

3.2.1 Phases of LEACH Protocol

Advertisement phase: Each node decides whether or not to become a CH for current round. The decision to become a CH depends on the prior percentage of CHs and number of times the node has been a CH so far. After making this decision each node that has elected itself as a CH for the current round broadcasts an advertisement message to rest of the nodes. At the end of this phase each noncluster-head node decides the cluster to which it belongs for this round. Node n assigned a number between 0 and 1, if the number is less than the threshold, then n becomes a cluster head.

$$T(n)= p/(1-p*[r \bmod (1/p)]) \quad n \in G$$

Notations

- T(n) is the threshold number
- P = the desired percentage of cluster heads
- r = the current round
- G is the set of nodes that have not been cluster-heads in the last 1/P round.

Cluster setup phase: Each node informs the selected CH node that it will be a member of the cluster. During this phase all CH nodes must keep their receivers on receiving messages from nodes that would like to be a member of the cluster. Depending on the number of nodes in the cluster, the CH creates a time division multiple access (TDMA) schedule and sends this schedule to all other sensor nodes.

Steady-state phase: In this phase, sensor nodes start sending data to the CH. Sensor nodes transmit their information towards the CH in their own time slot allocated by the CH. The radio of each noncluster-head nodes can be turned off except node's allocated time slot. After receiving data from all sensor nodes, cluster-head performs some signal processing prior to transmit them towards higher order cluster-head or sink node.

Data Transmission: Nodes send with minimal required energy to the local cluster head, and turn off their radio when not sending. Local cluster heads receive data, compress it into a single signal at the end of the round. To avoid interference between clusters, CDMA codes are picked at random by local cluster heads and broadcasted to their cluster nodes.

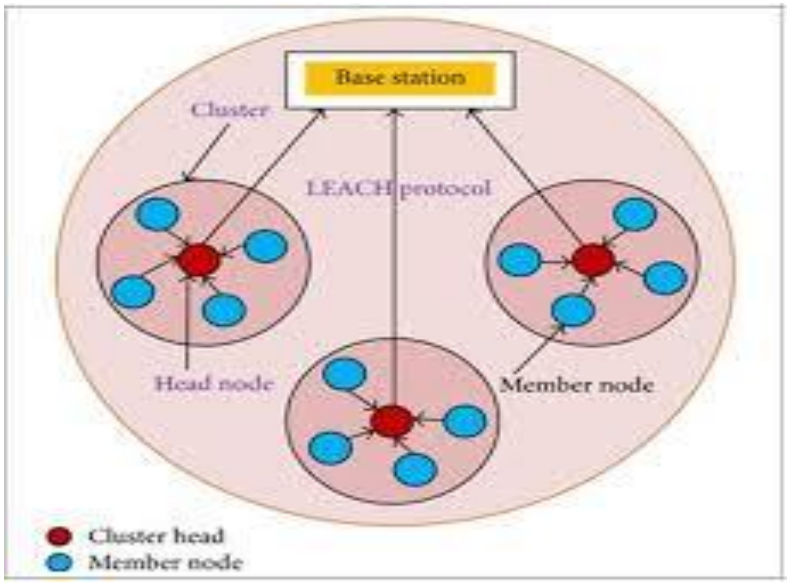


Fig 3.2: Schematic structure of LEACH protocol

3.2.2 Flowchart of LEACH protocol:

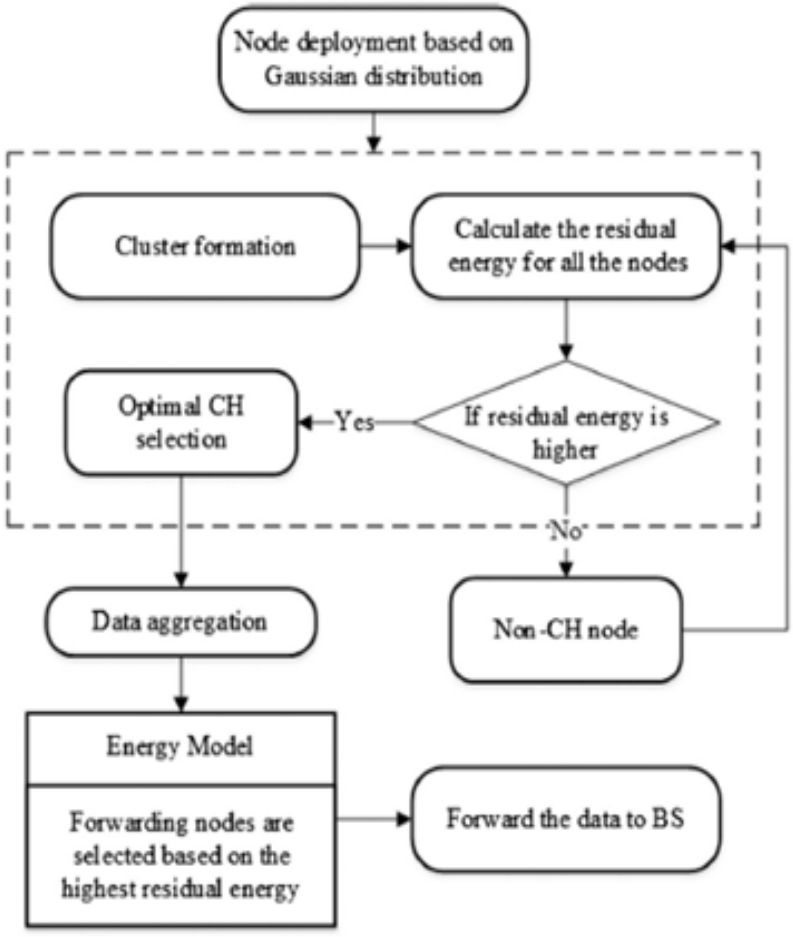


Fig 3.3: Flowchart of LEACH protocol

3.3 PEGASIS Protocol

PEGASIS is a near optimal chain-based routing protocol and the main thought in this protocol is for every node to only communicate with their nearest neighbors and alternate being the leader in transmission to the BS. In PEGASIS, All the sensor node locations are random, and each node has the power of data detection, data fusion, wireless communication and positioning. Energy load is distributed equally among all sensor nodes in the network. In this the chain is shaped by the nodes themselves, they can first acquire the location data of all nodes and plot the chain using the greedy algorithm. For data gathering, each node gets data from one neighbor, fuses its own data and transmits data to the next neighbor in the chain. Alternatively, control token passing approach started by the leader is applied to begin data passing from the ends of the chain. In the Token Passing Scheme in PEGASIS, node is the leader, it passes the token along the chain to the node at first. Then, node passes its data toward node . After node receives data from node it passes the token to node and node passes its data towards node with data fusion occurring along the chain. As indicated by these, PEGASIS protocol is able to outperform LEACH for distinctive network sizes and topologies. PEGASIS diminishes the overhead of dynamic cluster formation in LEACH. It also decreases the number of data transmission volume through the chain of data collection and the energy load is spread out consistently in the network.

PEGASIS improves by saving energy at following stages.

- In PEGASIS there is just single node which manages the data collecting and data fusion. Thus, compared to LEACH where each cluster head is taking part in communication with the base station. Along these lines, thus the energy will likewise be spread out by each cluster head. PEGASIS will spread out less energy because only leader will take part in data aggregation and data fusion.
- At the local gathering, the distance of the node transmits is very less as compared to the CH in LEACH.
- The leader will receive at most only two messages from the neighbors which is not in the case of LEACH.

  The goals of PEGASIS are as follows:
  - To minimize the transmission distance of each node
  - To minimize the overhead
  - To minimize the messages that need to be sent to the BS
  - To pass out the energy consumption equally across all nodes

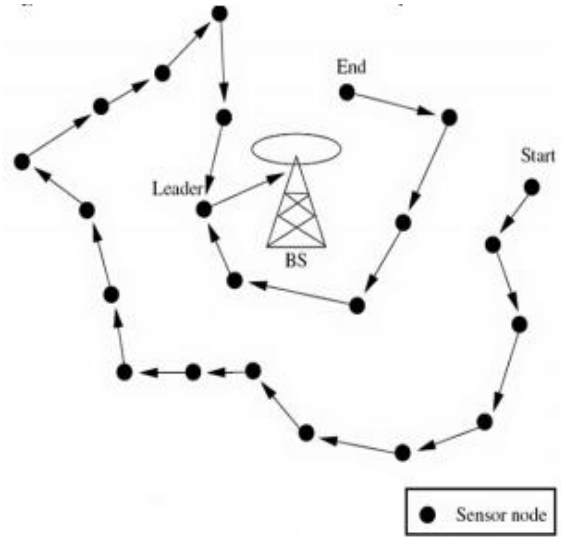


Fig 3.4: Schematic Structure of PEGASIS protocol

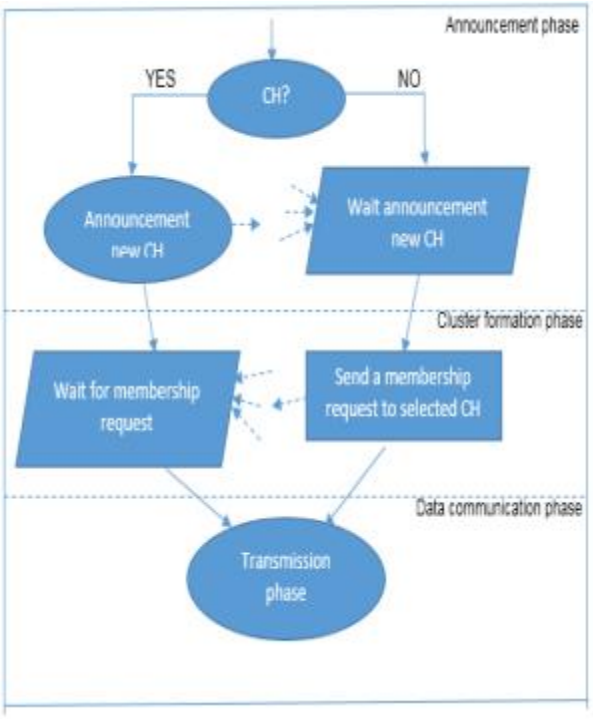


Fig 3.5: Algorithm of PEGASIS protocol

Parameter	LEACH	PEGASIS
Type of protocol	Hierarchical	Hierarchical
Network Lifetime	High	Very high
Data Aggregation	Yes	No
Power Consumption	High	Maximum
Overhead	High	Low
Data Delivery Model	Cluster-based	Chain-based
QoS	No	No
Specified path	Yes	Yes
Scalable	Yes	Yes
Query Based	No	No

Table 3.1: Comparison between LEACH and PEGASIS

3.4 P-LEACH Protocol

PEGASIS protocol uses one CH that communicates with the BS, but in our Method Proposed we combined the technique using PEGASIS Protocol and LEACH technique. In P-LEACH Protocol proposed, the technique LEACH protocol to select CH in the architecture network, and then a chain between all cluster formed by LEACH protocol using technique PEGASIS Protocol is constructed to have finally one node is responsible to send data to BS.

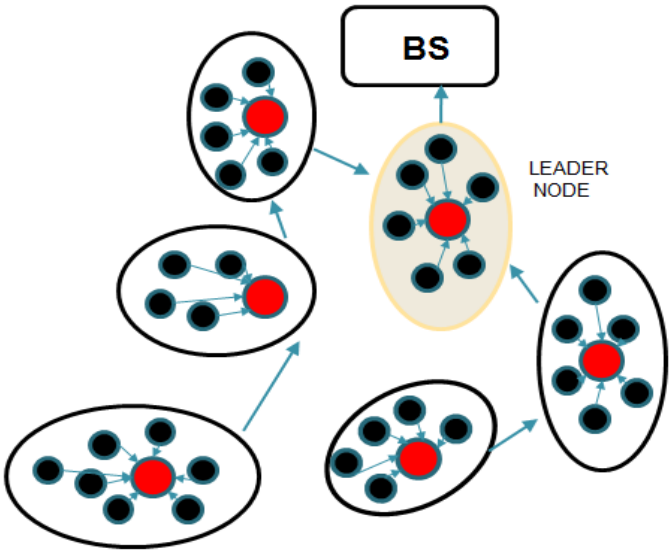


Fig 3.6: Topology for the P-LEACH Protocol

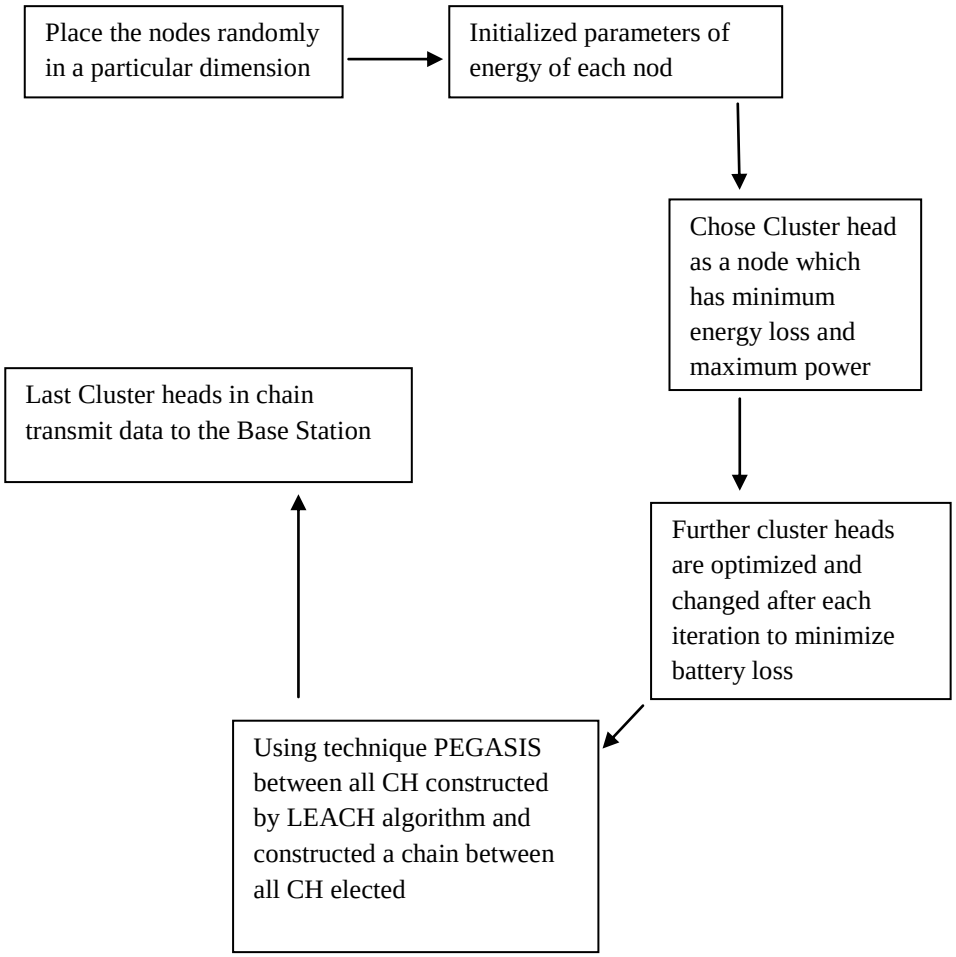


Fig 3.7: Steps of P-LEACH protocol

CHAPTER 4

RESULTS AND DISCUSSION

4.1 LEACH Protocol

4.1.1 Distribution Pattern of Nodes

- X-denotes the location of the base station.
- Light coloured circles denote the nodes employed in the network.
- Dark coloured nodes denote the cluster head in the given round.
- Red coloured nodes denote the dead nodes in the network.

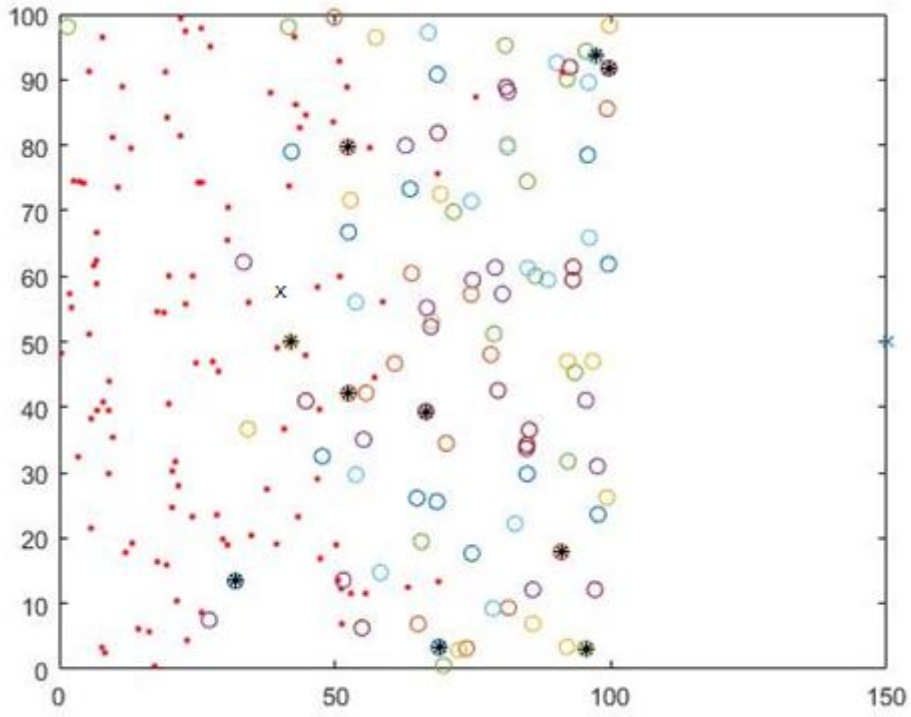
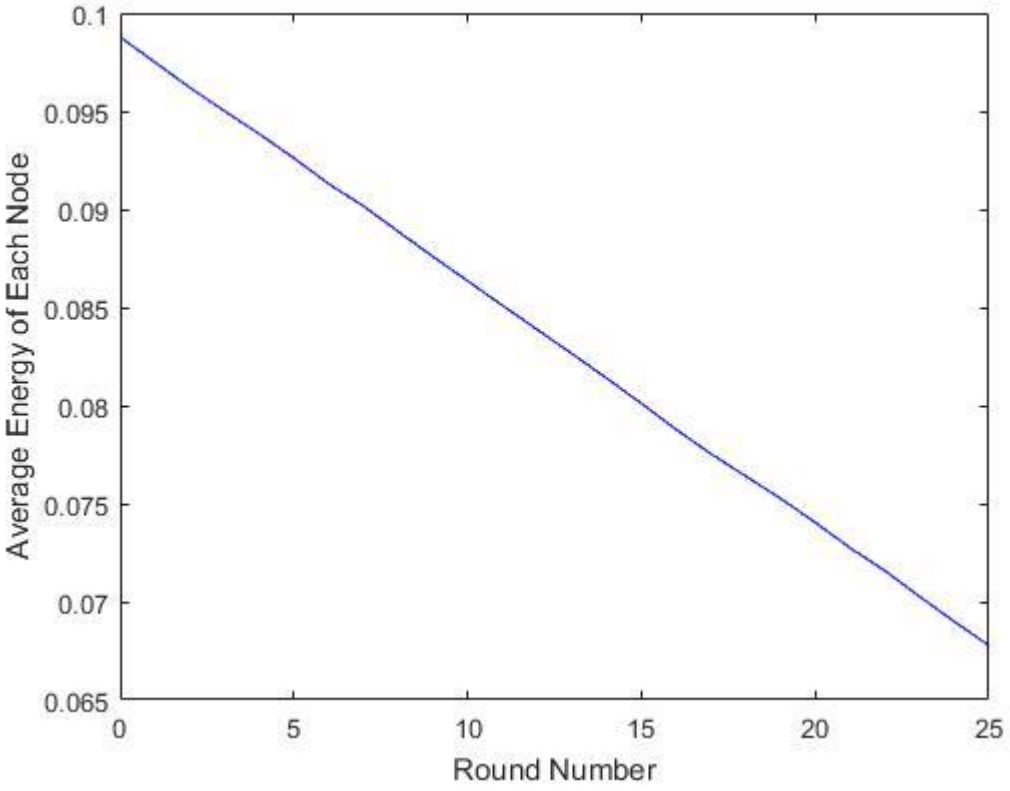


Fig 4.1: Distribution of nodes in LEACH Simulation

4.1.2 Average Energies of Nodes

Fig 4.2: Average energy of each node – LEACH Protocol in 25 Rounds



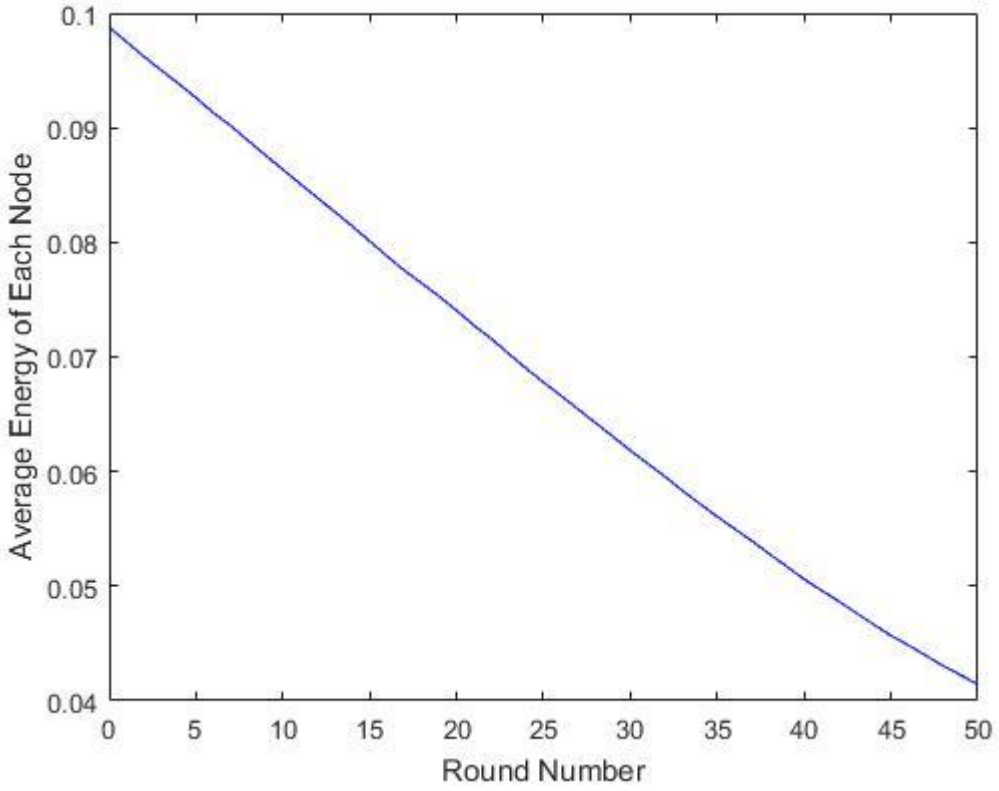
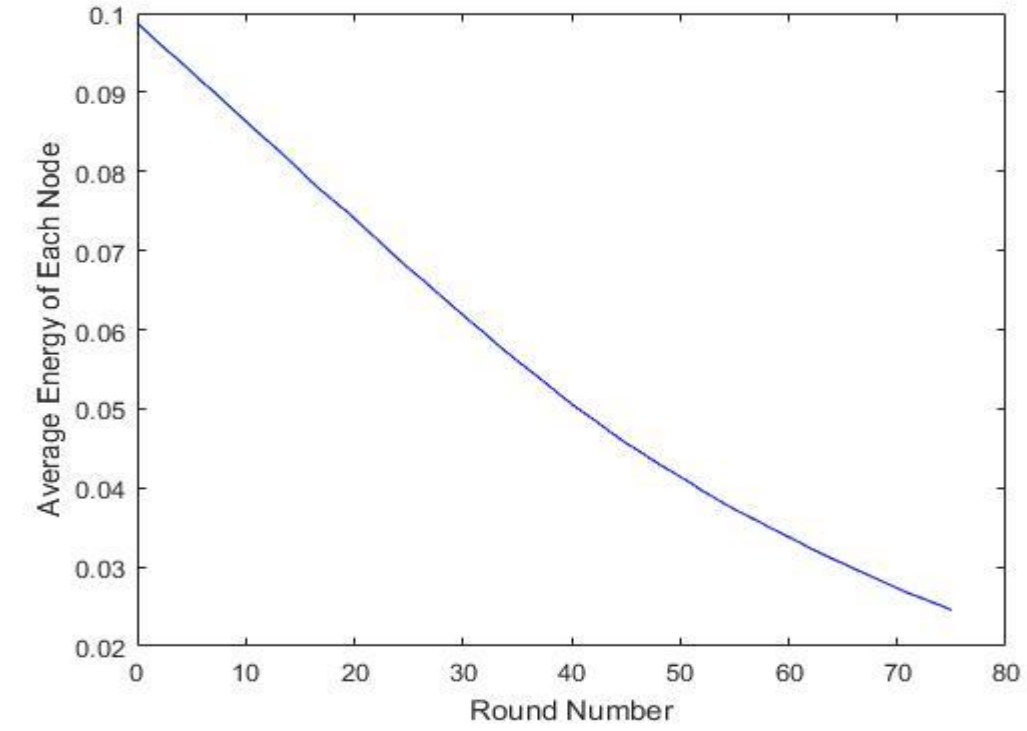


Fig 4.3: Average energy of each node – LEACH Protocol in 50 Rounds

Fig 4.4: Average energy of each node – LEACH Protocol in 75 Rounds



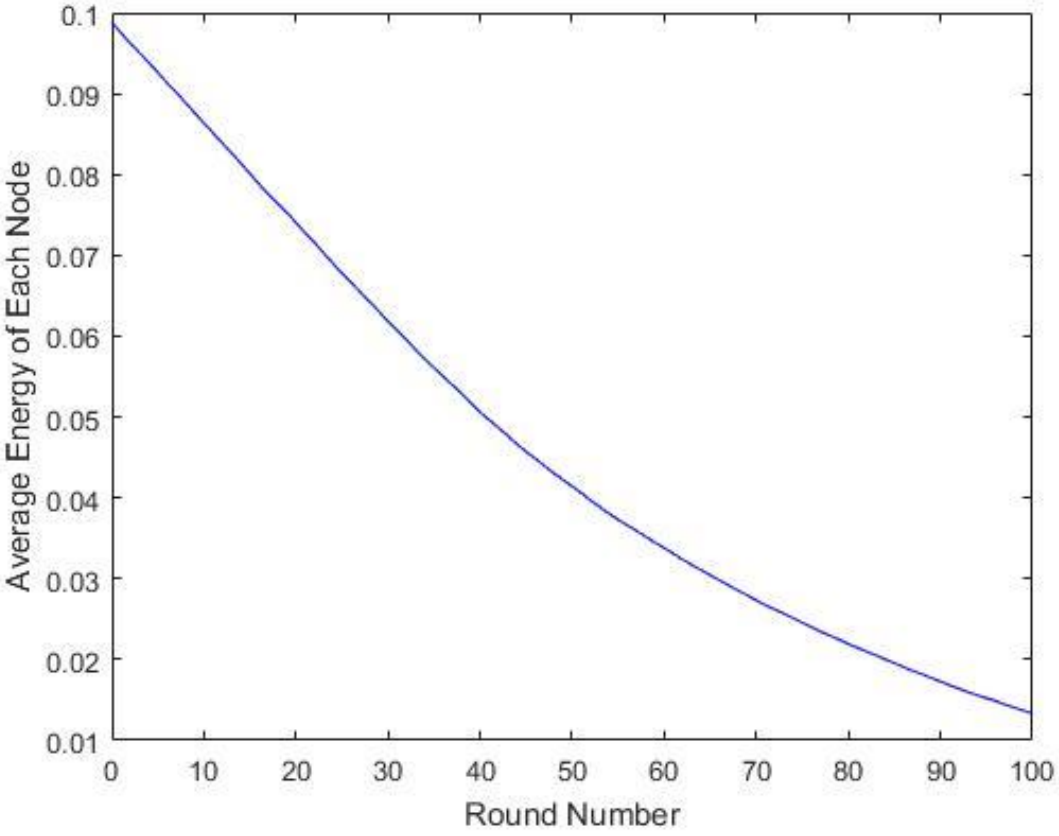


Fig 4.5: Average energy of each node – LEACH Protocol in 100 Rounds

4.1.3 Number of Dead Nodes

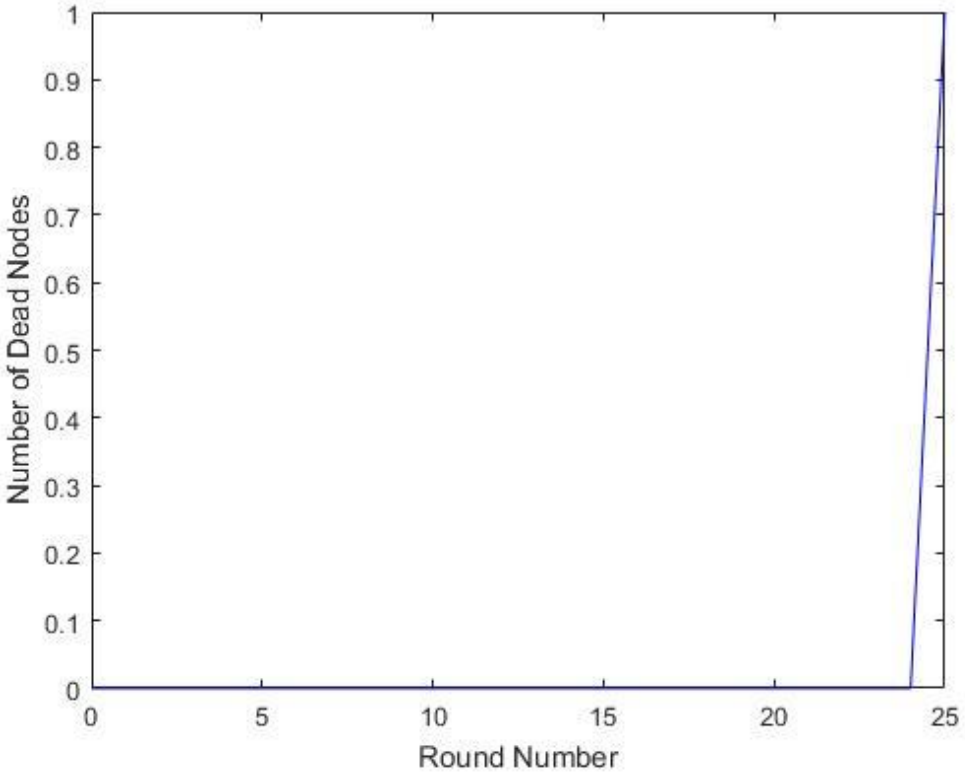


Fig 4.6: Number of dead nodes – LEACH Protocol in 25 Rounds

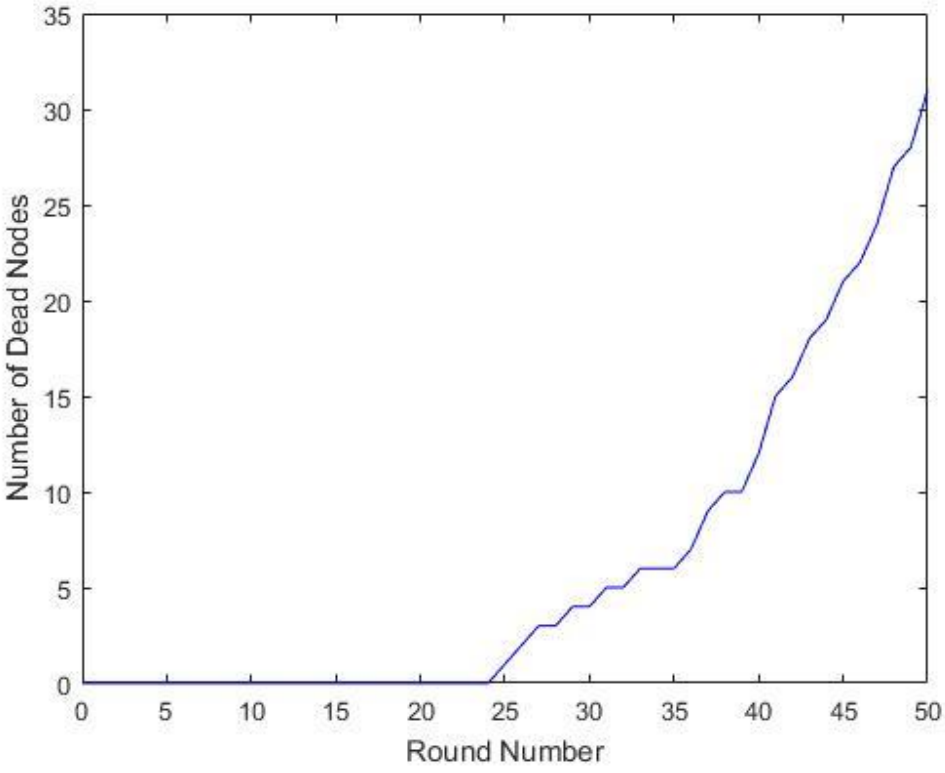


Fig 4.7: Number of dead nodes – LEACH Protocol in 50 Rounds

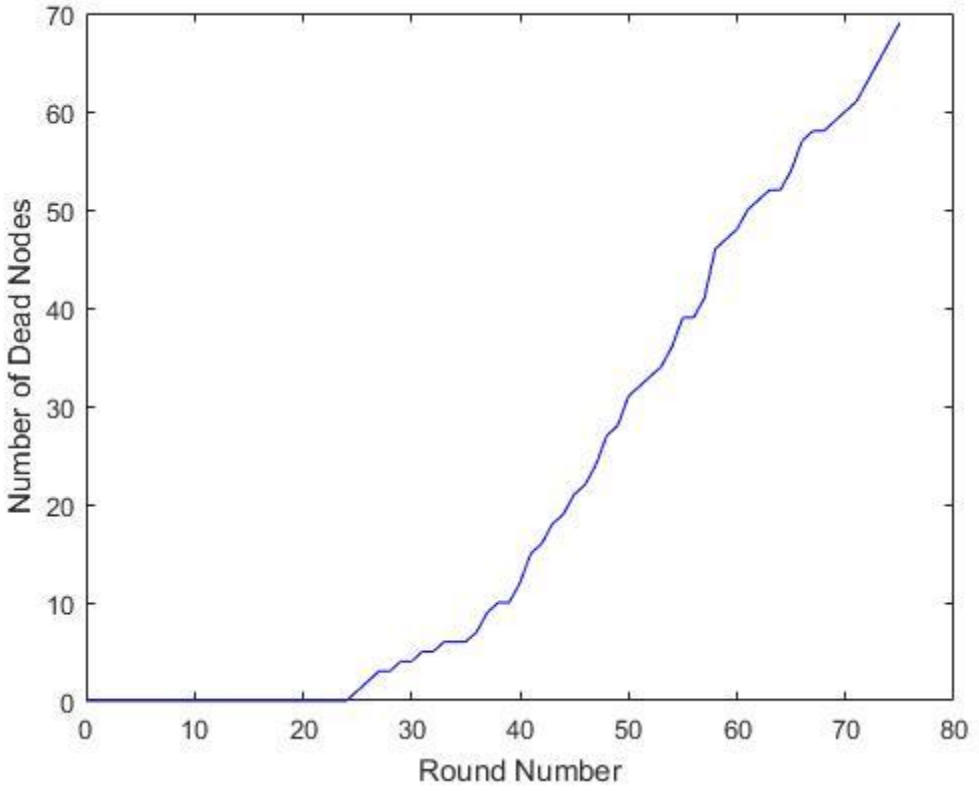


Fig 4.8: Number of dead nodes – LEACH Protocol in 75 Rounds

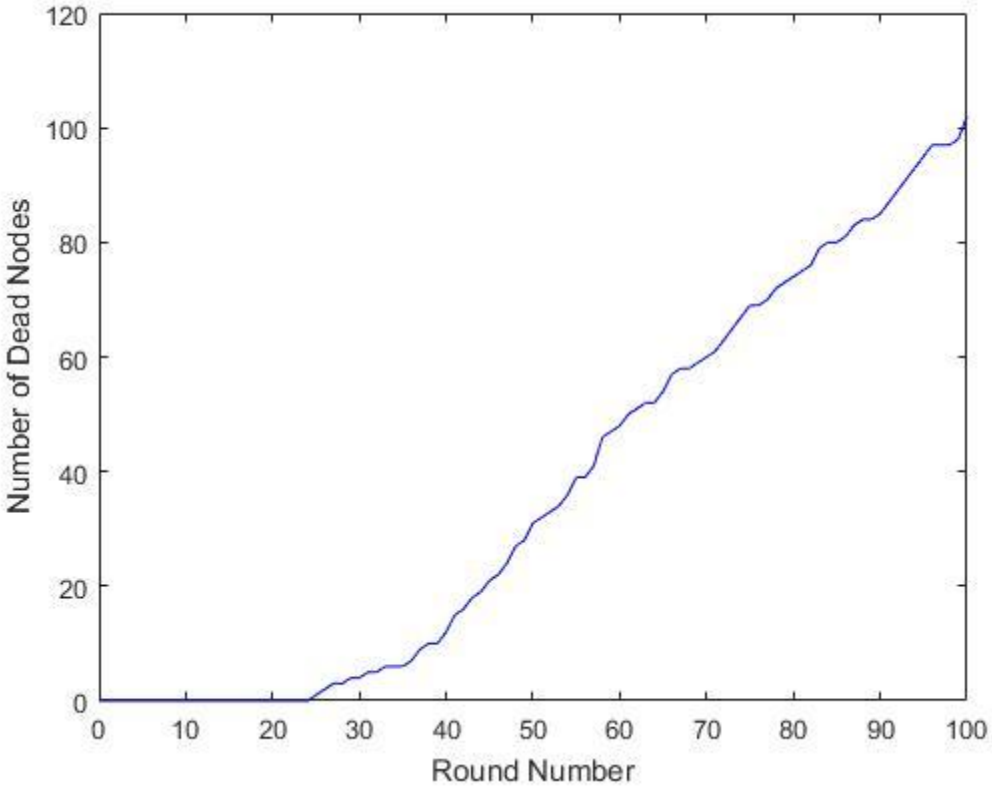


Fig 4.9: Number of dead nodes – LEACH Protocol in 100 Rounds

4.2 PEGASIS Protocol

The following simulation results of PEGASIS Protocol are plotted:

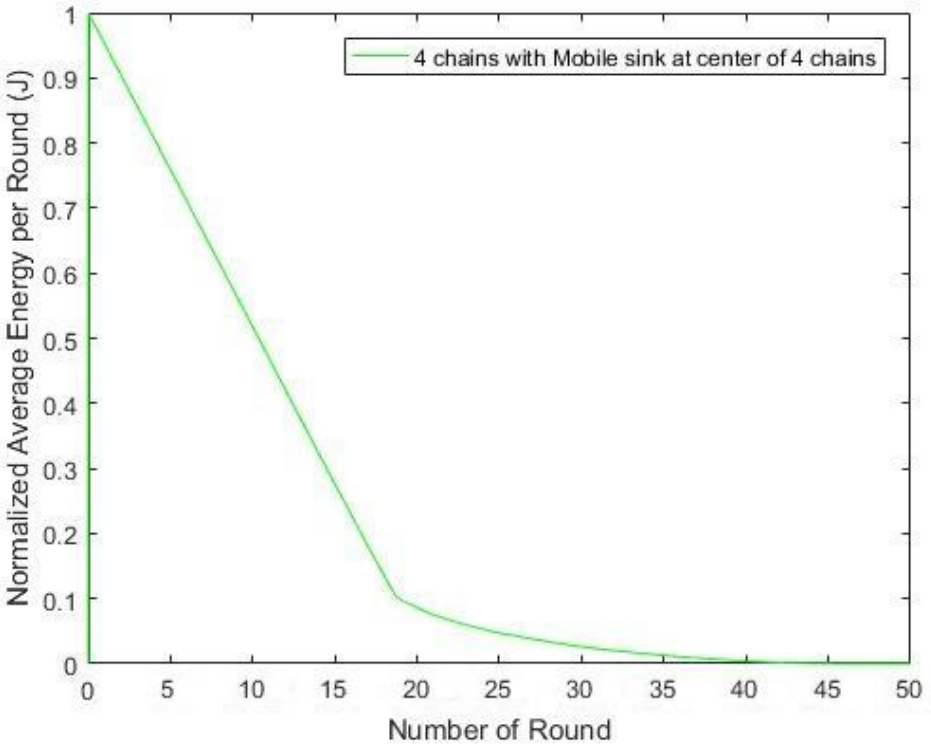


Fig 4.10: Average energy per round – PEGASIS Protocol

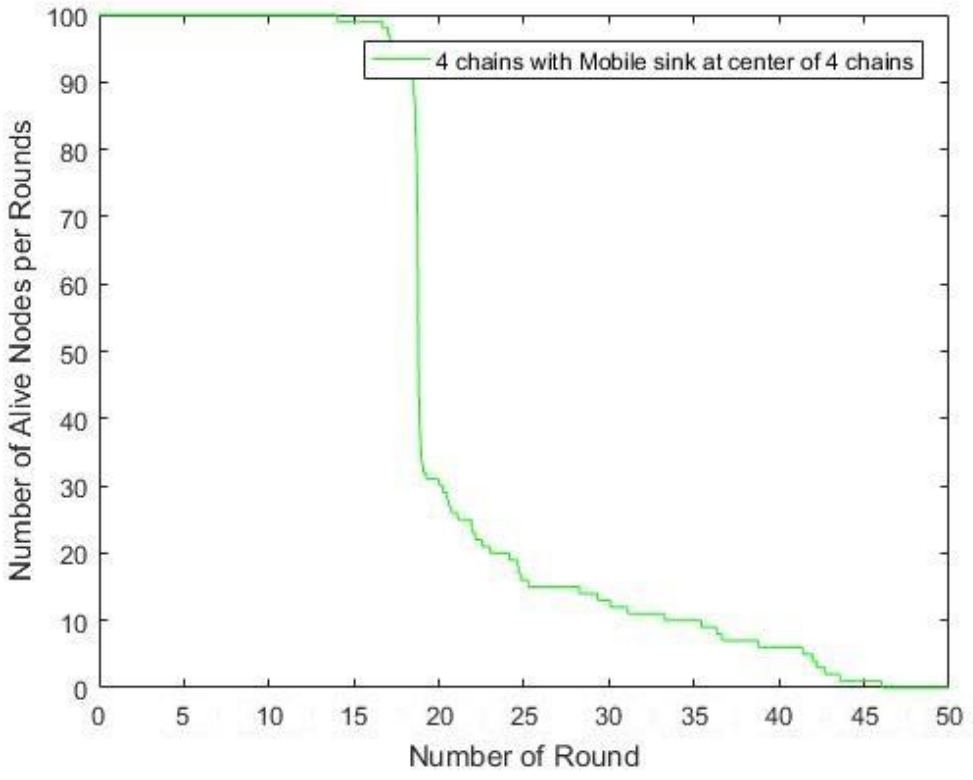


Fig 4.11: Number of Alive Nodes per Round – PEGASIS Protocol

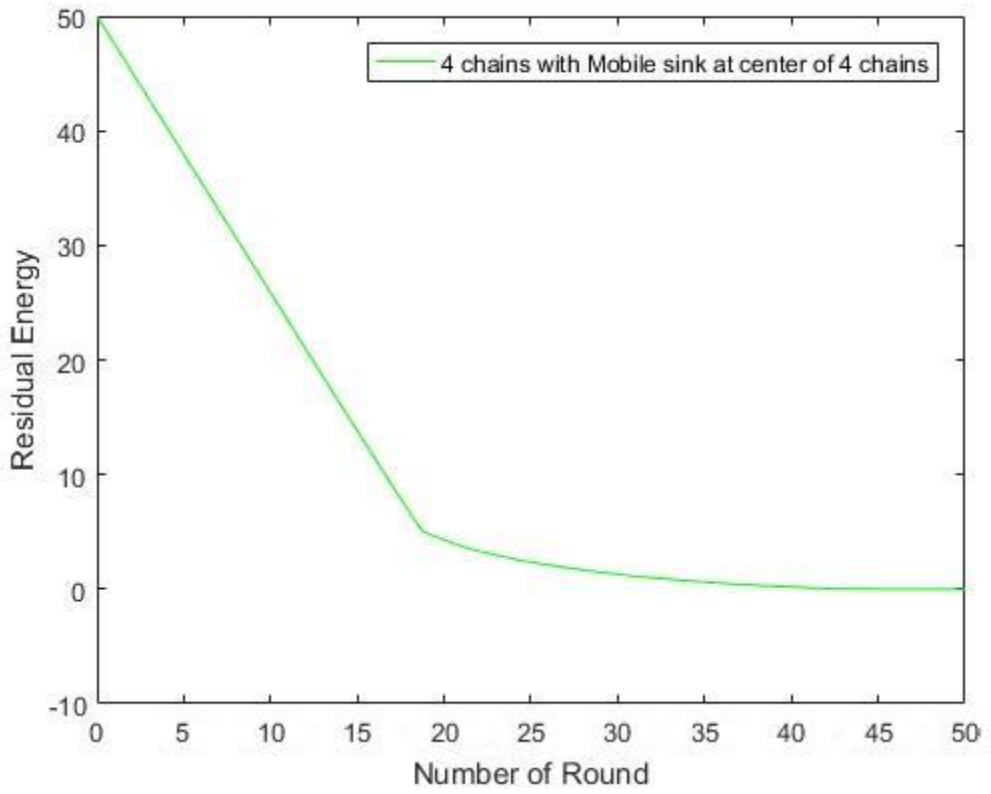


Fig 4.12: Residual Energy – PEGASIS Protocol

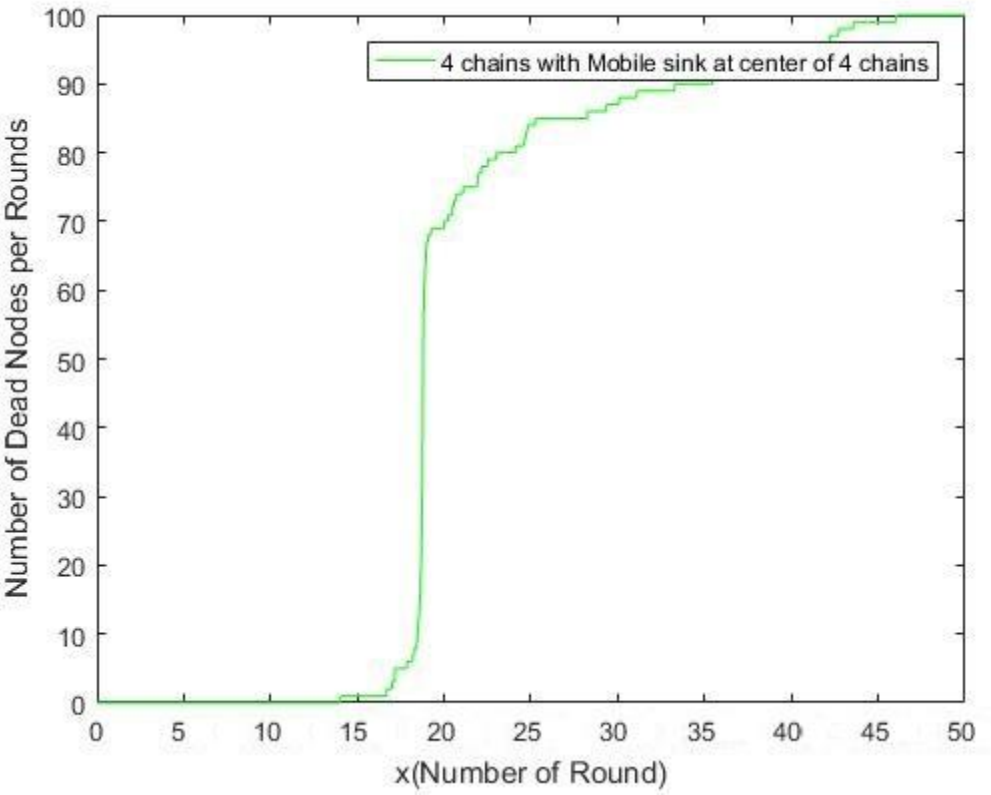


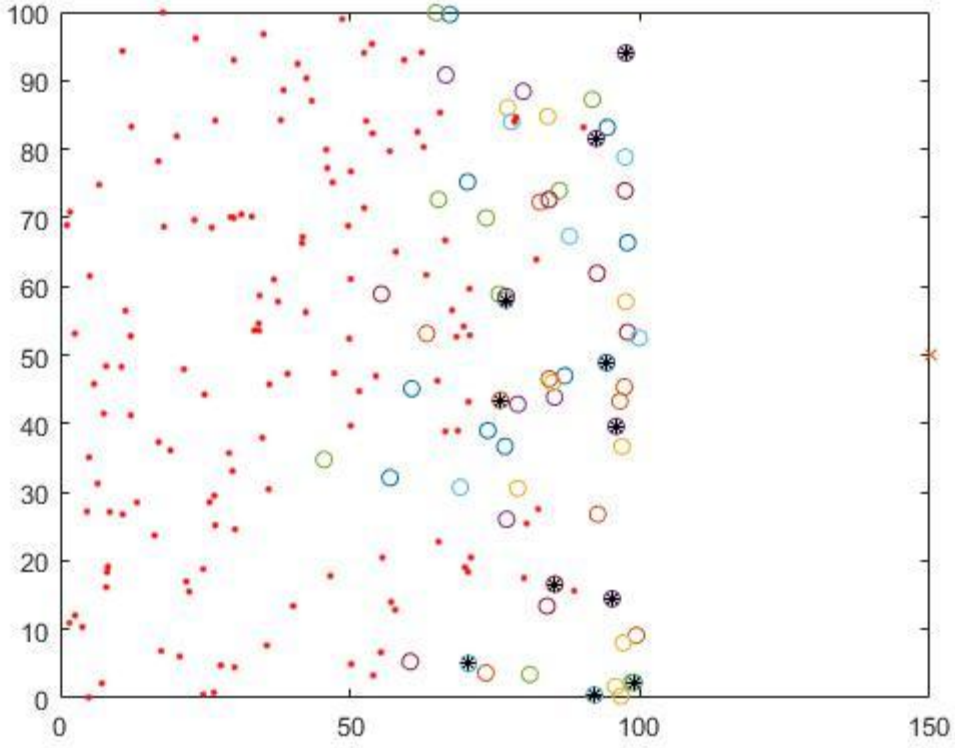
Fig 4.13: Number of Dead Nodes per Round – PEGASIS Protocol

4.3 P-LEACH Protocol

4.3.1 Distribution Pattern of Nodes

- X-denotes the location of the base station.
- Light coloured circles denote the nodes employed in the network.
- Dark coloured nodes denote the cluster head in the given round.
- Red coloured nodes denote the dead nodes in the network.

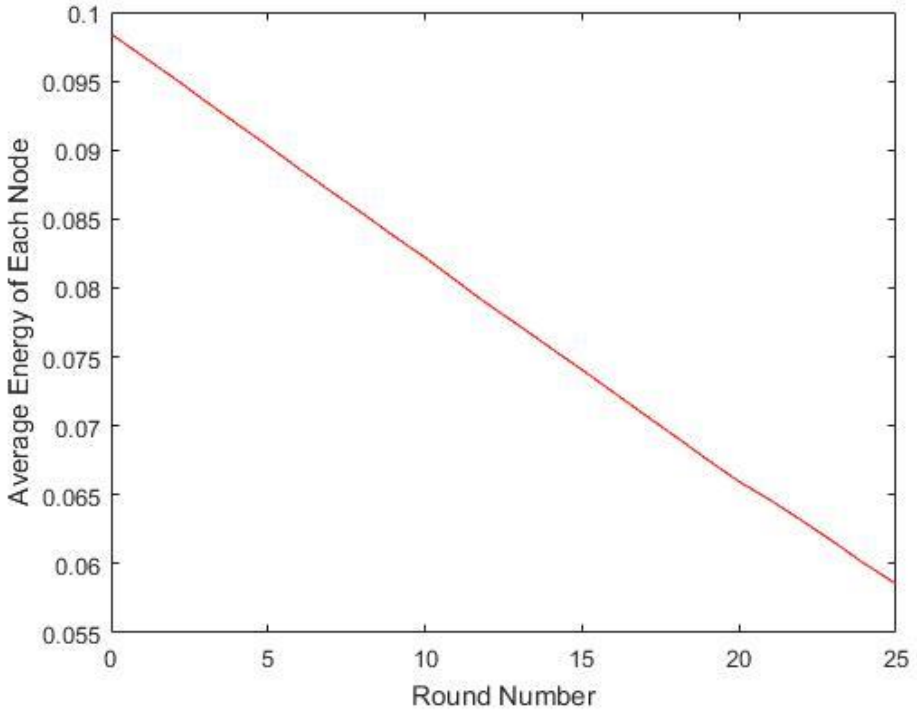
Fig 4.14: Distribution of Nodes – P-LEACH Protocol



4.3.2 Simulation Results of P-LEACH

Following plots for P-LEACH Protocol have been simulated:

Fig 4.15: Average energy of each node – P-LEACH Protocol in 25 Rounds



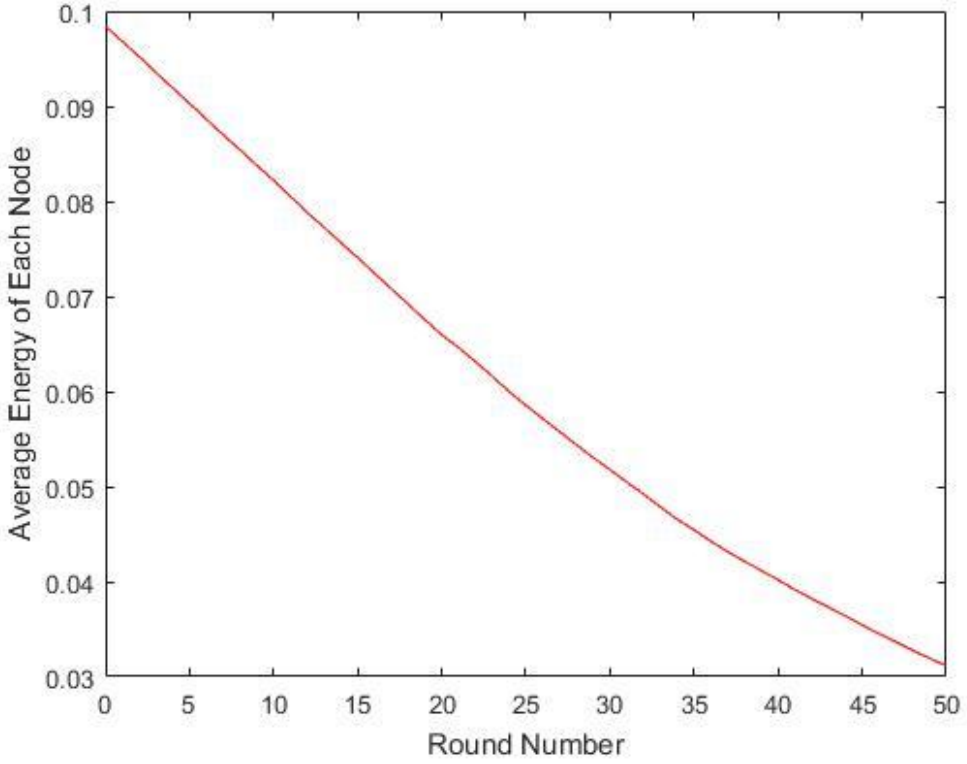
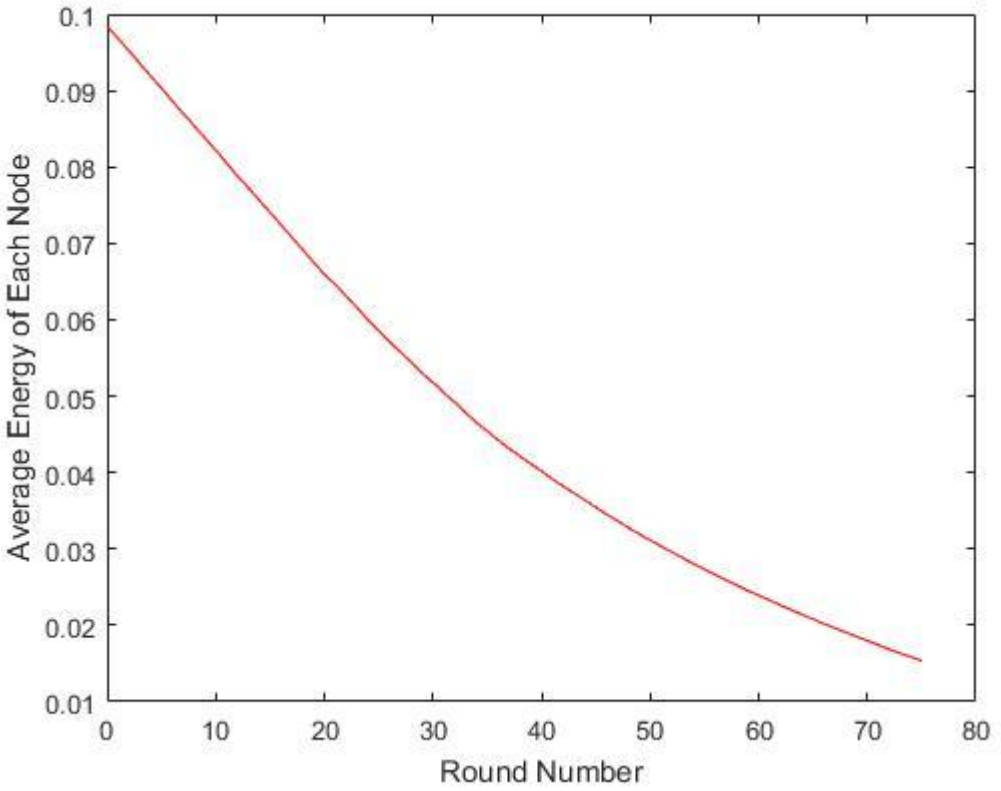


Fig 4.16: Average energy of each node – P-LEACH Protocol in 50 Rounds

Fig 4.17: Average energy of each node –P- LEACH Protocol in 75 Rounds



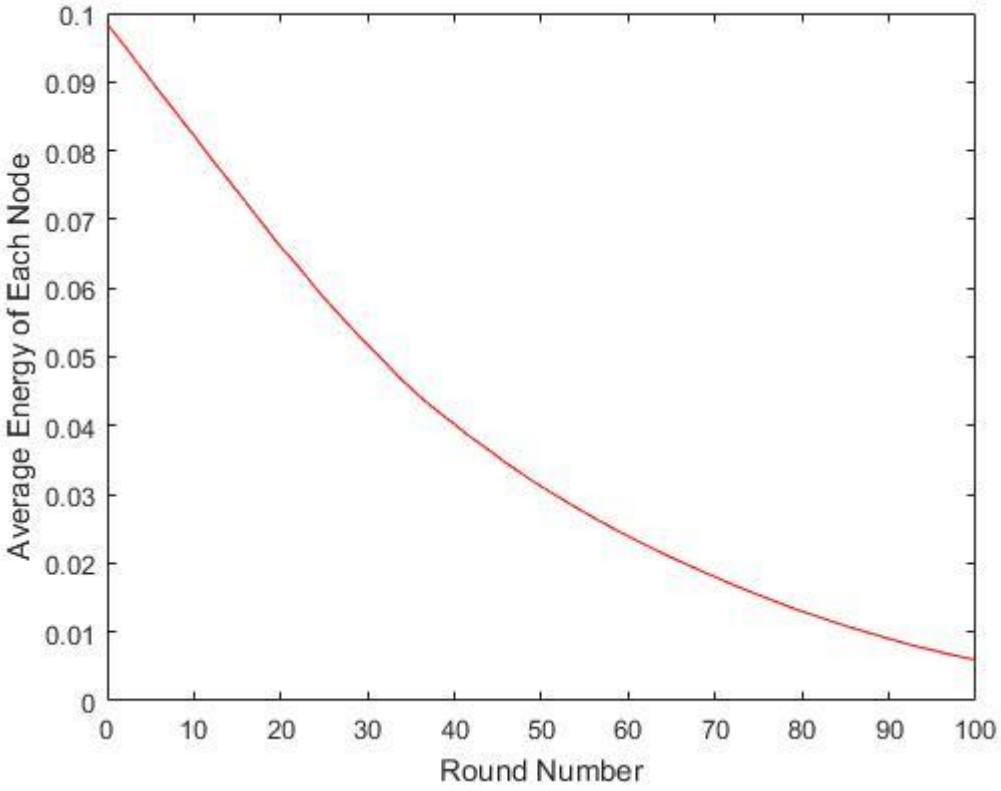
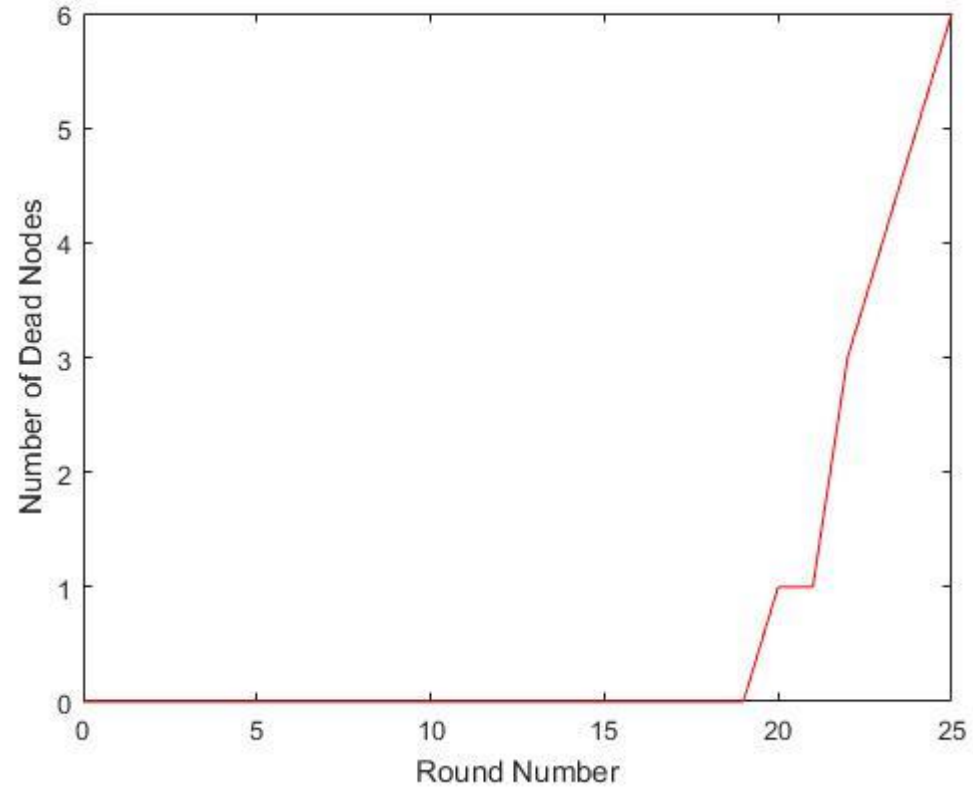


Fig 4.18: Average energy of each node – P-LEACH Protocol in 100 Rounds

Fig 4.19: Number of Dead Nodes – P-LEACH Protocol in 25 Rounds



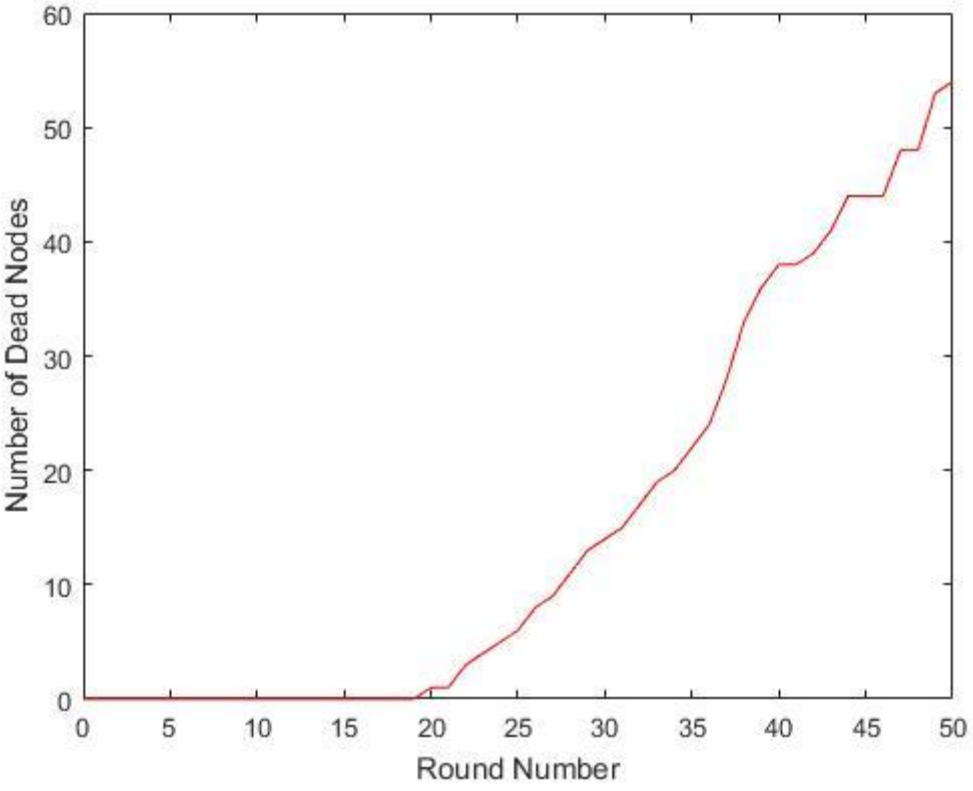
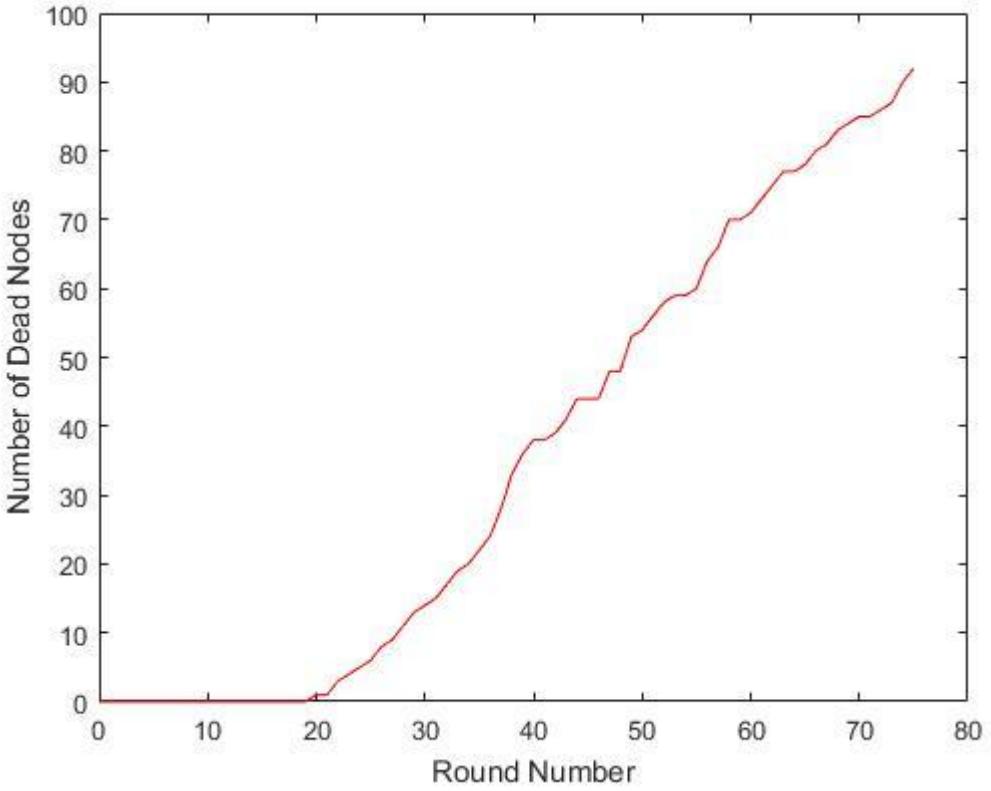


Fig 4.20: Number of Dead Nodes – P-LEACH Protocol in 50 Rounds

Fig 4.21: Number of Dead Nodes – P-LEACH Protocol in 75 Rounds



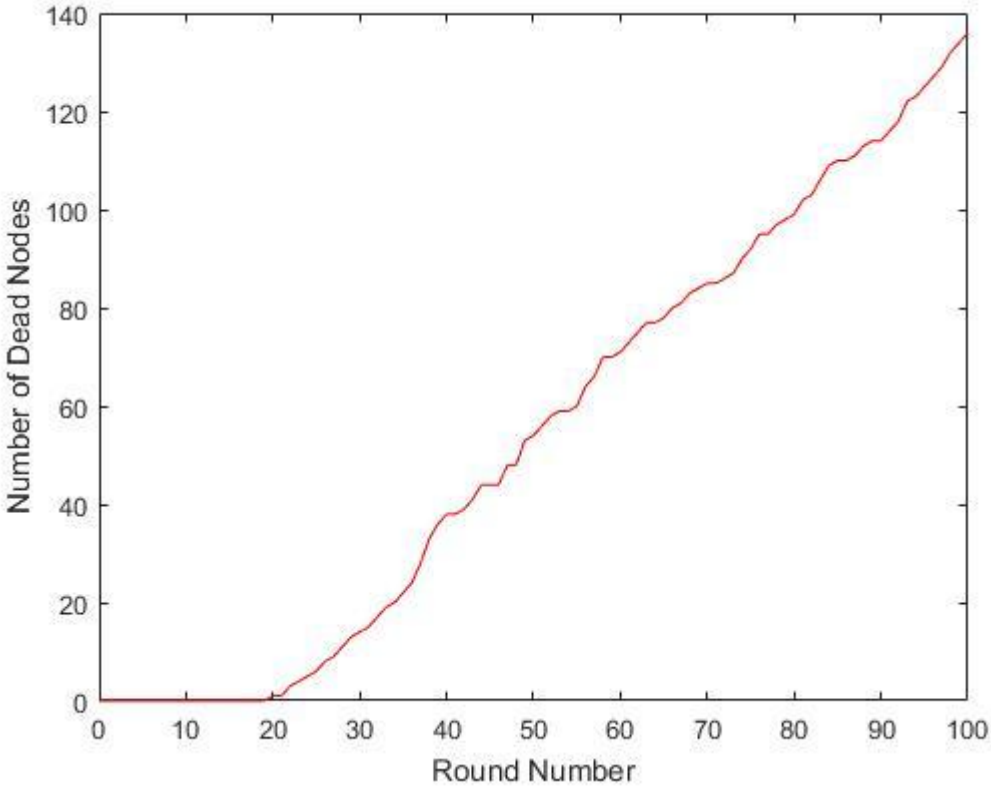


Fig 4.22: Number of Dead Nodes – P-LEACH Protocol in 100 Rounds

Chapter 5

Conclusion

We simulated the P-LEACH Routing Protocol for improving energy efficiency in wireless sensor networks. The performance of P-LEACH is compared with the LEACH and PEGASIS protocols. With simulation we observed that P-LEACH performs much better than LEACH, and PEGASIS in terms of network lifetime, number of dead nodes and energy consumption. MATLAB is used for evaluating the performance of the protocol. Based on the simulation results, we determined that P-LEACH performs better than LEACH and PEGAIS in terms of energy and lifetime of the network. The simulation results validate that our proposed approach could extend the network for WSNs applications.

In both LEACH and PEGASIS, we have certain advantages and disadvantages. By using P-LEACH protocol we are combining advantages of both LEACH and PEGASIS protocol. We are removing the disadvantages of these protocols. LEACH reduces the traffic in the entire network and saves energy. LEACH is completely distributed as it does not need any control information from the base station as well as no global knowledge of the network is required. By using PEGASIS, transmission distance is reduced and energy dissipation is balanced among the sensor nodes. The protocol P-LEACH overcomes the shortcomings of LEACH and PEGASIS both. In P-LEACH, we use the cluster formation technique of LEACH in the chain based architecture of PEGASIS. As a result, the system will have higher lifetime, low energy consumption, and unlike PEGASIS, can also deal with a dynamic system. PLEACH protocol helps us to get data for larger period of time.

References

[1] Abdul Razaque, Musbah Abdulgader, Chaitrali Joshi, Fathi Amsaad and Mrunal Chauhan, "P-LEACH: Energy Efficient Routing Protocol for Wireless Sensor Networks.*" In Systems, Applications and Technology Conference (LISAT), 2016 IEEE Long Island.*

[2] Jigish Rana, Sangeeta Vhatkar and Mohommad Atique,"Comparative Study of PEGASIS and PDCH Protocols in Wireless Sensor Network." *In International Journal of Computer Applications (0975 – 8887) International Conference and Workshop on Emerging Trends in Technology (ICWET 2015)*

[3] Parul Bansal,Poonam Kundu, and Prabhjot Kaur,"Comparison of LEACH and PEGASIS Hierarchical Routing Protocols in Wireless Sensor Networks.*" Int. J. of Recent Trends in Engineering & Technology, Vol. 11, June 2014*

[4] Hiba S. Mahdi , Imad J. Mohammed , Nushwan Y. Baithoon,"Low Transmission Delay Based on LEACH and PEGASIS Protocol in WSN.*" IJCSMC, Vol. 4, Issue. 5, May 2015, pg.209 – 217*

[5] Agrawal, Palak, and P. R. Pardhi,"Routing Protocols For WSN." *International Journal Of Computer Science And Applications 8, no. 1 (2015).*

[6] Al-Karaki, Jamal N., and Ahmed E. Kamal,"Routing techniques in wireless sensor networks: a survey." *Wireless communications, IEEE 11, no. 6 (2004): 6-28.*

[7] J. N. Al-Karaki and G. Al-Mashaqbeh,"SENSORIA: A New Simulation Platform for Wireless Sensor Networks,"*International conference on Sensor Technologies and Applications, SensorComm. pp: 424 – 429. 2007.*

[8] Laiali Almazaydeh, Eman Abdelfattah, Manal Al- Bzoor, and Amer Al- Rahayfeh, "Performance Evaluation of Routing Protocols in Wireless Sensor Networks," *International Journal of Computer Science and Information Technology, Volume 2, Number 2, April 2010*

[9] S. Lindsey, and C. Raghavendra, "PEGASIS:Power- efficient gathering in sensor information systems," *IEEE Aerospace Conference Proceedings,2002, pp.1125-1130.*