A Dissertation on
on

Performance Analysis of LEACH-C and EAMMH protocols in WSN using MATLAB

Submitted in partial fulfillment of the requirements

for the award of the degree of

MASTER OF TECHNOLOGY
IN
COMPUTER SCIENCE & ENGINEERING

Submitted by

HARSHIT CHAUDHARY

(2K19/CSE/08)

Under the supervision of

Dr. VINOD KUMAR
Associate Professor

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Bawana Road, Delhi 110042

June,2021

DECLARATION

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi 110042

I, **Harshit Chaudhary**, Roll Number **2K19/CSE/08**, student of **M.Tech**(Computer Science and Engineering), hereby declare that the project Dissertation titled **"Performance analysis of LEACH and EAMMH Protocols in WSN using MATLAB"** which is submitted by me to the **Department of Computer Science & Engineering**, Delhi Technological University, New Delhi in partial fulfillment of the requirement for the award of degree **Master of Technology**, is original and not copied from any source without citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi 110042

I, hereby certify that the Project Dissertation titled **"Performance analysis of LEACH-C and EAMMH Protocols in WSN using MATLAB"** which is submitted by **Harshit Chaudhary**, Roll No. 2K19/CSE/08, Department of Computer Science & Engineering, Delhi Technological University, Delhi in partial fulfillment for the requirement of the award of degree of **Master of Technology** (Computer Science and Engineering) is a record of a project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi

Dr. Vinod Kumar

SUPERVISOR

Associate Professor

Department of Computer Engineering

Delhi Technological University

ACKNOWLEDGEMENT

No amount of words is enough to express my gratitude towards my guide **Dr. Vinod Kumar,** Department of Computer Science & Engineering, Delhi Technological University, Delhi, who has been very concerned and has aided for all the materials essentials for the preparation of this project report. He has helped me to explore this vast topic in an organized manner and provided me with all the ideas on how to work towards a research-oriented venture.

I would also like to thank my colleagues who were always there at the need of an hour and provided with all the help and facilities which I required for the completion of this work.

Harshit Chaudhary

(2K19/CSE/08)

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ABBREVIATIONS

1.	**WSN**	Wireless Sensor Network
2.	**LEACH**	Low-Energy Adaptive Clustering Hierarchy
3.	**LEACH-C**	Centralized LEACH
4.	**EAMMH**	Energy-Aware Multi-Hop Multi-Path Hierarchical
5.	**GEAR**	Geographic and Energy Aware Routing
6.	**GPS**	Global Positioning Systems
7.	**CH**	Cluster Head
8.	**TDMA**	Time Division Multiple Access
9.	**BS**	Base Station
10.	**DRAND**	Distributed Randomized time slot assignment algorithm

ABSTRACT

A proficient and good design for a WSN(Wireless Sensor Network) has become a main area of research these days. We have applications of WSN in many areas like health care, remote area monitoring, Environmental sensing, Agriculture sector, Military operations etc. There are a number of difficulties in WSN because of the areas in which these networks are deployed and the limited resources that we have in WSN. The major challenge in these networks is the proficient utilization of the limited power supply. All the protocols in WSN should be designed by keeping limited power supply constraints in mind. In this project, the intentions were to simulate and compare the two famous Energy Efficient protocols. Researchers have introduced many routing systems to enhance numerous applications for cluster-based networks. By using these routing strategies, routing algorithms can extend the life and performance of the network. The highlight of cluster-based networks is to limit performance fluctuations and shifts in the system. In this project, the intentions were to simulate the two energy efficient protocols and compare them. LEACH-C (Centralized Low-Energy Adaptive Clustering Hierarchy) and homogeneous EAMMH (Energy-Aware Multi-Hop Multi-Path Hierarchical) routing techniques are compared for basic scenarios like dead nodes and energy dissipation. These protocols are intricately compared for a few general situations, and a brief investigation of simulation results against the lifetime of the network and average energy of nodes is done. The results obtained show that the EAMMH protocol outperforms LEACH-C in every scenario.

CHAPTER-1

INTRODUCTION

1.1 Wireless Sensor Networks (WSN)

In the course of recent years, we have seen an exponential increase in computer processing power while the size and price have decreased considerably. With such a revolution, computers with embedded sensors have become economical. Thus, the limitations of sensor networks have become a keen area of interest for researchers. In this project, some of the limitations of wireless sensor networks are addressed. In the real world, senses help living beings to interact with each other by gathering information of some particular attribute and then some action is performed based on this information. Similarly, some devices measure physical attributes like temperature, humidity etc. from the real world and then react based on the data received. This sensory data is provided with the help of Wireless Sensor Network (WSN). In WSN, there is one base station (sink) and a large number of sensor nodes. Sensor nodes are equipped with at least one sensing device and transceiver. Various physical attributes like temperature, pressure, noise, motion etc. can be monitored by these sensing devices. The collected information is then sent to the base station or sink using the transceivers. Thus, we can say that the basic building blocks of WSN are Wireless sensing and Data networking.

The sensing nodes are generally deployed in remote areas mostly at very difficult terrains which are inaccessible, and these nodes operate with the help of batteries. It is also desirable that sensor nodes are small in size. Because of these factors [1] sensor nodes have a lot of constraints like limited power supply, limited memory, communication range. Nodes that run out of battery are referred to as Dead nodes and such nodes don't contribute to the WSN. These factors make WSN topology very dynamic as the number of active nodes may differ considerably with time. All these constraints are challenges that need to be taken care of while designing WSN.

1.2 WSN Components

There are two main components in WSN architecture [2]:

1. Sensor nodes

2. Base Station

A WSN can be shown as:

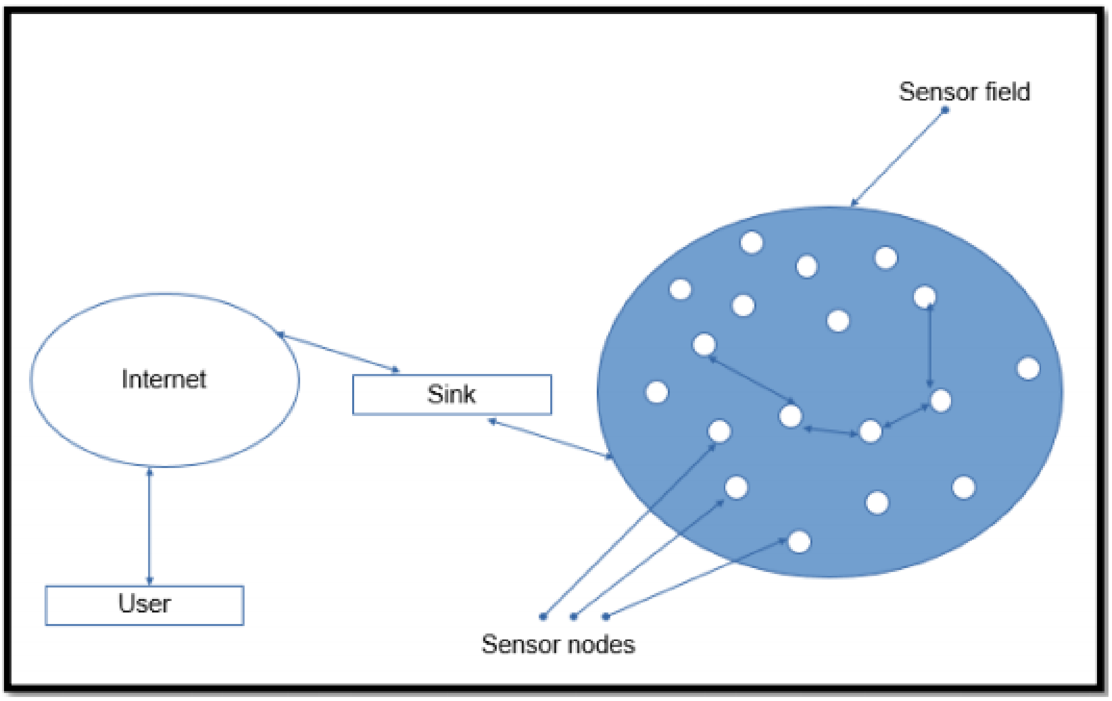

Fig 1: Wireless sensor network architecture

1.2.1 Sensor Nodes

The essential function of the sensor node is to detect, process, and finally send the information to the ideal destination. Sensor node has the following elements:

i. Sensing unit

ii. Processing unit

iii. Transceiver unit

iv. Power unit

i. Sensing unit:

Sensing units are the hardware devices that measure the physical attributes like temperature, humidity, pressure or other attributes for which it is deployed. The Sensing unit monitors the environment. They continuously keep on taking measures and send the data to the processing unit. Sensing units are designed in such a way that they can operate autonomously without any need for manual intervention. These are electronic devices and operate with the help of a power supply through a battery.

ii. Processing unit:

The Processing unit receives the data from the sensors. The size of the data received from sensors can be very large and it can have a lot of redundant data. So, directly transmitting this data can consume a lot of energy and resources, thus making our system very inefficient in terms of energy and lifetime. Thus, the data is first processed, the redundant data is removed, and data compression is performed so that less energy is consumed for data transmission to the final destination.

iii. Transceiver unit:

The sensor units are mostly deployed in remote areas where we don't have the feasibility of wired networks. Thus, the data needs to be transmitted wirelessly. A transceiver is a combination of the transmitter and receiver which is used for wireless communication. Wireless sensor networks generally use license free frequencies for radio communication. It is to be noted that, in the context of energy data transmission in wireless sensor networks is the most expensive task. Most of the energy in the system is consumed for data transmission only. Thus, the transceivers are completely shut down when not transmitting the data.

iv. Power unit:

All the units in the sensor nodes are electronic only. They need energy for operation. A continuous energy supply is provided with the help of a power unit which is mostly a battery. Because of the remote deployment of sensor nodes, it is not feasible to charge the battery unit. The battery should have sufficient capacity to last longer while keeping size constraints in mind.

The sensor nodes are desired to be small and have battery constraints as well. We can add other units in sensor nodes which will add more functionality to our sensor node, but it will increase the size and will also consume more power which is not desired. Thus, we have the trade-off between functionalities and the size of sensor nodes. Additional functional units can be added but we have to make sure that the size doesn't increase too much, and the power consumption is also less.

A sensor node can be shown as:

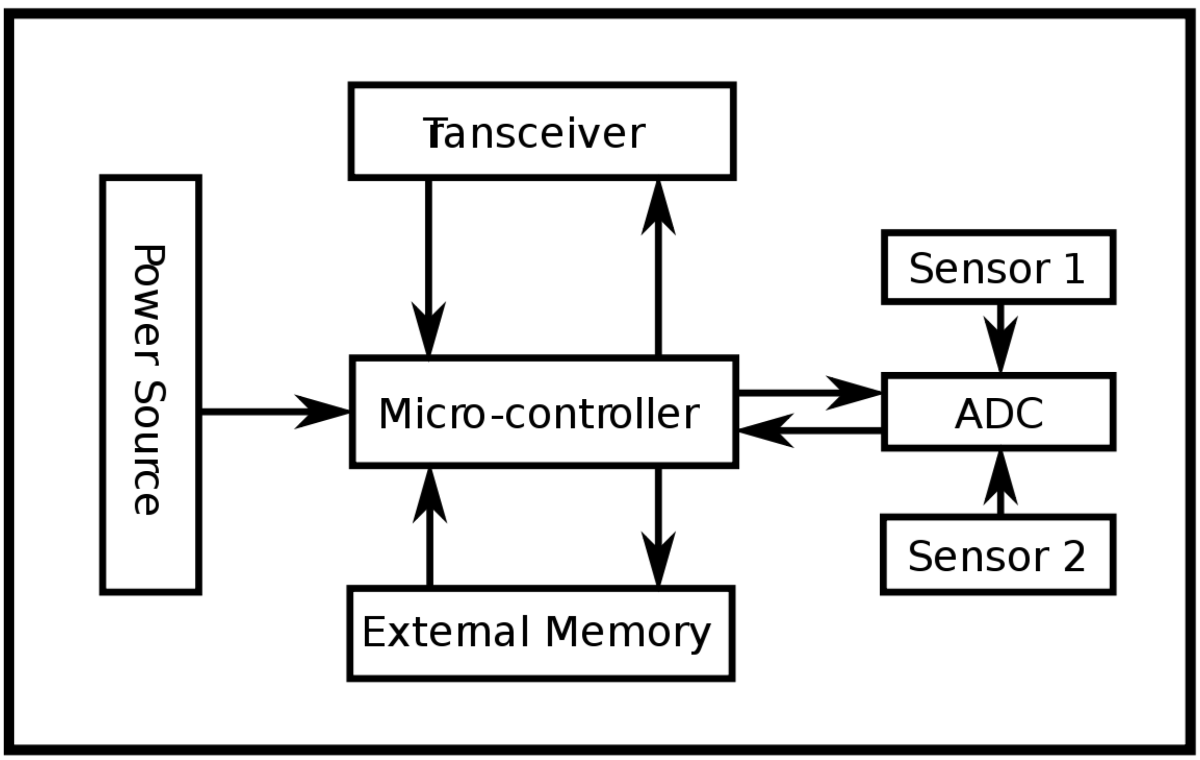

Fig 2: <u>Components of a sensor node</u>

1.2.2 Base Station (BS)

BS links WSN to other networks. Base stations are generally static and have a continuous power supply. Thus, we don't have battery constraints with base stations.

Also, base stations don't change position, once deployed. Since all the sensor nodes are required to communicate with the BS, the position of the base station turns out to be significant. The network planning phase takes care of the base station deployment position.

1.3 Application of WSN

The improvement of remote sensor networks was initially spurred by military applications, for example, combat zone reconnaissance. Late improvements in this technology have made these sensor nodes accessible in a wide scope of applications like:

1. Military operations
2. Area monitoring
3. Transportation
4. Health Application
5. Environmental sensing
    a. Air pollution monitoring
    b. Forest Fire detection
    c. Greenhouse monitoring
    d. Landslide detection
6. Industrial monitoring
7. Agriculture sector

1.4 Energy-efficient Routing Algorithms

We can comprehensively classify energy-effective routing algorithms as follows: hierarchical, data-centric, and location-based routing algorithms. In data-centric [3] routing, a course from source to objective is found with the assistance of metadata before any real information transmission. This assists with wiping out excess information transmission in the network.With hierarchical routing [3], the sensor network is isolated into groups. In each group a cluster head (CH) is elected, who collects the information of its members, sums up the information, and can also handle the information alternately before it is sent to the base station or sink. This methodology is energy productive yet in addition moderately complex when contrasted with different methodologies. Location-based routing algorithms [3] need real GPS-based area data for each sensor node.

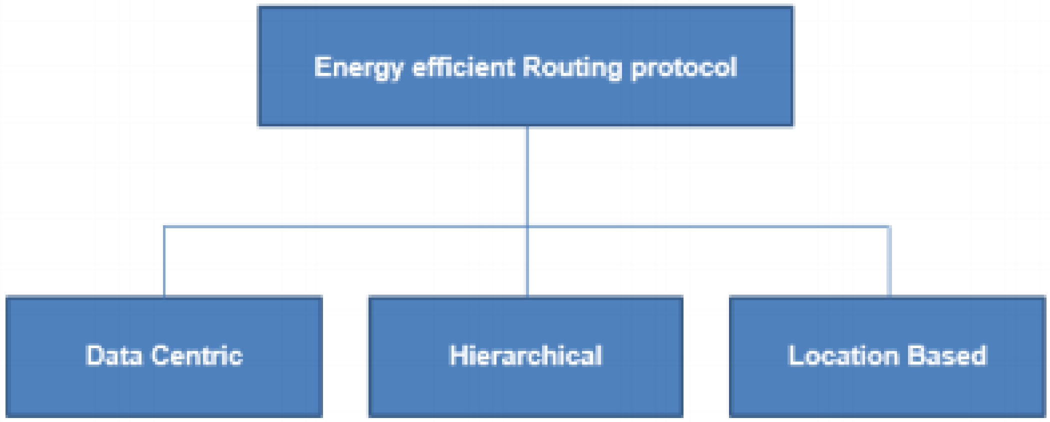

Fig 3: Energy-efficient routing protocol

1.4.1 Data-Centric

Data-centric conventions are query-based protocols where the naming of information is complete. Attribute-based naming is used to indicate the properties of the information. The base station sends a request to a specific area for specific information and waits for the prospect's response node. Sensor nodes gather the specific mentioned information according to a query from the area of intrigue and send it to the base station. Attribute based naming aids in reducing the number of transmissions, henceforth limiting transmission cost. The first data-centric protocol was SPIN.

1.4.2 Hierarchical

This is utilized for energy-effective routing. In hierarchical conventions, higher energy nodes are utilized for information processing and information transmission over enormous distances; low energy nodes perform detection in areas of interest and send data to higher energy nodes which are placed at relatively small distances thus transmission cost of low energy nodes is reduced. E.g. LEACH[4], TEEN[5], APTEEN[6].

In Hierarchical routing, nodes are assembled depending on some common factor to frame clusters. One node is chosen as cluster head dependent on some predefined conditions. All the nodes in one cluster are called cluster nodes and for each cluster, we have one cluster head node. Cluster nodes continue detecting the information and send that information to the cluster head. Cluster head node assembles information from all the nodes and communicates the information to the BS after processing it. Thus, cluster heads have to perform more tasks as compared to cluster nodes resulting in high energy consumption in these nodes. The CH selection algorithm should be efficient so that nodes with sufficient energy above some predefined thresholds are selected as cluster heads. Some of the hierarchical protocols are discussed in detail in later chapters.

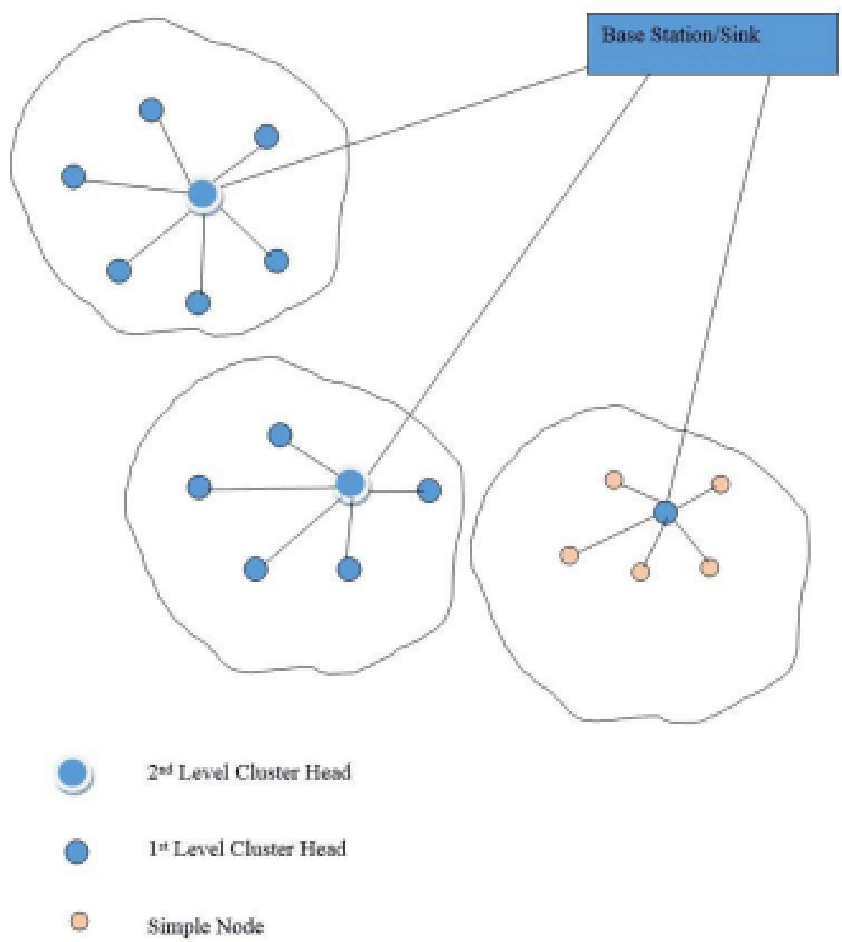

Fig 4: <u>Hierarchical Routing</u>

1.4.3 Location-Based

These routing protocols need GPS (Global Positioning System) based on the location information of all the sensor nodes. An optimal path for data transmission is formed based on the location information thus reducing transmission cost. e.g. GEAR(Geographic and Energy Aware Routing).

CHAPTER-2

LITERATURE SURVEY

2.1 LEACH

LEACH [7] is an innovative WSN cluster routing protocol. The main goal of LEACH is to use random numbers to determine CH according to speed to improve energy efficiency. The schematic diagram of the LEACH agreement is as follows:

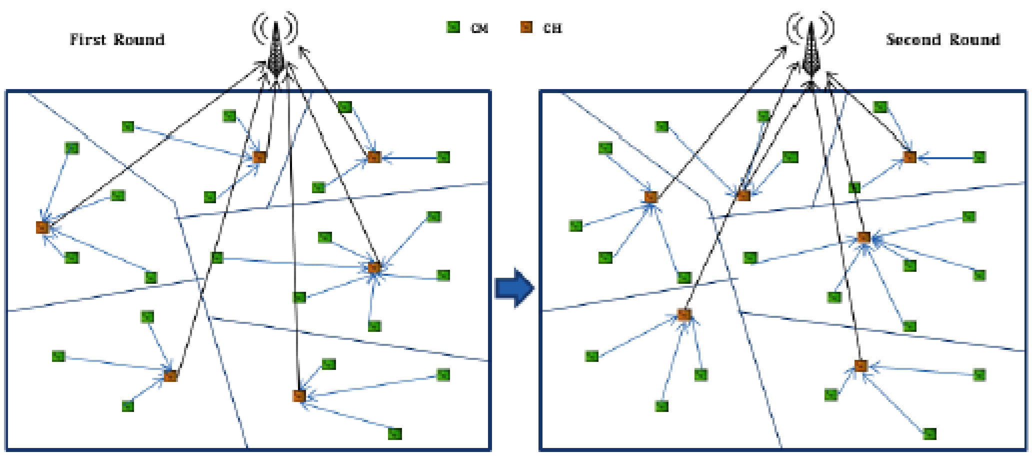

Fig5. Illustration of LEACH protocol

The LEACH activity has several rounds in which each round is divided into two phases: the setup phase, and the steady phase, as shown in Figure 6. In the setup phase, the CH determination, the cluster development and the task of a TDMA (Time Division Multiple Access) plans are carried out by the CH for the member nodes. In CH selection, each node participates in the CH selection process by randomly generating a priority value somewhere in the range of 0 and 1.If the number generated by a sensor node is less than the threshold T (n) at that point, that node becomes CH. The estimate of T (n) is determined using the equation:

$$T(n) = \begin{cases} \frac{P}{1-P*(r \mod \frac{1}{P})} : & if\ n \in G \\ 0 : & otherwise \end{cases}$$

P: Percentage of nodes to become CH among all the nodes

r: Current round

G: Those set of nodes that are yet to participate in the election

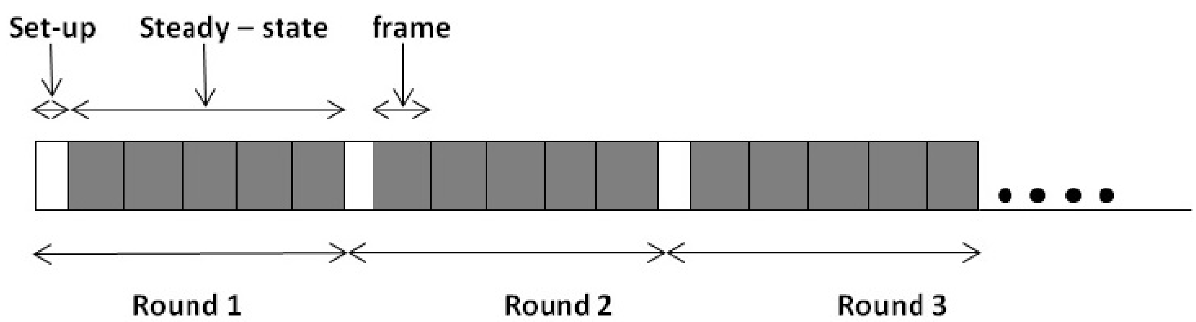

Fig 6: Timeline of LEACH operation

The node that becomes CH in the r^{th} round cannot participate in the subsequent 1=P round. Therefore, each node has an equal chance of becoming CH, and the energy distribution between sensor nodes is evenly distributed. Chosen CH sends warning messages to all other nodes. According to the signal strength received from the advertisement, the sensor node chooses to join the channel of the current round and sends a join message to the channel. According to Equation 1, CH rotates in each cycle to evenly distribute the energy load on the sensor nodes. After the cluster is developed, each channel will create a TDMA schedule and broadcast these schedules to the members of the cluster, bypassing the conflict information sent by the member nodes and allow the member nodes to sleep. When each sensor node executes its TDMA plan, the setup phase ends.

The steady-state phase follows. In the steady-state phase, the transfer of the captured information from the member nodes to the head of the cluster and from the head of the cluster to the base station is done using the TDMA schedule. The member nodes send information to the head of the cluster only during its allocated scheduled slot. The moment a member node sends information to the CH during its assigned scheduled slot, another member node of that cluster remains dormant. This LEACH property reduces collisions within the cluster and the spread of power which extends the battery life of all nodes of the part . In addition, CHs aggregate information from their cluster members and send it directly to the base station. The information transfer from the cluster head to the BS also takes place with the aid of the assigned TDMA plan. It recognizes the channel states to send its information. For example, if the channel is busy, it is used by another CH, then it pauses; otherwise, it uses the channel to convey the information to the BS..

2.2 LEACH-C (Centralized LEACH)

As the name suggests, LEACH-C is a centralized protocol[8] where the decisions like CH selection, cluster formation, and the distribution of information in the network are taken by the BS itself. The traditional LEACH protocol follows an architectural pattern that uses the distributed system-based aggregation type. The cluster head is selected autonomously. Centralized LEACH is an enhanced version of LEACH in which during every round of cluster head selection, the remaining energy and position of each node are reported to the BS at the starting of the round. The base station then computes the network's average energy and enables only nodes with energy greater than the average energy to be candidates for CH. Then a simulated annealing[9] algorithm is used to minimize the objective function. This algorithm minimizes the energy dissipation of the non-CH nodes that transmits data to the CH. After the application of this algorithm, the base station broadcasts the CH and its members to the network. If the ID of a node matches with the cluster head ID transmitted by the base station, the node elects itself as cluster head; else it finds the TDMA slot for sending data to the appropriate CH. The data transfer step in LEACH-C is then the same as in LEACH.

LEACH-C is not considered better than LEACH protocol. It depends more on the base station to complete its execution. All the overheads like every node transmitting its information to the BS, the selection choice of the cluster heads and formation of clusters and the cluster heads sending all this information to each node creates an additional energy cost that affects the performance of the protocol.

2.3 EAMMH

EAMMH is an intra-cluster hierarchical pathway protocol in which the level of the hierarchy is dependent upon the size of the network [10]. Similar to other routing protocols, the operation of the EAMMH protocol consists of 2 rounds. In the first round clusters are formed i.e set-up phase and the second round is the steady-state phase where the data transfer to the base station occurs. Fig. 2 depicts the functioning of EAMMH protocol. This protocol is mostly heuristic as the remaining energy of the adjacent nodes has an important role in the execution of the hop process. First, an input is provided by the user in the form of a number of nodes in the network. All the nodes in the network have limited amounts of energy. The random positions of the nodes are allocated and displayed. After the deployment of nodes, each node runs a neighbor discovery algorithm to get the information of adjacent nodes. The nodes are then assigned to a cluster. This approach helps to increase the lifetime of the network as it neglects all those nodes that have less energy during data transmission.

The data is transmitted in different directions and the transmission is continued depending upon the remaining nodal energy. The data is gathered from neighboring nodes using a table maintaining different parameters like energy of the node, node data, hop count, etc. This table gets updated from time to time to maintain the data transfer using a multi-hop pattern. When a path is needed to reduce communication load, routing generates one in this manner. The CH selection is done to gather the information from all member nodes. Aggregation of data is done by CH and it then transmits the information to the base station. There are many rounds in EAMMH approach and each round has 2 phases: The set-up phase and the steady phase.

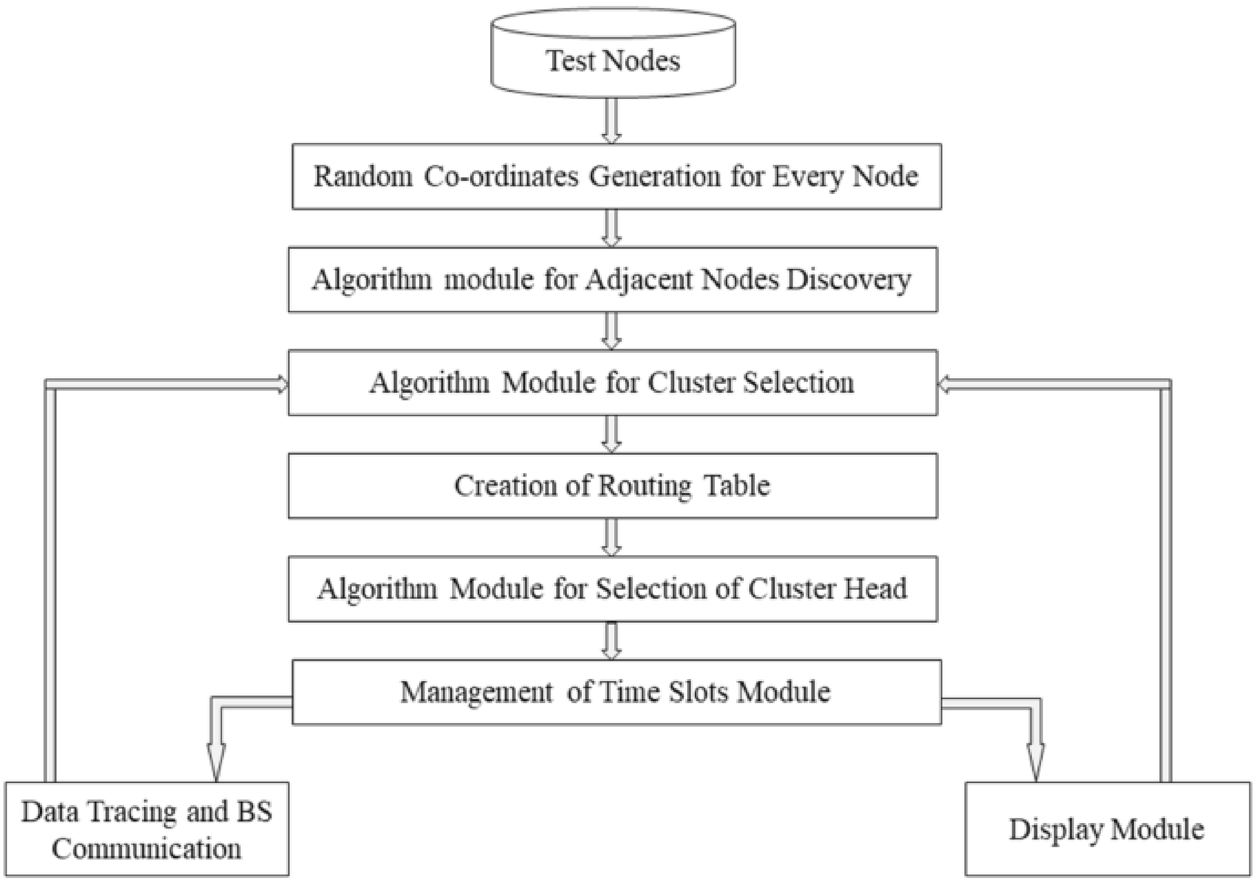

Fig 7: Flowchart - EAMMH

A. SETUP PHASE

In this phase, the neighbor discovery algorithms are used after the deployment of nodes.This is done by conducting the various methods like beacon messaging, k of n method, etc. Next, cluster formation takes place and CH is selected for the present round.

B. DATA TRANSMISSION PHASE

This is the data transmission phase in which a TDMA schedule is generated, and each node is given a time slot. in which the data is transferred at regular intervals. A heuristic approach is followed by the sensor nodes for transmission of data efficiently as shown in the following equation:

$$h = K (E_{avg} / h_{min} * t)$$

Here, E_{avg} denotes the current path's average energy, the current path's traffic is indicated by t, K is a constant and h_{min} is the minimum hop count. If a route's E_{min} value exceeds the threshold, the route with the highest heuristic value is chosen. Otherwise, pick the path with the next higher heuristic value, where

$$E_{min} = E_{avg} / K$$

C. PERIODIC UPDATES

After a few rounds, the information in the routing tables of each node becomes stale. The data entries become outdated and calculations can't be performed on this information as it can cause errors. Therefore, updated information is provided to the nodes from time to time[11]. Along with the accuracy, the heuristic function timing is also increased. The exchange of required information is done from time to time[12].

CHAPTER-3

SIMULATION SETUP AND RESULT ANALYSIS

Both LEACH-C and EAMMH are simulated using MATLAB. The parameters taken into consideration while evaluating EAMMH and LEACH are as follows -

- ➔ Round no. against dead nodes count with variable probability.
- ➔ Round no. against average node energy with variable probability.
- ➔ Round no. against dead nodes count with variable node count.
- ➔ Round no. against average node energy with variable node count.

3.1 SIMULATION DETAILS:

Simulation Area	100m by 100m
Channel Type	Wireless Channel
Initial Energy	0.1 Joules
Energy Model	Battery
BS Location	(150,50)
LEACH-C	Color: RED
EAMMH	Color: BLUE
Number of Rounds	100

Table 3.1

3.2 SIMULATION RESULTS: Both LEACH-C and EAMMH protocols are simulated at varying probabilities of a node to be a cluster head. Different probabilities with different numbers of nodes are taken into consideration and the following results are obtained.

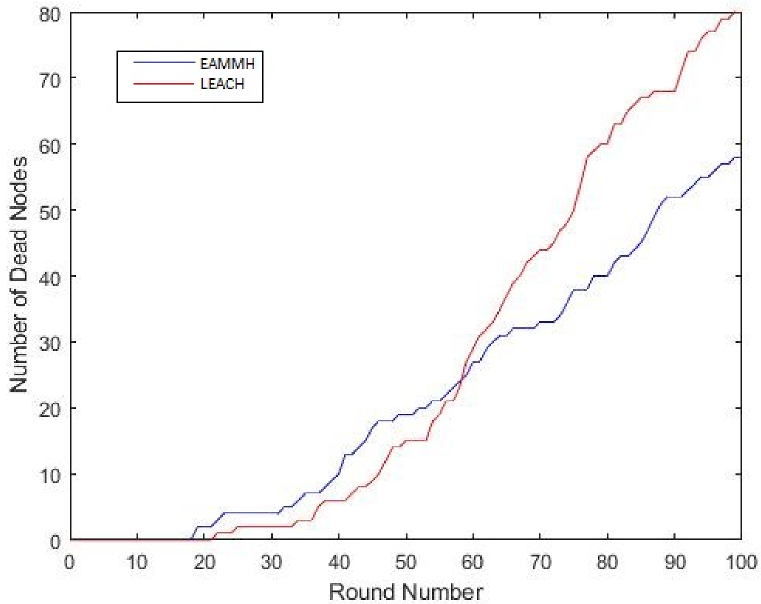

Fig 8 No. of dead nodes vs Round No(N=100) at 0.05 probability

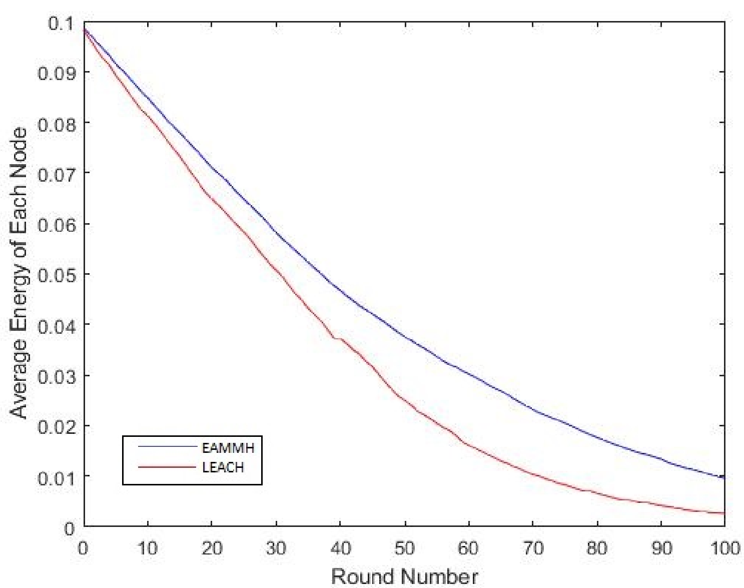

Fig 9 Avg. Energy of each node vs Round No. (N=100) at 0.05 probability

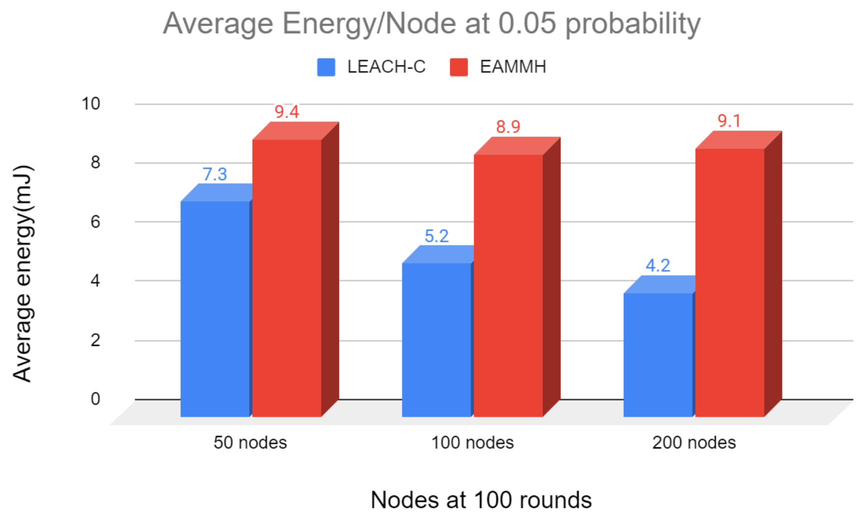

Fig 10 Average energy vs no. of nodes at 0.05 probability

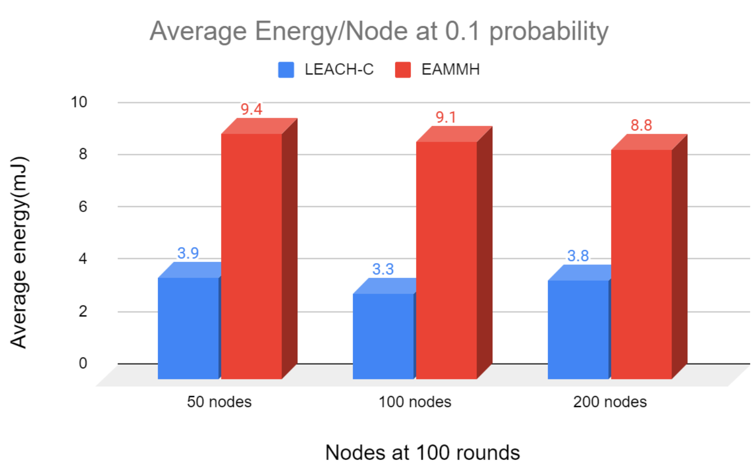

Fig 11 Average energy vs no. of nodes at 0.1 probability

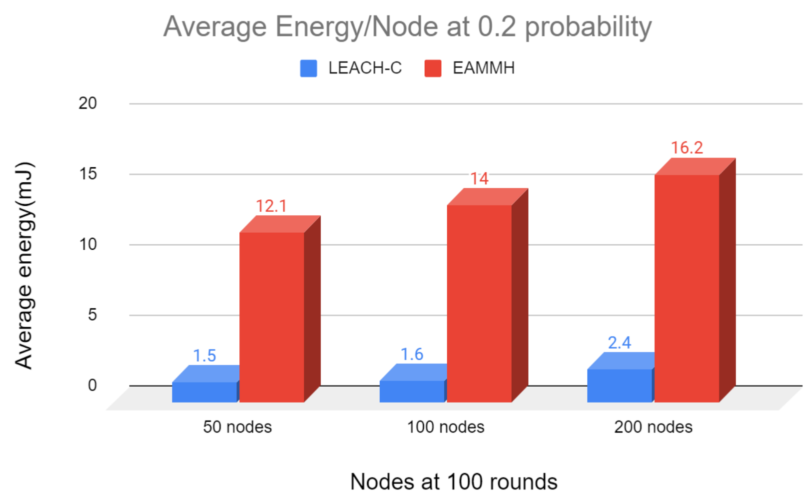

Fig 12 Average energy vs no. of nodes at 0.2 probability

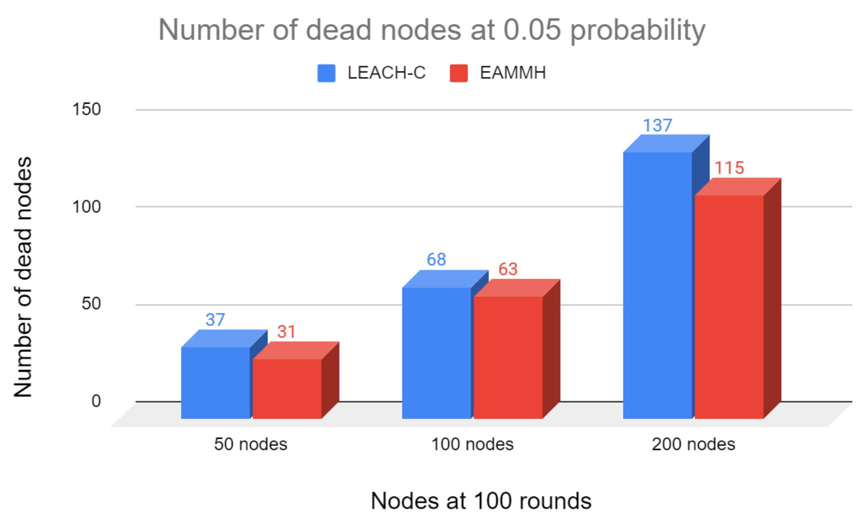

Fig 13 No. of dead nodes vs no. of nodes at 0.05 probability

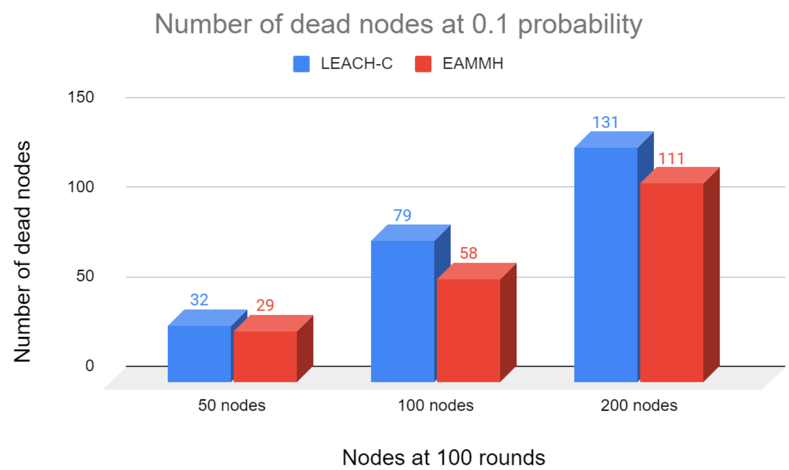

Fig 14 No. of dead nodes vs no. of nodes at 0.1 probability

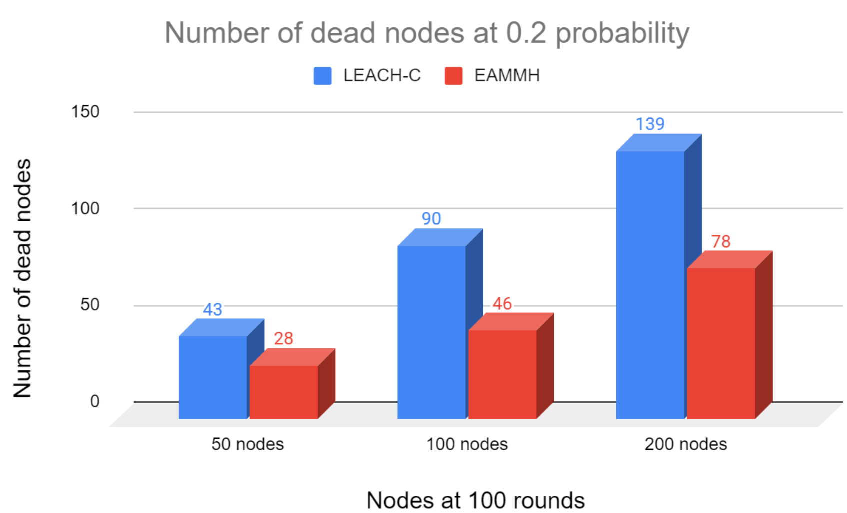

Fig 15 No. of dead nodes vs no. of nodes at 0.2 probability

3.3 Analysis Of The Results

The results obtained show that both the protocols lose energy as the number of rounds increases. When the energy of a particular node reaches the value zero, it is known as a dead node and is no longer functional. The curves obtained from the simulation indicate that the average energy for every node is better than that of LEACH-C protocol in every case. This is because in centralized LEACH, the overhead of formation of clusters, maintaining clusters and transmitting information from the base station to the nodes is more. And hence, more energy is dissipated during these tasks. Also, the dead nodes count in the centralized LEACH protocol is higher than that of EAMMH with an increase in the round numbers. In most cases, LEACH-C has a delay in getting the first dead node, but more nodes are exhausted of energy in a short time.The fact that the EAMMH protocol performs better than LEACH-C is because an inter-cluster routing approach is followed in EAMMH that increases the network lifetime. On the contrary, LEACH-C protocol has single hop communication with the CH and then to the BS. With the use of hierarchical and multi-path routing and multi hop techniques in EAMMH, better energy efficiency is obtained over LEACH-C.

CHAPTER-4

CONCLUSION AND FUTURE SCOPE

The key principle of WSN is the reduction of energy spread without compromising the accuracy of data transmission. Therefore, numerous strategies are required to deal with networks appropriately. Increasing the energy productivity and the lifetime of the network while keeping the transmission delay as low as possible is the main challenge with the low-powered sensor nodes. In a network where the node count is less, the traditional LEACH protocol performs slightly better than that of EAMMH[13], but this is not the case with LEACH-C as the overhead is more in centralized LEACH.

In this paper, a detailed simulation of the two protocols, namely LEACH-C and EAMMH is observed in MATLAB and the results of the simulation conclude that EAMMH performs better than the LEACH-C protocol. This conclusion is made by comparing these protocols on metrics like the number of dead nodes after a certain number of rounds and the average energy of the network. In the future, other variants of routing protocols in WSN can be compared in different environments such that the network lifetime can be improved by the selection of the best possible protocol according to the requirements.

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