A Major Project Report on

IMPLEMENTATION OF ADAPTIVE THRESHOLD AGGREGATION DISTRIBUTED ENERGY-EFFICIENT CLUSTERING PROTOCOL IN WIRELESS SENSOR NETWORKS

Submitted in partial fulfilment of the requirements for the Award of Degree

BACHELOR OF TECHNOLOGY

In

ELECTRONICS AND COMMUNICATION ENGINEERING

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We hereby declare that the major project report title "**IMPLEMENTATION OF ADAPTIVE THRESHOLD AGGREGATION DISTRIBUTED ENERGY EFFICIENT CLUSTERING PROTOCOL IN WIRELESS SENSOR NETWORKS**" is a bonafide record work done and submitted under the esteemed guidance of **Dr. D.Srinivasa Rao**, Professor, Department of ECE, JNTUH CEH, in partial fulfillment of the requirements for Major project in Electronics and Communication Engineering at the Jawaharlal Nehru Technological University during the academic year 2020-21 is a bonafide work carried out by us and the results kept in the major project have not been reproduced. The results have not been submitted to any other institute or university for the award of a degree or diploma.

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ABSTRACT

Wireless Sensor Networks (WSN) discover their appropriateness from military to medicinal fields. Recent trends show significant advancements in wireless sensor networks where sensor networks are having several nodes with the specified energy level in batteries for wireless communications, which are deployed to collect environmental information from source to destination. Energy viability and network lifetime are the essential troubles that are to be addressed. To enhance the network survivability, utilization of sensor nodes energy efficiently a hybrid protocol i.e., ‘Adaptive Threshold Aggregation Distributed Energy Efficient Clustering (ATADEEC)’ based on Adaptive Periodic TEEN (APTEEN) hierarchical protocol and Enhanced Distributed Energy Efficient Clustering (EDEEC) will be implemented. ATADEEC scheme is effective for overcoming the energy consumption problem due to redundant data transfer in EDEEC and APTEEN used network.

The main aim of this project is to implement and evaluate the performance of the Adaptive Threshold Aggregation Distributed Energy Efficient Clustering (ATADEEC) protocol in wireless sensor networks. The performance of the ATADEEC will be compared with other existing clustering protocols such as APTEEN and EDEEC.

APTEEN (Adaptive Periodic Threshold Energy Efficient Network (APTEEN) protocol is an increase to TEEN protocol and goes for catching irregular data collections and reacting to time essential events both at a time. APTEEN protocol is a directing tradition that considers exhaustive information recuperation. The hubs in such a framework react to time-fundamental conditions, and also give a general architecture of the system in an especially vitality effective way.

EDEEC is a clustering-based node organization technique and contains three sorts of hubs in expanding the lifetime and security of the framework. EDEEC uses the points of view of probabilities for CH choice depends upon starting vitality, remaining vitality levels of the gathering nodes, and the normal energy of the system.

ATADEEC expands the lifetime of the network and reductions correspondence time in both reactive and proactive network systems. In sensor network hubs have two targets detected information and prepared information. Clustering is an essential factor in EDEEC because clustered node centers have discovered information. However, the issue with this convention is redundant information that is sent to the base station over and over by the CH hub. To stay away from this disadvantage of the EDEEC convention we hybrid APTEEN with advancement quality. This mixture protocol ATADEEC handling with selected features of node centers like characteristic, Threshold, Schedule, and include time TDMA condition which maintains a strategic distance from impact at the time of information correspondence by dispensing time slots.

Simulations will be performed using MATLAB software to evaluate the performance of the ATADEEC, APTEEN, and EDEEC protocols. Performance of these protocols will be evaluated based on the parameters like Network lifetime, Number of dead Nodes per round and also Alive nodes per round, Number of Cluster heads formed per round, Number of Data packets transferred from Cluster heads to Base Stations in a round, energy consumption, and throughput.

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1.1 INTRODUCTION

Wireless sensor networks (WSNs) are one of the most promising technologies and have immense potential in both the military and civil field. WSNs offer a range of challenges for scientists and engineers of today. The biggest challenge among all is the energy constraint of these networks. In this context, various schemes have been presented in order to improve the life time of these networks and to overcome the energy constraint. One of the effective schemes is based on clustering of sensor nodes within a network in order to improve the network life time and decrease communication latency. Clustering algorithms are believed to be the best for wireless sensor networks because they work on the principle of divide and conquer. WSNs are able to monitor a wide range of applications which include Temperature, Humidity, Pressure, Lightning conditions, Soil makeup, Presence of objects, Mechanical stress, Speed, direction, and size of objects. Typical applications include surveillance and battle space monitoring by military, and in the agricultural, and environmental fields.

A WSN consists of nodes with sensing, computing, and communication capability connected according to some topology. The network is capable of monitoring activities and phenomenon which cannot be monitored easily by human beings such as the site of a nuclear accident, some chemical field monitoring, or environment monitoring for a longer period of time. The wireless sensor network protocols are mainly designed to increase the lifetime of network and using energy of sensor nodes in an efficient manner. To achieve these various basic protocols were implemented on both homogenous and heterogenous nodes. Researches are still going on to achieve better efficiency in wireless sensor network protocols. Matlab is one of the special tools to design and calculate efficiency of wireless sensor networks.

1.2 AIM:

The main aim of the project is to implement Enhanced Distributed Energy Efiicient Clustering Protocol in Wireless Sensor Networks and to compare various parameters between EDEEC, APTEEN, and ATADEEC clustering protocols like:

1. Network lifetime(No of alive nodes)
2. No of Data packets delivered from cluster head to Base station(Throughput)
3. Energy Consumption/Total remaining energy
4. No of Dead nodes per round
5. No of Cluster Heads formed per round
6. Throughput.

1.3 OBJECTIVES:

- To Study about different wireless sensor protocols like EDEEC, APTEEN, and ATADEEC.
- To implement Adaptive Threshold Aggregation Distributed Energy Efiicient Clustering Protocol using MATLAB.
- To Study about Basics of Matlab required for these protocols and to Simulate the protocols using Matlab.
- To Compare the performance between EDEEC, APTEEN, and ATADEEC using MATLAB simulation results.

CHAPTER-2

2.1 Wireless Sensor networks

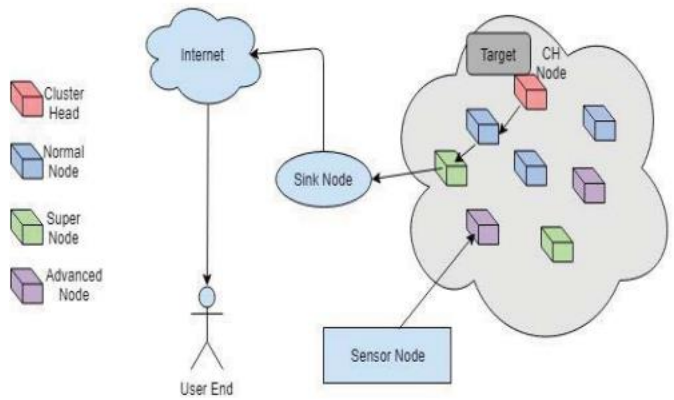


Figure 2.1 Block diagram for WSN

A wireless sensor network (WSN) can be defined as a network consists of low-size and low-complex devices called as sensor nodes that can sense the environment and gather the information from the monitoring field and communicate through wireless links; the data collected is forwarded, via multiple hops relaying to a sink (also called as controller or monitor) that can use it locally, or is connected to other networks.

A sensor node usually consists of four sub-systems i.e., sensing unit, processing unit, communication unit and power supply unit. In WSN, the sensor nodes are deployed in a sensor field. The deployment of the sensor nodes can be random (i.e., dropped from the aircraft), regular (i.e. well planned or fixed) or mobile sensor nodes can be used. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Each sensor node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication, and energy resources. Each sensor nodes collect the data and route the data to the base station.

All of the nodes are not necessarily communicating at any particular time and nodes can only communicate with a few nearby nodes. The network has a routing protocol to control the routing of data messages between nodes. The routing protocol also attempts to get messages to the base station in an energy-efficient manner. The base station is a master node. Data sensed by the network is routed back to a base station. The base station is a larger computer where data from the sensor network will be compiled and processed. The base station may communicate with the Remote Controller node via Internet or Satellite. Human operators controlling the sensor network send commands and receive responses through the base station.

A routing protocol is used for the routing of the data in terms of packets between the nodes in a network. These protocols will postulate the routers of the way these routers transfer the data between them and distribution of information which allows those routers to select the available routes for transferring the data between these nodes. The routing algorithms will play a vital role in the implementation and working of the routing protocols. These routing algorithms will define and determine the routes of the choice which provides guarantee of data transfer. There are several topologies that were available for the users to arrange the nodes in wireless sensor networks. Some of the topologies that were being used mostly in these wireless sensor networks are the star topology and the mesh topology. Two points are to be considered as very important and the challenging operation in the working and functioning of a wireless sensor network. Several sensor nodes will have various characteristics which make it differ from modern-day communication and wireless ad hoc networks. As these sensor nodes will have no proper infrastructure, it becomes very much difficult and unfeasible to construct addressing which is acceptable globally and various algorithms which were conventional for the internet protocol.

1. Routing protocols are of three types. These protocols are classified into three types on the basis of the way the source identifies the destination to be reached. The three types of protocols are proactive, reactive and hybrid protocols. A proactive protocol identifies and sets the paths for routing and states for routing only before the when there is a request for routing traffic. The routing paths identified and fixed were maintained even no traffic at all in the routes. The reactive routing protocol working is different compared to the proactive protocols. In this type of protocols, the routing of the packets or the data is sent when there is a need for the data transmission and it is being distributed to other nodes.

i. In proactive protocols, all the routes that were needed to be sent are calculated beforehand when those were needed to be send

ii. In reactive protocols, the routes for sending the data or packets are to be calculated and identified at the time only if they were needed to be transmitted

iii. Hybrid protocols are the third type protocols which is an amalgamation of the above two types of protocols.

2. The routing in the wireless sensor networks can be divided in to three types based on the structure the network was constructed or the network was developed. The first type of routing in the wireless networks was the flat based routing. In this type of routing model, the nodes were present in the network are the nodes that were connected in the network will work in the same role or in same functioning. The second type of routing in the wireless sensor networks is the hierarchical based routing in which all the nodes present in the network are assigned with several functions based on the hierarchy of the nodes in the network. The third type of routing model in the wireless sensor network is the location-based routing. In this model of routing the paths for the routing mechanism was identified and sent based on the position of the sensor nodes in the area they need to be placed or intended to work on the area.

3. Another model of classifying the routing protocols was based on the initiation of the protocol i.e., the protocol was either initiated towards destination or initiated towards source. Routing paths will be set up by the source-initiated protocol when it gets the request from the source node and starts the node from the source. The source will make a publicity of the data it is having and starts delivering the data at the destination. The destination-initiated protocol works on the basis of setting a path from the destination node.

4. Another model of classifying the routing protocols was based on the operation of the protocol. Several model or types of protocols were being classified in this model, they are multipath based routing protocols, query-based routing protocols, negotiation-based routing protocols, QOS based routing protocols, or coherent based routing protocols.

a. In multipath-based routing type of protocols, numerous paths are being used by the several users for the enhancement of the network performance.

b. In negotiation-based routing type of protocols, various high data level descriptors are used by the designers and the users of the network such that to reduce the redundancy in the data that was being available for the transmission.

c. In Quality of Service based routing protocols, the data will have an equilibrium among the ingestion and data excellence is sustained.

d. In coherent-base routing, the data is aggregated with minimum processing before forwarding. Here energy efficiency is achieved by path optimality.

2.2 EDEEC Protocol:

EDEEC is designed to deal with nodes of heterogeneous WSNs. For CH selection, EDEEC uses the residual energy and average energy levels of nodes.

Since the probabilities calculated depend on the average energy of the network at round r, hence this is to be calculated. This average energy is estimated in equation.

$$\bar{E}(r) = \frac{1}{N} E_{total}\ (1 - \frac{r}{R})$$

Where R denotes the total rounds of the network lifetime. R can be calculated in equation.

$$R = \frac{E_{total}}{E_{round}}$$

d_{toBS} & d_{toCH} is calculated in equation.

$$d_{toCH} = M/\sqrt{2\pi k},\ d_{toBS} = 0.765*M/2$$

During each round, the node decides whether to become a CH or not based on the threshold calculated by the suggested percentage of CH and the number of times the node has been a CH so far. This decision is taken by nodes by choosing a random number between 0 & 1. If the number is less than threshold T(s), the node becomes a CH for the current round. A threshold is calculated as:

$$T(s) = \begin{cases} \dfrac{p}{1 - p(r mod \frac{1}{p})} & if\ s \in G \\ 0 & otherwise \end{cases}$$

where p, r, and G represent, respectively, the desired percentage of cluster-heads, the current round number, and the set of nodes that have not been cluster-heads in the last 1/p rounds. Using this threshold, each node will be a cluster head, just once at some point within 1/p rounds. In the three-level heterogeneous networks, there are three types of nodes normal nodes, advanced nodes, and super nodes, based on their initial energy. Hence the reference value of p is different for these types of nodes. The probabilities of normal, advanced, and super nodes are

$$p_i = \begin{cases} \dfrac{p_{opt} E_i(r)}{(1+am)\bar{E}(r)} & for\ Nml\ nodes\ , E_i(r) > Th_{REV} \\ \dfrac{(1+a)p_{opt}\ E_i(r)}{(1+am)\bar{E}(r)} & for\ Adv\ nodes\ , E_i(r) > Th_{REV} \\ c\dfrac{(1+a)p_{opt}\ E_i(r)}{(1+am)\bar{E}(r)} & for\ Adv, Nml\ nodes\ , E_i(r) \geq Th_{REV} \end{cases}$$

The threshold for cluster head selection is calculated for normal, advanced, super nodes by putting the above values in Equation (17)

$$T(s_i) = \begin{cases} \dfrac{p_i}{1 - p_i(r\ mod \frac{1}{p_i})} & if\ p_i \in\ G' \\ \dfrac{p_i}{1 - p_i(r\ mod \frac{1}{p_i})} & if\ p_i \in\ G'' \\ \dfrac{p_i}{1 - p_i\left(r\ mod \frac{1}{p_i}\right)} & if\ p_i \in\ G''' \\ 0 & otherwise \end{cases}$$

where G' is the set of normal nodes that have not become cluster heads within the last 1/pi rounds of the epoch where s_i is a normal node, G'' is the set of advanced nodes that have not become cluster heads within the last 1/pi rounds of the epoch where s_i is an advanced node, G"' is the set of super nodes that have not become cluster heads within the last 1/pi rounds of the epoch where s_i is super node.

2.3 TEEN Protocol:

TEEN protocol which stands for Threshold sensitive Energy Efficient sensor Network is a reactive protocol. In this type of sensor networks, the sensor nodes uninterruptedly sense the signal and identify the signal from the nature and communicate the data or value shortly to the receiving station whenever the data limitation surpasses the threshold value which was declared or specified by the user. With this type of feature, these sensor models and network models are used highly for critical applications which runs on the basis of time or time dependent applications. Nevertheless, if the required or the thresholds values are not reached, the user cannot be able to find or identify the state or the status of the network, which makes it poor for applications that work on the data being updated from time to time. In this scheme, at every cluster change time, in addition to the attributes, the CH broadcast the following message to its members:

Hard threshold (HT): This is a threshold value for the attributes which were sensed and established for reactive networks. It is the absolute value of the attributes, from where the node senses the present particular value should switch on its transmitter and report the data to its CH.

Soft threshold (ST): This is the value that was observed which is very small in the value attribute which triggers the node in the on mode of its transmitter and transmits the data.

The nodes sense their environment continuously. The first time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends the sensed data. The sensed value is stored in an internal variable in the node, called the sensed value (SV). The nodes will next transmit data in the current cluster period, only when both the following conditions are true:

1. The current value of the sensed attribute is greater than the hard threshold.

2. The current value of the sensed attribute differs from SV by an amount equal to or greater than the soft threshold.

Whenever a node transmits data, SV is set equal to the current value of the sensed attribute. Thus, the hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The soft threshold further reduces the number of transmissions by eliminating all the transmissions which might have otherwise occurred when there is little or no change in the sensed attribute once the hard threshold.

2.3.1 Important Features

The main features of this scheme are as follows:

1. Time critical data reaches the user almost instantaneously. So, this scheme is eminently suited for time critical data sensing applications.

2. Message transmission consumes much more energy than data sensing. So, even though the nodes sense continuously, the energy consumption in this scheme can potentially be much less than in the proactive network, because data transmission is done less frequently.

3. The soft threshold can be varied, depending on the criticality of the sensed attribute and the target application.

4. A smaller value of the soft threshold gives a more accurate picture of the network, at the expense of increased energy consumption. Thus, the user can control the trade-off between energy efficiency and accuracy.

5. At every cluster change time, the attributes are broadcast afresh and so, the user can change them as required.

2.3.2 Advantages and disadvantages:

Advantages:

This scheme is it is eminently suited for time critical data sensing application. Energy consumption in this scheme can be much less than in proactive network because data transmission consumes more energy than data sensing and in this scheme data transmission is done less frequently.

Disadvantages:

The main drawback of this scheme is that, if the thresholds are not reached, the nodes will never communicate, the user will not get any data from the network at all and will not come to know even if all the nodes die. Thus, this scheme is not well suited for applications where the user needs to get data on a regular basis. Another possible problem with this scheme is that a practical implementation would have to ensure that there are no collisions in the cluster.

TDMA scheduling of the nodes can be used to avoid this problem. This will however introduce a delay in the reporting of the time-critical data. CDMA is another possible solution to this problem.

2.4 APTEEN Protocol:

A hybrid network protocol called APTEEN is Adaptive periodic threshold sensitive energy efficient sensor network protocol. Hybrid Networks combine the best features of proactive and reactive networks, while minimizing their drawbacks. Nodes in such a network transmit data periodically at relatively longer intervals while at the same time transmitting data when the sensed value goes beyond its threshold. Thus, the sensor energy is used very efficiently by reducing the number of transmissions of noncritical data. The user can change the periodicity, threshold value(s) and the parameter to be sensed in different regions. This network can emulate either the proactive or the reactive network by suitably changing the periodicity or threshold values. Thus, this network can be used in any type of application by suitably setting the various parameters

However, this flexibility and versatility does increase the complexity at the sensor. Here a new protocol APTEEN (Adaptive Periodic Threshold-sensitive Energy Efficient sensor Network Protocol) is introduced for hybrid networks. There are applications in which the user wants time critical data and also wants to query the network for analysis of conditions other than collecting time critical data. In other words, the user might need a network that reacts immediately to time critical situations and gives an overall picture of the network at periodic intervals, so that it is able to answer analysis queries. None of the above sensor networks can do both jobs satisfactorily since they have their own limitations. APTEEN is able to combine the best features of proactive and reactive networks while minimizing their limitations to create a new type of network called a hybrid network. In this network, the nodes not only send data periodically, they also respond to sudden changes in attribute values. In this way it works as a proactive protocol as well as reactive protocol. This uses the same model as the TEEN protocols with the following changes. In APTEEN, once the CHs are decided, the following events take place in each cluster period. The CH first broadcasts the following parameter.

Attributes: This is a set of physical parameters which the user is interested in. Thresholds: This parameter consists of a HT and a ST. HT is a value of an attribute beyond which a node can be triggered to transmit data. ST is a small change in the value of an attribute that can trigger a node to transmit.

Schedule: This is a TDMA schedule, assigning a slot to each node.

Count time: This is the maximum time period between two successive reports sent by a node. It can be a multiple of the TDMA schedule length, and it introduces the proactive component in the protocol.

However, only those nodes that sense a data value at or beyond the hard threshold transmit. Furthermore, once a node senses a value beyond HT, it next transmits data only when the value of that attributes changes by an amount equal to or greater than the ST. Since nodes near each other may fall in the same cluster and sense similar data, they may try sending their data simultaneously, leading to collisions between their messages. Hence, a TDMA schedule is used and each node in the cluster is assigned a transmitter slot. The main features of the scheme are as follow.

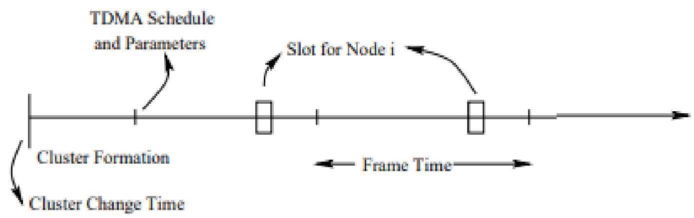


Figure 2.2: Time line for APTEEN

i. By sending periodic data, it gives the user a complete picture of the network, like a proactive scheme. It also senses data continuously and response immediately to drastic changes, making it responsive to time critical situations. Thus, it behaves as a reactive network.

ii. It offers a lot of flexibility by allowing the users to set the count time interval and the threshold values for the attributes.

iii. Changing the count time as well as the threshold values can control energy consumption and can support proactive and reactive behavior in a sensor network.

Drawback:

The main drawback of this scheme is the additional complexity required to implement the threshold functions and the count time. However, this is a reasonable trade-off and provides additional flexibility and versatility.

2.4.1 Query Modeling

To handle queries efficiently in a network, with hundreds and thousands of sensors, we could consider two possible alternatives of a flat topology and a cluster-based approach. In a flat topology, each node satisfying the query conditions has to individually send the data to the requesting node. At best, some intermediate nodes may do some aggregation, as shown in Fig 4. In a hierarchical cluster, only the CH needs to aggregate and so it seems more efficient. This is the scheme used here. If we assume that adjacent nodes can sense similar data, we can form pairs of two nodes and make only one node from each pair respond to a query. The other node can go to a "sleep" mode and need not receive the query. Thus, two nodes can alternately take the role of handling queries if there are nodes close enough to form pairs.

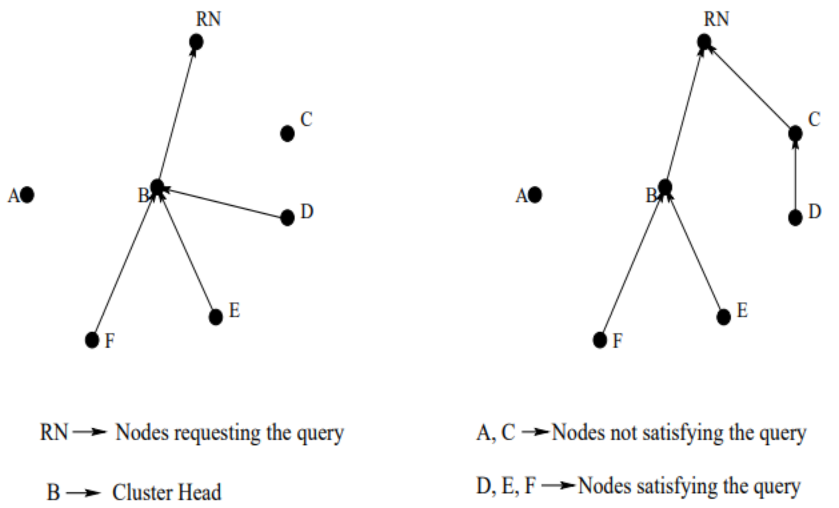


Figure 2.3: Comparison of query routing topologies

2.4.2 Modified TDMA Schedule

A best possible pairing of sleeping and idle nodes can be found by the BS using simulated annealing. The nodes which listen for the queries have to be always awake (i.e., in idle state ready to receive any query). Also, these idle nodes will have more data to send if they receive queries, since they might have to send data as well as the queries. Hence, the slots for these idle nodes have to be larger than the slots for the sleeping nodes. By modifying the TDMA schedule, we can have the sleeping nodes send their data first and then the idle nodes. For example, if adjacent node a and node b constitute sleep/idle pair, they will have their slots at an average distance of half the frame time. So, even though the interval between two successive slots of node a is larger because of larger slots for idle nodes, the critical data can still be sensed and transmitted by node b without having to wait for node a's next slot. The nodes can change their roles midway between cluster change times, so that sleeping nodes now go into idle mode to handle queries and the idle nodes now go into sleep mode. The CH aggregates all the data and sends it to its higher-level CH (or the BS). Once the BS receives the data from all the CHs, it extracts the queries and the answers from the data and transmits them in down-link mode, directly to the sensor nodes or the user rather than going through the CHs. Different CDMA code is used in each cluster to avoid inter-cluster collision. However, a common CDMA code is employed for the up-link from the cluster heads to the BS and the down-link from the BS to all sensor nodes. This implies that the BS should not transmit to the nodes when the nodes are transmitting data to their CHs in their slots. So, we need to assign a separate slot for the BS and include it in the TDMA schedule. However, each cluster might have different number of members, leading to different TDMA frame lengths. So, the BS has to calculate the length of the longest TDMA schedule among the clusters and make allowance for the transmitted data from the CHs to reach it, after which it can transmit its own data. Finally, incorporating all these factors,

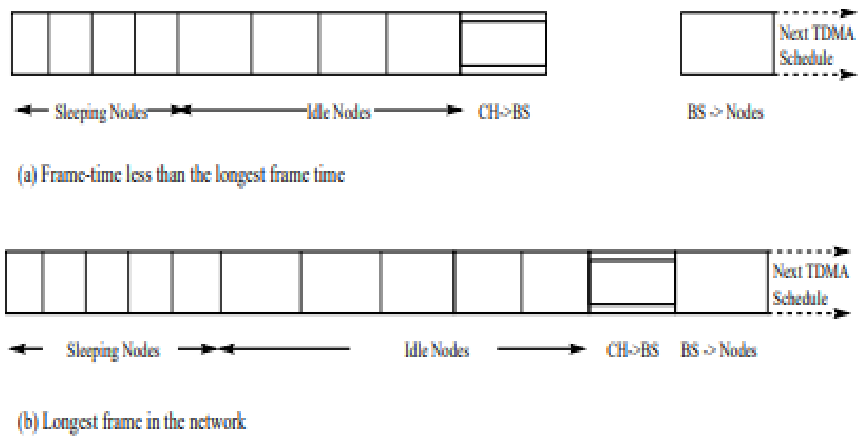


Figure 2.4: Different frame length in a network.

2.4.3 Query Routing

Most current protocols developed for queries are suitable for only one of the types of queries. Our model can handle all the three types. To our knowledge, this is the first protocol which handles all types of queries efficiently.

(i) Historical Query

The format of the query is as follows:

type 0 // type of query

temp -1 // -1 for”?”

location northwest quadrant

time 120 //in minutes

The node that receives this query transmits it to its CH in its slot. The CH aggregates all the data and transmits it to the BS at the end of the schedule. The BS checks the query type and retrieves the answer from its memory and sends the answer to the nodes directly in its down-link slot. So, the node gets the answer to its query in a minimum of x and a maximum of x+frame-time where x is the time interval between the arrival of the query and the end of that frame

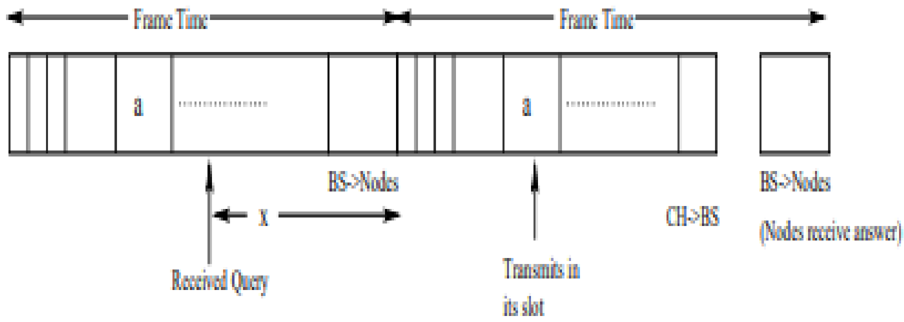


Figure 2.5: Handling of history queries

(ii) One-time Query

The format of the query is as follows:

type 1 // type of query

temp -1 // -1 for”?”

location northwest quadrant

The node sends the query to its CH in its slot and the BS receives it at the end of the schedule. If the query is about time critical data, the BS already has this data from the nodes and so it answers such queries immediately in its down-link slot in the same frame. For other queries of this type for which the BS does not have data, it broadcasts the queries to the nodes in its slot. All the idle nodes that satisfy the queries send the data in their slot to the BS via their CHs. The BS station aggregates all the received data and broadcasts the answer. So, if the query is about data which the BS can answer immediately, the delay is same as that for the history queries. For other one-time queries, the response time will be between x+frame-time and x + 2∗frame-time.

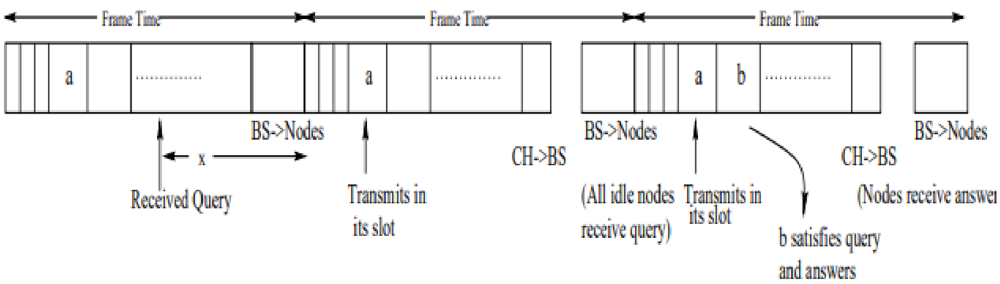


Figure 2.6: Handling of one-time queries.

(iii) Persistent Query

The format of the query is as follows:

type 2 // type of query

temp-1 // -1 for ”?”

location northwest quadrant time 120 //in minutes

This type of query is handled almost exactly as the onetime query. The initial delay is the same as that of the onetime query, and then the delay is one frame-time for the duration of the query.

2.5 ATADEEC Protocol:

Adaptive Threshold Aggregation Distributed Energy Efficient Clustering (ATADEEC) approach expands the lifetime of network and reductions correspondence time in both reactive and proactive network system. In sensor network hubs have two targets detected information and prepared information. Clustering is an essential factor in EDEEC because clustered node centres have discovered information. However, the issue with this convention is redundant information which is sent to the base station over and over by CH hub. To stay away from this disadvantage of EDEEC convention we hybrid APTEEN with advancement quality with it.

This mixture protocol ATADEEC handling with selected features of node centres like characteristic, Threshold, Schedule, and include time TDMA condition which maintains a strategic distance from impact at the time of information correspondence by dispensing time slots. This hybrid system is more successful than past convention. It takes less time since its utilizing best functionalities of both protocols. Architecture of ATADEEC shown in figure 2.7

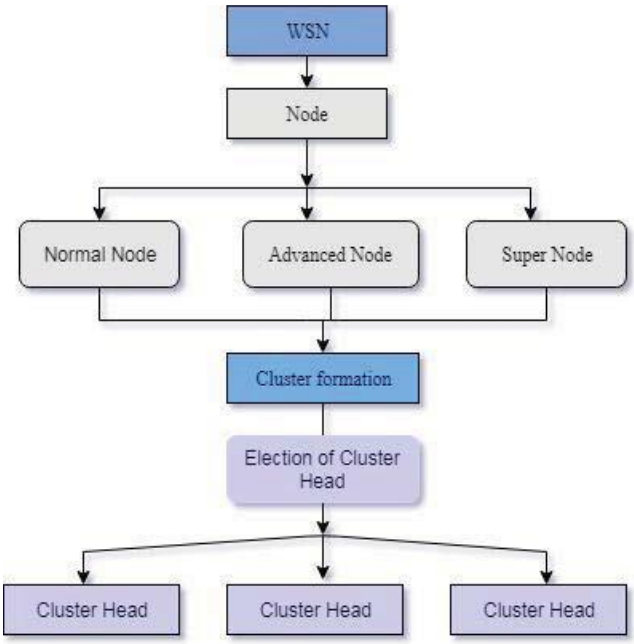


Figure 2.7: Architecture of ATADEEC

2.5.1 Overall Cluster Head Election

The election procedure picks a cluster head that represents the detecting system which is appeared in Fig. The picked cluster head assembles the detected data and advances to the various clusters in the way of exchange. The whole move in the cluster is controlled by the cluster head. The election of cluster head is a basic procedure where the super node in the cluster is picked. At that point this CH is presently contrasted and the various nodes in the cluster. Just the node with most extreme likelihood of remaining vitality should be picked as the CH shown in figure

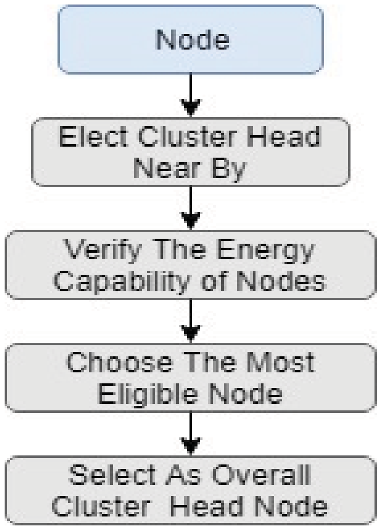


Figure 2.7.1: Cluster Head selection chart

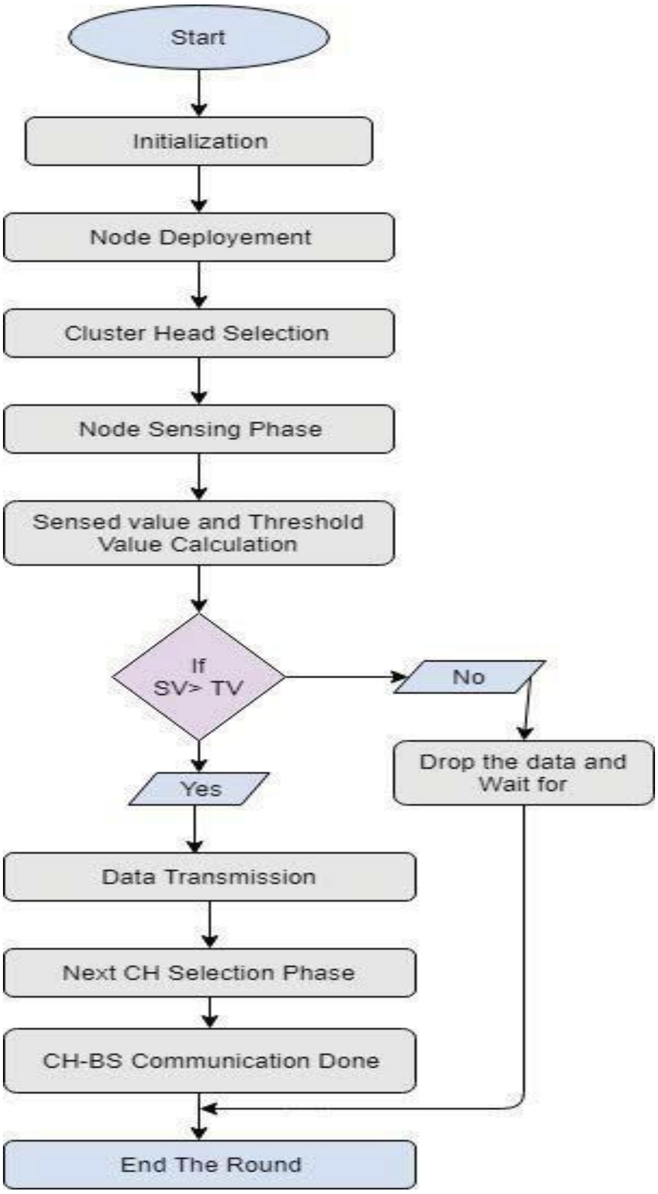


Fig 2.9 The working of this ATADEEC scheme can be understood by flow chart

2.7.2 Algorithm

Step1: Select number of nodes, area for the deployment and initialize network for transmission.

Step2: Define the energy level for different nodes in the designed network (Normal node is less energy node and super node is higher energy node).

Step3: Select cluster head by using the constraints- attributes, schedule, threshold energy level and count time.

Step4: If node belongs to normal node, then nodes send data to base station. Else, Node belongs to advanced node then cluster head sends data to base station. Else, Node belongs to super node then cluster head sends data to base station. End if

Step5: When the one cluster head will about to die then selection for new cluster head will come into process.

Step6: New cluster head will calculate all energy, schedule, count time and attribute of nearby nodes again and then compare it and higher value node will get selected as new cluster head node and broadcast process will be doing by new cluster head in the network.

Step7: This process will be repeating till all the rounds will get complete for the data transmission

2.7.3. Implementation

Here p is the probability of choosing the cluster heads in the network so a node become eligible for cluster head again after 1/p0 rounds. So average no of cluster heads should be n*p if n is total no of nodes. In our scheme nodes are distributed according to constant m and m0 and nodes are:

A. Cluster Head Threshold value selection Formula

Where, 'r' is current round number (lifetime). 'P' is probability for selection of cluster head node. 'n' is total number of nodes. 'G' is normal node that has not become a cluster head. E0 is normal node energy and a, b are the factors having more times energy in advanced node and super node respectively. In our scheme nodes are distributed according to constant m and m0 and nodes energy are:
Normal node energy = E0 ;
Advanced node energy = E0(1+a);
Super node energy = E0(1+b);

B. Number of nodes in the network

Number of Normal Nodes= (1-m)*n;
Number of Super nodes= (m0*m*n)/2;
Number of Advanced nodes= (1-m0)*m*n;

C. Total energy in one round

$$E = E_0*(1-m)*n + E_0\,(1+a)*(1-m0)\,*m*n + E_0\,(1+b)*(m0*m*n)/2$$

$$E = n*\,E_0\,(1-a*m + m*m0\,(a-(1+b)/2));$$

D. Probabilities for nodes are

Normal node probability, Pnormal = P0/E;
Advanced node probability, Padvanced = P0*(1+a)/E;
Super node probability, Psuper = P0*(1+b)/E;

ATADEEC legitimately utilized the heterogeneity of nodes in the network for enhancing the performance of the system. In this system we can see that this advancement calculation enhanced the correspondence among the heterogeneous nodes and delay the lifetime of the nodes to expand the correspondence. Along these lines this system is fruitful in accomplishing high solidness period, lifetime and throughput of the network. It has maintained lifetime of the nodes by modulating the energy of all node present in the network for large number of rounds

Comparison of Protocols:

Type/Parameters	Classification (Routing)	Energy Levels	Network Lifetime	CH Mobility	CH selection	Hard threshold And soft Threshold
EDEEC	Proactive-Cluster based	Three	Good	Fixed	Residual Energy and Average energy	Not Present
APTEEN	Hybrid (Proactive and reactive)	One	Good	Fixed	Average energy and Initial energy	Present
ATADEEC	Hybrid (Proactive and reactive)	Three	Best	Fixed	Residual Energy and Average energy	Present

Table 1. comparison of EDEEC, APTEEN, and ATADEEC for different parameters

CHAPTER-3

MATLAB Simulator

3.1 Introduction to Matlab

MATLAB (an abbreviation of "matrix laboratory") is a proprietary multi-paradigm programming language and numeric computing environment 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.

The MATLAB application is built around the MATLAB programming language. Common usage of the MATLAB application involves using the "Command Window" as an interactive mathematical shell or executing text files containing MATLAB code.

3.2 Basic Commands in Matlab

Variables

Variables are defined using the assignment operator, =. MATLAB is a weakly typed programming language because types are implicitly converted.[33] It is an inferred typed language because variables can be assigned without declaring their type, except if they are to be treated as symbolic objects,[34] and that their type can change. Values can come from constants, from computation involving values of other variables, or from the output of a function. For example:

```
>> x = 17
x =
 17
```

Vectors and matrices

A simple array is defined using the colon syntax: initial:increment:terminator. For instance:

```
>> array = 1:2:9
array =
 1 3 5 7 9
```

Functions: When creating a MATLAB function, the name of the file should match the name of the first function in the file. Valid function names begin with an alphabetic character and can contain letters, numbers, or underscores. Variables and functions are case-sensitive.

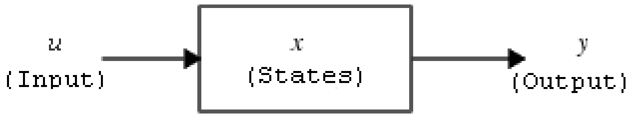
S Function: S-functions (system-functions) provide a powerful mechanism for extending the capabilities of the Simulink® environment. An *S-function* is a computer language description of a Simulink block written in MATLAB.

S-functions use a special calling syntax called the S-function API that enables you to interact with the Simulink engine. This interaction is very similar to the interaction that takes place between the engine and built-in Simulink blocks.

S-functions follow a general form and can accommodate continuous, discrete, and hybrid systems S-functions define how a block works during different parts of the simulation, such as initialization, update, derivatives, outputs, and termination. In every step of a simulation, a method is invoked by the simulation engine to fulfill a specific task. S-function basics require fundamental knowledge of mathematical relationships between the block inputs, states, and outputs.

Mathematics of Simulink Blocks:

A Simulink block consists of a set of inputs, a set of states, a set of parameters, and a set of outputs, where the outputs are a function of the simulation time, the inputs, parameters, and the states.



Rand Function: The rand function generates arrays of random numbers whose elements are uniformly distributed in the interval (0,1).

Y = rand(n) returns an n-by-n matrix of random entries. An error message appears if n is not a scalar.

Y = rand(m,n) or Y = rand([m n]) returns an m-by-n matrix of random entries.

Y = rand(m,n,p,...) or Y = rand([m n p...]) generates random arrays.

Y = rand(size(A)) returns an array of random entries that is the same size as A.

rand, by itself, returns a scalar whose value changes each time it's referenced.

s = rand('state') returns a 35-element vector containing the current state of the uniform generator. To change the state of the generator:

rand('state’, s)	Resets the state to s.
rand('state',0)	Resets the generator to its initial state.
rand('state',j)	For integer j, resets the generator to its j-th state.
rand('state',sum(100*clock))	Resets it to a different state each time.

Commands for Managing a Session

MATLAB provides various commands for managing a session. The following are such commands −

Command	Purpose
clc	Clears command window.
clear	Removes variables from memory.
disp	Displays contents of an array or string.
input	Displays prompts and waits for input.
length	Computes number of elements.
linspace	Creates regularly spaced vector.
max	Returns largest element.
min	Returns smallest element.
ones	Creates an array of ones.
zeros	Create an array of zeros.
axis	Sets axis limits.
grid	Displays gridlines.
plot	Generates XY plot.
print	Prints plot or saves plot to a file.
title	Puts text at top of the plot.
xlabel	Adds text label to the x-axis.
ylabel	Adds text label to the y-axis.
axes	Create axes objects.
close	Closes the current plot.
close all	Closes all plots.
figure	Opens a new figure window.
hold	Freeze's current plot.
legend	Legend placement by mouse.
refresh	Redraws current figure window.
subplot	Creates plots in sub windows.
bar	Creates bar chart.

MATLAB has tightly integrated graph-plotting features. For example, the function plot can be used to produce a graph from two vectors x and y. The code:

```
x = 0: pi/100:2*pi;
y = sin(x);
plot(x,y)
```

produces the following figure of the sine function

CHAPTER-4

Simulation scenario and Simulation Results

4.a Simulation scenario and Simulation results:

Parameter	**Value**
Network size	100m*100m
Number of Nodes	50,100
Probability of cluster heads p0	0.1
Initial Energy E0	0.1J
Fraction of Energy Advancement of Advance nodes(a)	1
Packet size	4000 bits
Rounds(r max)	2000,5000
Transmitting Energy cost	50nJ/round
Receiving energy cost	50nJ/round
Other parameters	• m=0.5 • m0=0.4 • b=3

Table 2. Simulation parameters

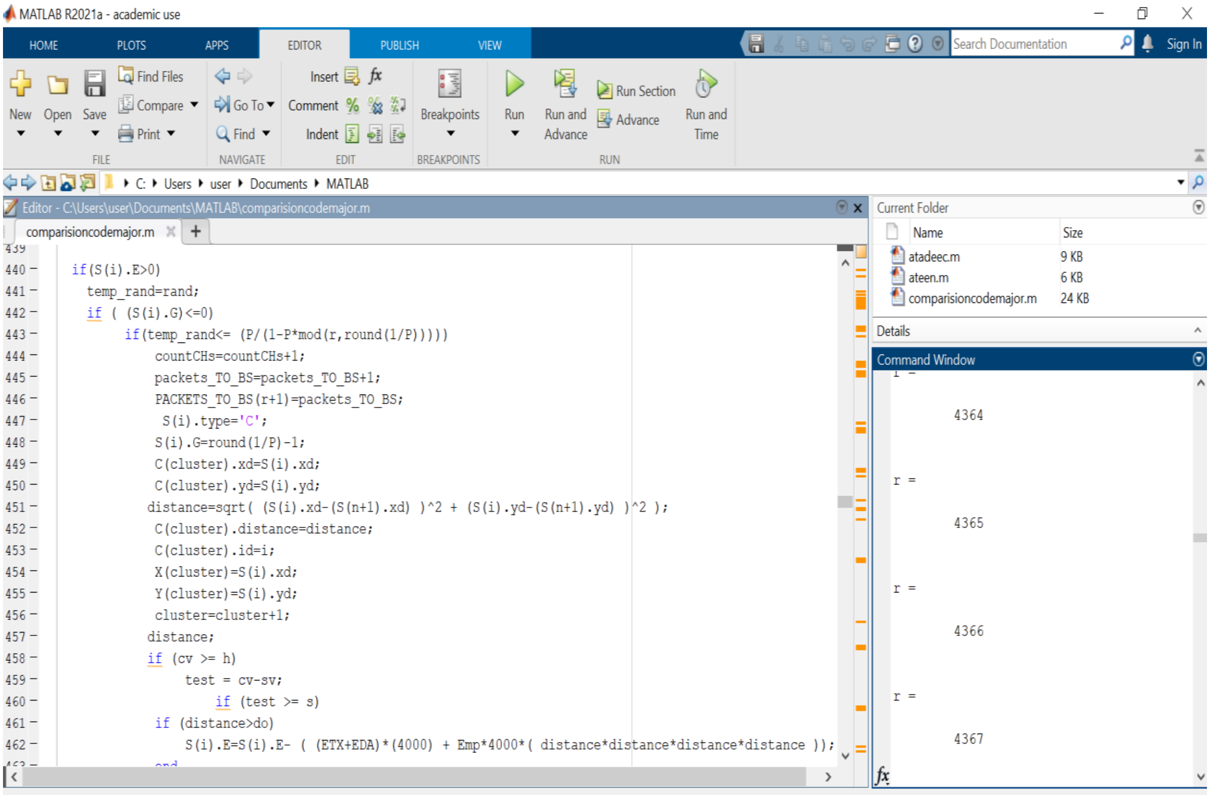


Figure 4.1.1 Scenario at 4345th round in ATADEEC protocol

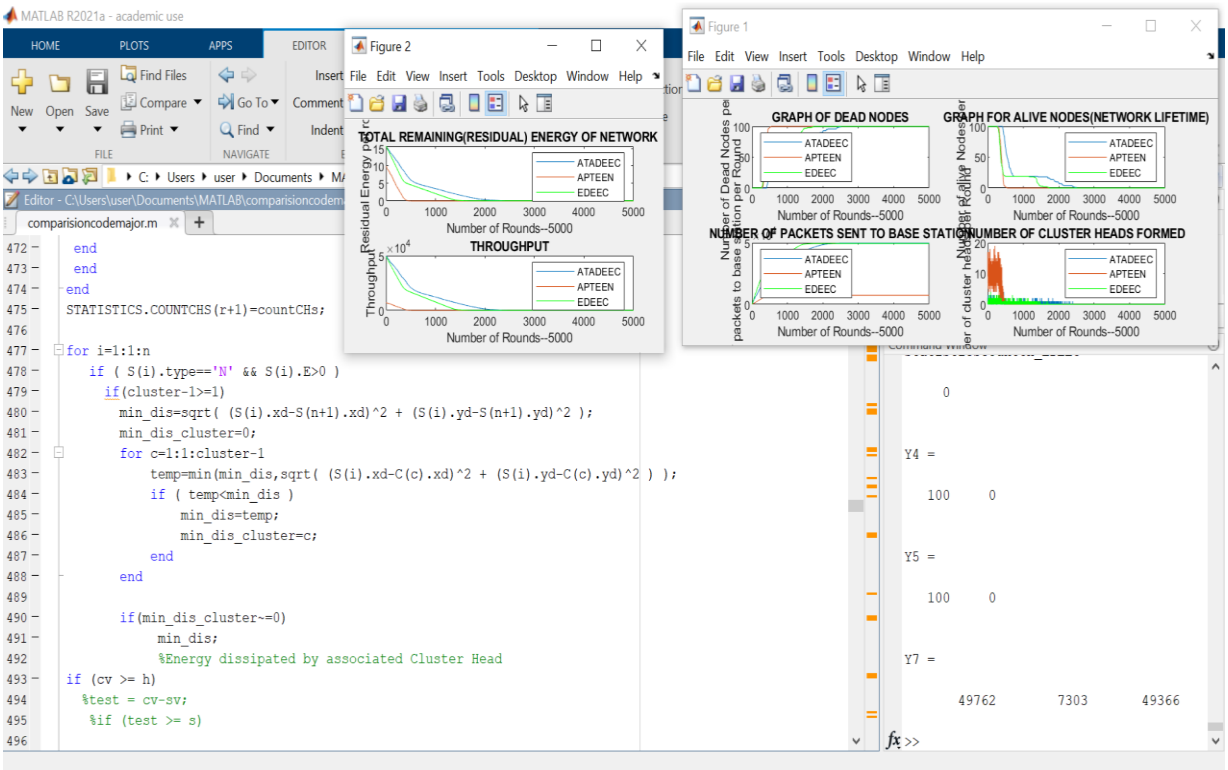


Figure 4.1.2 Final Scenario after completion of all rounds in all protocols

4.b Simulation Results

4.2

Let the number of nodes be 50 Rounds=1000

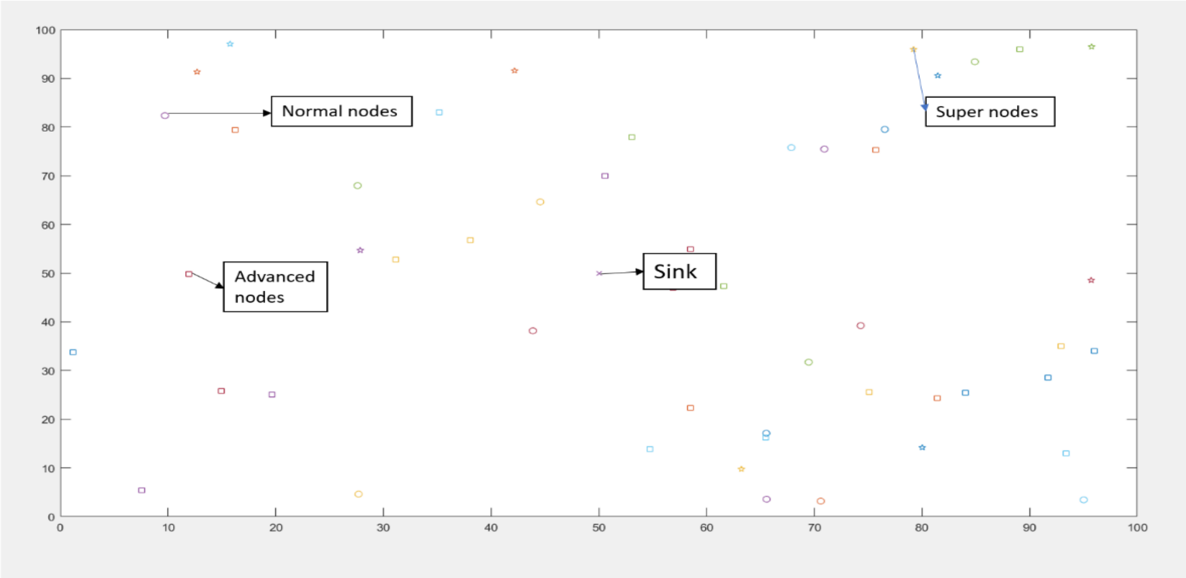


Figure 4.2.1 Wireless sensor Network-50 nodes

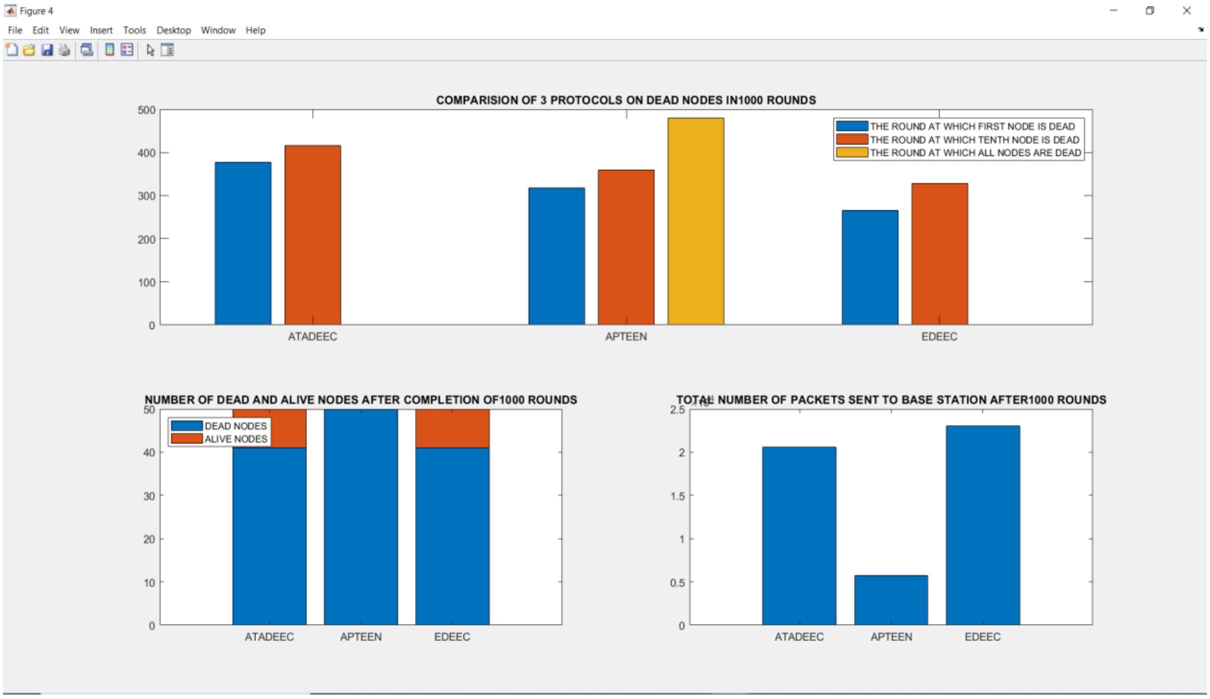


Figure 4.2.2

(i)represents the comparison of ATADEEC, APTEEN, and EDEEC protocols on dead nodes in 1000 rounds for 50 nodes

(ii). represent the no. of dead and alive nodes after 1000 rounds for 50 nodes.

(iii). represent the total no. of packets sent to the base station after 1000 rounds

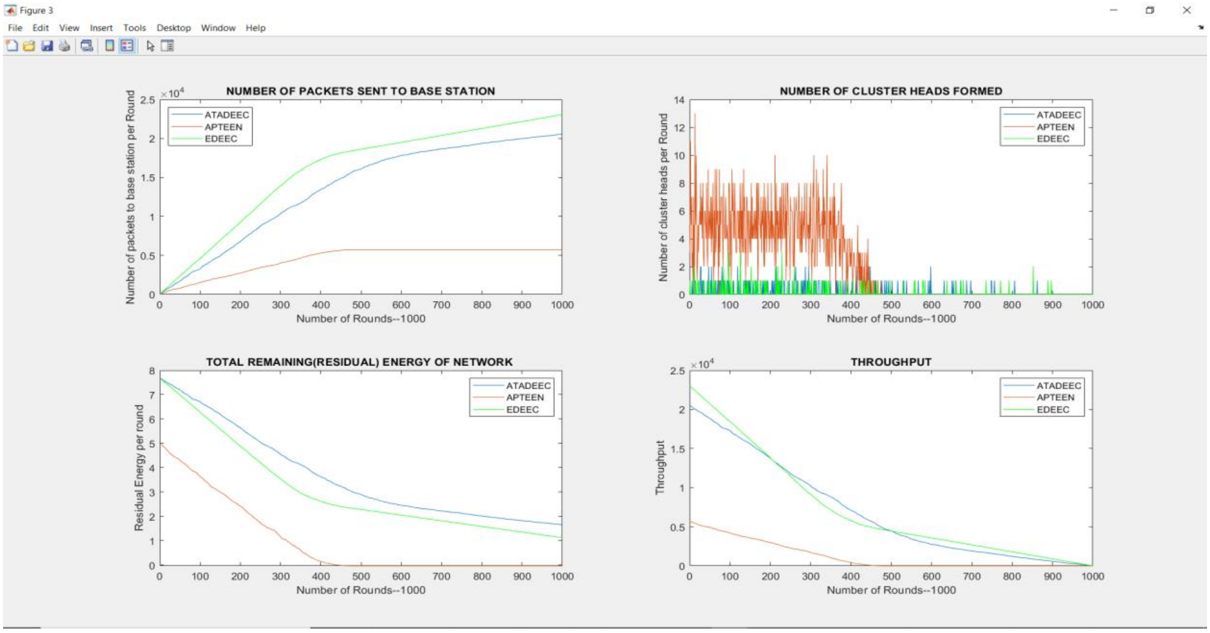


Figure 4.2.3

(i) represents the graph for no. of packets sent to the base station per round. Rounds up to 1000.

(ii) represents the graph for the number of cluster heads formed per round. Rounds up to 1000.

(iii) represents the graph for total residual energy per round. Rounds up to 1000.

(iv) represents the graph for throughput per no. of rounds.

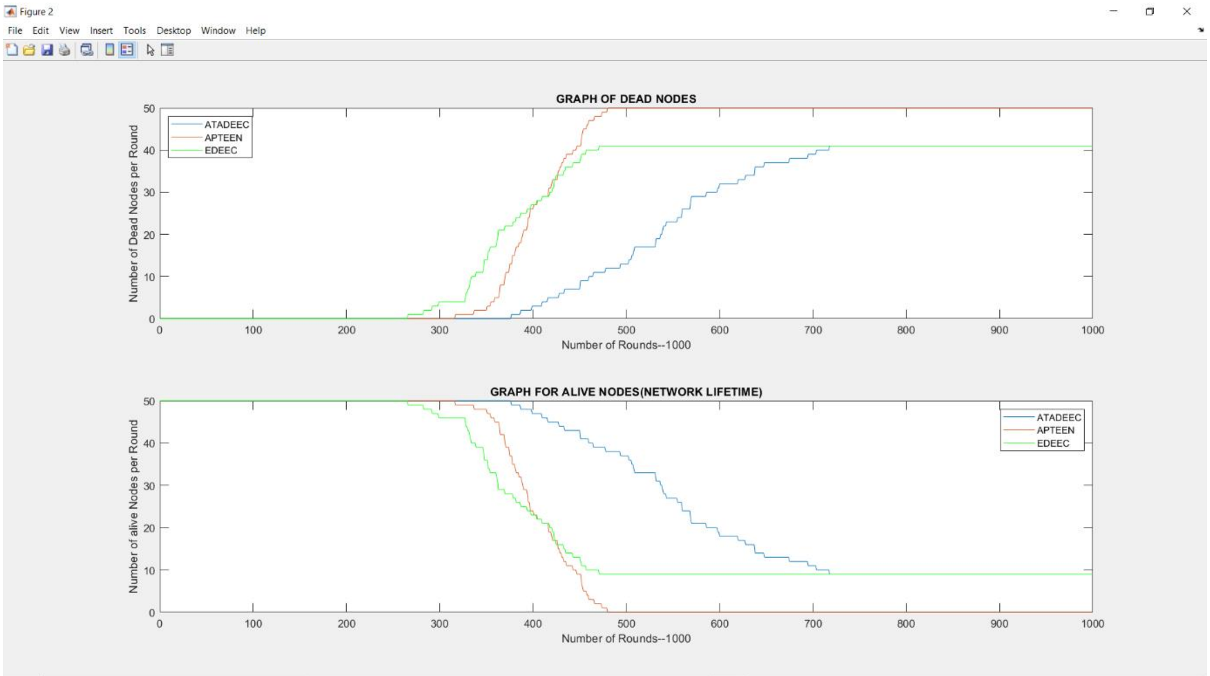


Figure 4.2.4

(i) represents the graph of dead nodes for no. of dead nodes per round. Rounds up to 1000.

(ii) represents the graph for alive nodes i.e., no. of alive nodes per round. Rounds up to 1000.

4.3 Let the number of nodes be 100

Let Rounds=2000

Figure 4.3.1

(i)represents the comparison of ATADEEC, APTEEN, and EDEEC protocols on dead nodes in 2000 rounds for 100 nodes

(ii). represent the no. of dead and alive nodes after 2000 rounds for 100 nodes.

(iii). represent the total no. of packets sent to the base station after 2000 rounds

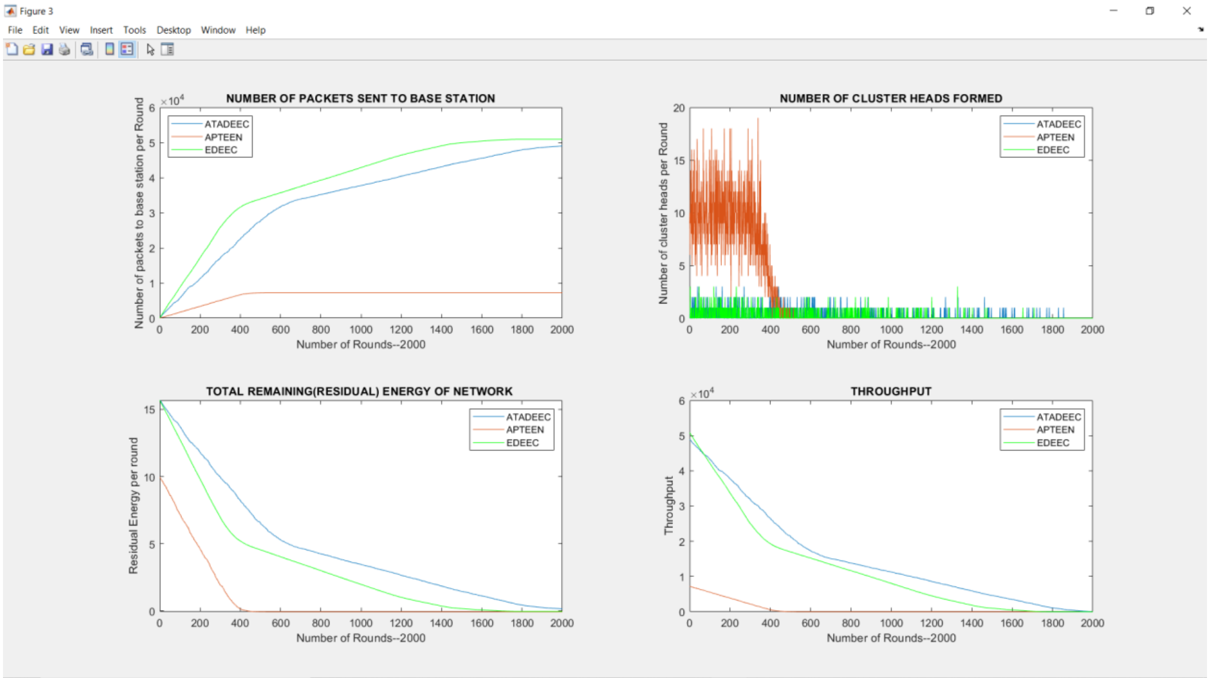


Figure 4.3.2

(i) represents the graph for no. of packets sent to the base station per round. Rounds up to 2000.

(ii) represents the graph for the number of cluster heads formed per round. Rounds up to 2000.

(iii) represents the graph for total residual energy per round. Rounds up to 2000.

(iv) represents the graph for throughput per no. of rounds.

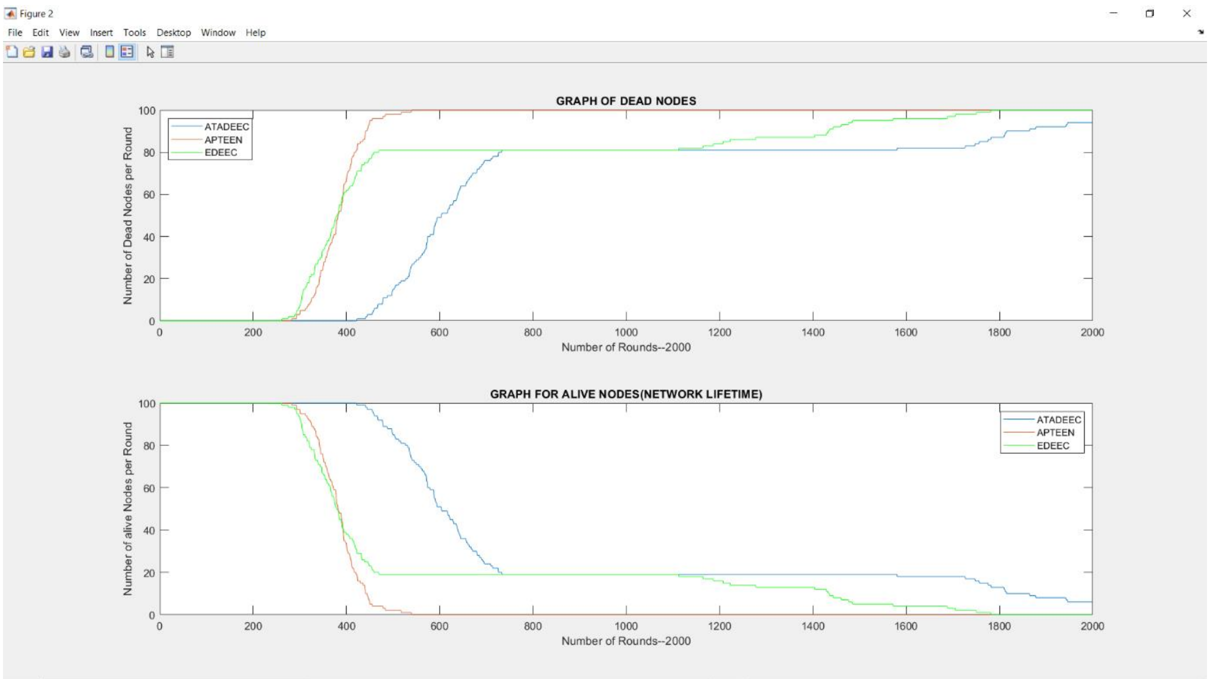


Figure 4.3.3

(i) represents the graph of dead nodes for no. of dead nodes per round. Rounds up to 2000.
(ii) represents the graph for alive nodes i.e., no. of alive nodes per round. Rounds up to 2000.

Let the nodes be 500.

rounds be 5000

Figure 4.4.1

(i)represents the comparison of ATADEEC, APTEEN, and EDEEC protocols on dead nodes in 5000 rounds for 500 nodes

(ii). represent the no. of dead and alive nodes after 5000 rounds for 500 nodes.

(iii). represent the total no. of packets sent to the base station after 5000 rounds

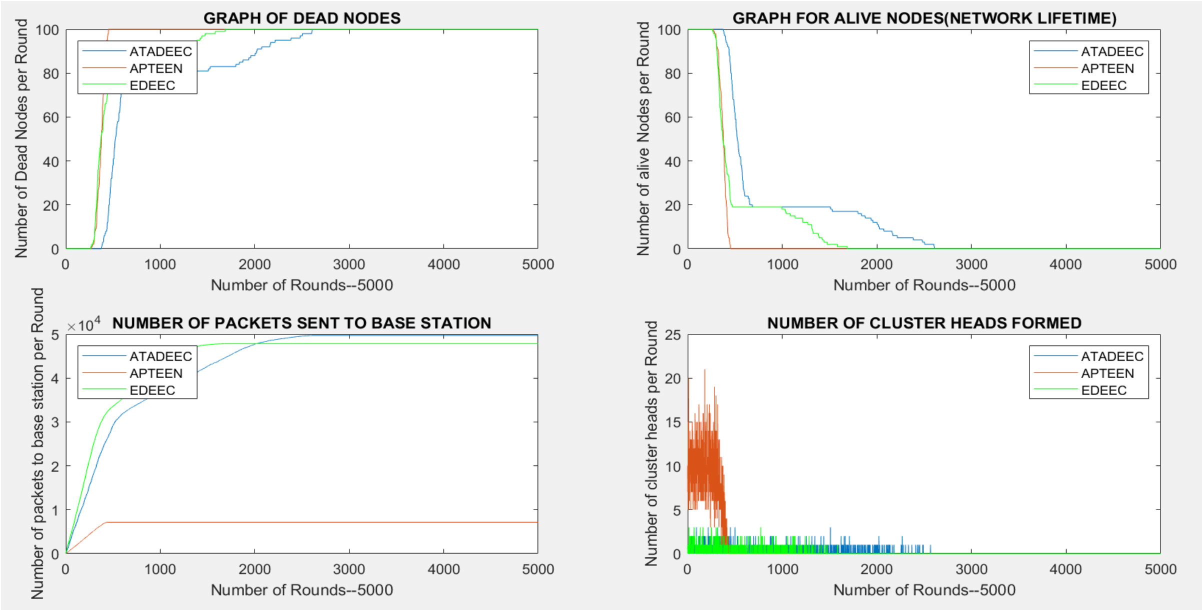


Figure 4.4.2

(i) represents the graph of dead nodes for no. of dead nodes per round. Rounds up to 5000.

(ii) represents the graph for alive nodes i.e., no. of alive nodes per round. Rounds up to 5000.

(iii) represents the graph for no. of packets sent to the base station per round. Rounds up to 5000.

(iv) represents the graph for the number of cluster heads formed per round. Rounds up to 5000.

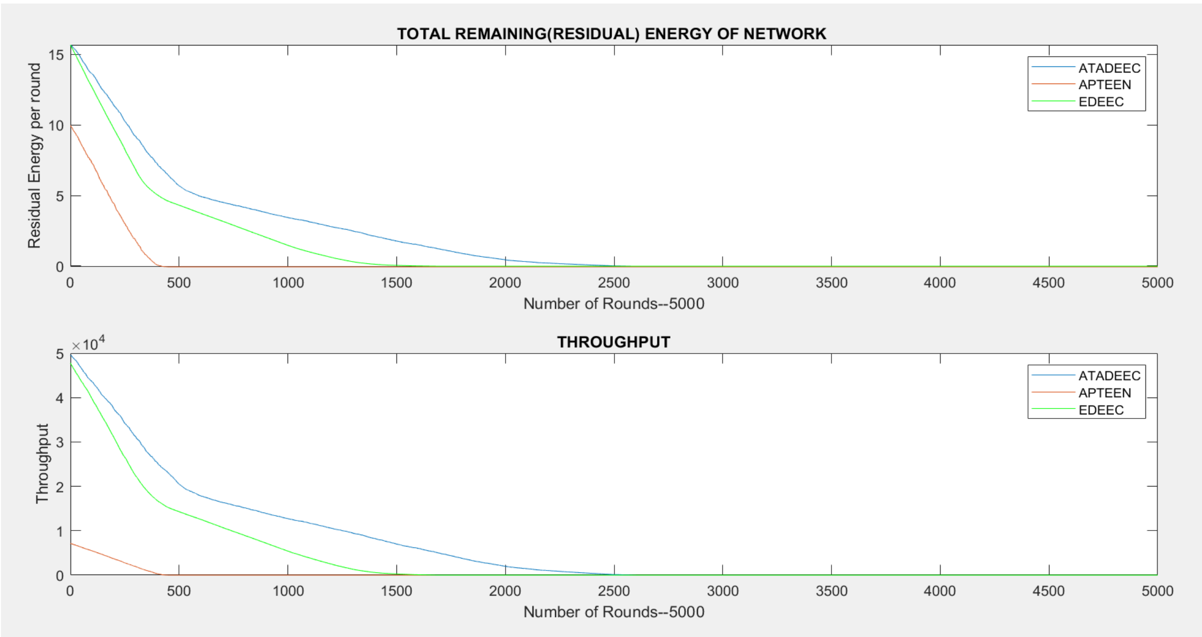


Figure 4.4.3

(i) represents the graph for total residual energy per round. Rounds up to 5000.

(ii) represents the graph for throughput per no. of rounds.

CONCLUSION:

In this project, ATADEEC (Adaptive threshold aggregation Distributed Energy Efficient Clustering) protocol improves the stability and energy-efficient property of the heterogeneous wireless sensor network. In terms of the numberof packets transmitted to the BS, Adaptive threshold aggregation DEEC gives a substantial improvement of 80.85 % when compared to APTEEN and 60% when compared to EDEEC. Whereas in terms of first node dead ATADEEC shows an improvement of 77.2% when compared to APTEEN and 70.5% when compared to EDEEC. When the last dead node is considered, there is an improvement of 80.85% when compared with APTEEN and 60.1% when compared to EDEEC. Simulation results show that ATADEEC performs better as compared to EDEEC and APTEEN in a heterogeneous environment for wireless sensor networks.

Protocol/(nodes=100) **Parameters**		**EDEEC** **Protocol**	**APTEEN** **protocol**	**ATADEEC** **Protocol**
Dead Nodes	**1st**	267th round	281th round	393th round
	All	1491th round	496th round	2471th round
Network lifetime **(Nodes are alive up to…)**		1490 rounds	495 rounds	2470 rounds
Packets sent to base station after 5000 rounds		48490 packets	6999 packets	49050 packets
Energy Consumption per round **(Joules)**		0.029533J	0.02814J	0.0207J
Average Throughput		29packets/sec	4packets/sec	31packets/sec

Table 3

LIMITATIONS:

- In ATADEEC, Sensor nodes are uniformly deployed and fixed.
- In ATADEEC sink mobility is not considered
- As ATADEEC is a hybrid protocol, it depends on current sensed value. So proper care needs to be taken while setting threshold.
- Nodes which are not in use are still active and energy is wasted unnecessarily.

FUTURE SCOPE:

- Nodes are fixed and protocol can be extended to mobility of nodes.
- Only Data transfer is considered, Protocol can be extended to Audio, Video transfer.
- Heterogeneity can be extended to multilevel.
- Future contribution to this work can be more variations in sink trajectories with static nodes. Network performance can be observed with nodes being mobile and sink being static or nodes and sink both being mobile

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