

A Comparative study of Energy Efficient Approach during Data Transmission

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Abstract: *Wireless Sensor Network has been used for collection of information from the non-approachable areas. WSN use sensor nodes for sensing the information from the environment. Sensor nodes have been powered using energy source that is battery connection. Battery source of WSN nodes can't be charged from any external device so that energy efficient utilization of the nodes for sensing and transmitting information is the major concern. Various approaches had been introduced in the past researches that provide better energy efficient protocol for enhancement of network lifetime and data transmission. In this paper various approaches have been implemented for WSN. Clustering based approaches have been utilized and assumed to be efficient approaches for data collection and data transmission over the network. In this paper approaches that have been reviewed and comparisons based on various parameters have been made are DEEC, LEACH, EIP-LEACH and Fuzzy based Clustering approach. Various parameters that are Network lifetime, Packet delivery Ratio and Network Stability period has been computed and discusses in this paper. Experimental results of above defined approaches have been demonstrated.*

Keywords: *WSN, Clustering, LEACH, Cluster Head, Energy Consumption*

I. INTRODUCTION

1.1 Wireless Sensor Network:

WSN (Wireless Sensor Network) comprises a set of nodes that have been used for sensing information from the environment so that information can be utilized for the process of information processing and data evaluation about the region. These types of sensor network have been used in various areas, in which human interaction is not possible. Monitoring of Environment conditions, Medical information collection from human body and ITS (intelligent Transport System) [1] are the major applications of WSN. A sensor network has been deployed over the region and locations points of the sensor nodes have been allocated so that a communication network can be established between the sensor nodes. In WSN nodes comprises of various parts that makes a node to sense the information and transmit that particular information to the base station. Base Station is the sink node that has been allocated to collect all the information from WSN network so that collected raw information can be processed for evaluation purpose. Nodes have been made using various components that are receiver, battery source, Transmitter, memory unit and antenna. On the basis of these small units a single node of WSN has been developed and worked for sensing of information. Various challenges and difficulties are there to process the WSN's nodes for collection of information that has been discussed below.

1.2 Clustering Parameters

Clustering is the method that has been used for energy efficient routing in WSN. Networks has been divided into small clusters and the clusters acts as a small network and collect the information and transmit particular information to the cluster head. Different parameters have been used for cluster division to be effective in terms of network utilization that has been illustrated below.

Division of the Clusters: in the clustering approaches this is the challenging factor that has to be determined the amount of clusters in which whole network has to be divided. Most of the algorithm uses the no. of nodes to be contributed in a single cluster. On the basis of nodes in the network no. of clusters has been evaluated and cluster head has been elected for the entire cluster based on cluster head election parameters.

Communication of intra clusters: a single hop communication has been available in the WSN nodes that a single node has allocated a particular radius in which a node can transmit and receive the information. Due to large area network clusters have been wide in nature such that nodes can't directly communicate with the cluster. So to overcome this issue multi-hop communication between the nodes had been required that provide extra overhead in terms of energy and routing efficiency.

Mobility in WSN: WSN's has been used mostly of two different types that are static WSN and Mobile WSN. Inter communication between nodes within the cluster and other cluster is an easy process in the static WSN, whereas this is the major difficult part to established communication between the nodes when mobility has been introduced in the network. Dynamic routing protocols have to be utilized that updates the route table after each interval of time using routing messages transmission. These route request message cause extra wastage of energy as well as bandwidth of the network that makes network costlier

Types of nodes in WSN: two types of network based on nodes properties have been designed and implemented in the region. A network designed with similar properties to all the nodes has been called as homogenous network and the nodes having different properties to other nodes in the network has been known as heterogeneous network. In the heterogeneous network some nodes have been provided with advance features like extra battery power, sensor type can be different from other sensor nodes.

Formation of Clusters and Cluster head Selection: cluster formation and selection of the cluster head is the most important part of the network. Efficient cluster formation and cluster head selection causes to easy data transmission for long lasting time with low information loss. In the past static clustering approach a cluster has been formed during deployment of nodes and a node has been allocated as cluster head, which can loss the information due to utilization of whole energy amount. In recent approaches dynamic clustering has been utilized that develops new cluster after a particular interval of time and all the nodes have been right to be become cluster head based on the properties of the selection of cluster head.

1.3 Energy Consumption in Transmission

In the process of node data accessing nodes use different analog signals for transmitting data. Signals are usually processed at node level using amplification and digitization. In the process of amplification and digitalization signal processing has been done. All these stages of message transmission and receiving at node level consume energy consumption. Distance is main factor that has been taken into account for computation of power consumption at each node. Transmission power has been adjusted on the basis of distance between source node to destination node and various parameters are based on transmission powers that are attenuation and range of communication[2].

Energy has been consumed in sensor network by transmitting duplicate packets over the network. Various routing protocols had been designed for avoiding duplicate packet transmission over the network so that energy consumption can be reduced and network lifetime can be enhanced to an extent. A node performs various operations that are switching of node operations that are active mode, idle mode and sleep mode. In the state of active mode various operations of sensing information, data transmission and control packets generation has been done. This process consumes a large amount of energy. While a node in sleep state consumes minimum amount of energy in performing various operations of wireless sensor network. In the sleep state frequency of the processor has been reduced to an extent so that no processing has been done and transmitter has been turned off so that data has not transmitted from source to destination. Third state of WSN is that in which state nodes activity has been gone in idle state so that no processing has been done and only sensing of information has been done. This state consumes large energy than state mode and less that in active mode.

1.3.1 Energy Aware routing protocol EAR

Energy is the main constraint in WSN so energy aware routing protocols are important factor for network lifetime in WSN. In this type of protocols various possible set of paths for network communication between two nodes has been discovered rather than that of one optimal path that having high rates. On the basis of probability these routes have been selected for communication process. In this type of energy aware routing protocols class based addressable approach has been used that having two different parameters that are location and type of the nodes. On initiating in static WSN routing protocol has been used for discovery of all the possible paths for communication with total cost incurred for data transmission from source node to destination. The routes that incurred high cost for data transmission has been discarded and low cost routes have been selected for communication process based on probability value. Probability of the route selection is reciprocal of the cost of the incurred that states that route having high cost having minimum probability of selection for data transmission. Localized flooding has been done by the base station to validate whether all the paths are still operative or not. These routing protocols provide high efficiency in energy savings as well as network lifetime improvement.

1.3.2 Low Energy Adaptive Clustering Hierarchy – LEACH

LEACH processing has been divided into two different classes that are setup phase and steady state phase. In the setup phase nodes has been divided into different sub groups that are act as clusters and on basis of various parameters a node has elected as cluster head. Mainly cluster head selection has been done on the basis of residual energy and probability value of selection of cluster head. All the clusters members have been notified about the cluster head nodes that have been elected after every cycle has been done using broadcasting message. Nodes interconnect itself with the cluster head that is in the communication range of that particular node. In LEACH protocol it is assumed that all the nodes have sufficient energy for data transmission to base station. Computational power has been distributed to all the nodes so that MAC protocols can be easily supported for route detection and selection. Due to these parameters and assumption LEACH protocol [3] is not validated for large scale networks. One more assumption has been made under LEACH that all the nodes have data for transmission and nodes that are closer to each other contain correlated data.

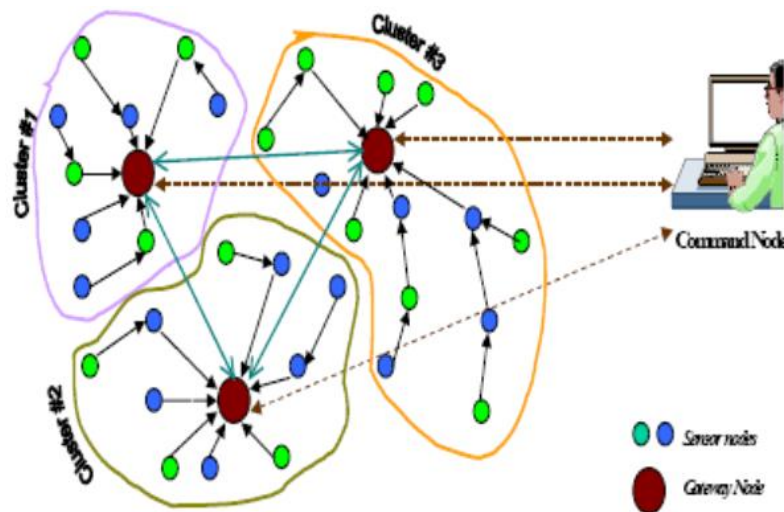


Figure 1 WSN Nodes and Cluster Formation [3]

To enhance the network lifetime and coverage in WSN LEACH use probability function for selection of a not to be cluster head. On the basis of probability value that has been computed for all the nodes using residual energy and location of the nodes selection of cluster head has been done. Nodes that having large value of probability has been selected as cluster head and these nodes leads to optimize energy consumption and provide reliable communication in WSN. CPCHSA algorithm has been used for selection of the nodes based on energy level that will die off first and their

sensing area has been affected due to nodes dead state. Network topology has to be changed on every instance when each node goes to die state that will affect the network sensing coverage. So clustering has been done again so that all the nodes have been covered after nodes that are dying. On the basis of this process cluster head selection has been done in such a manner so that all the nodes are covered in sensing area. This updating process consumes an amount of energy is setup phase that can be neglected for effective WSN.

1.3.3. Properties WSN clustering Protocols

- Dynamic Cluster division and cluster head Selection.
- Random cluster head selection each round with rotation.
- Cluster membership adaptive.
- Data aggregation at cluster head.
- Cluster head communicate directly with sink or user.
- Communication done with cluster head via TDMA.
- Communication done with cluster head via transmission modes.
- CDMA across clusters
- Data aggregation.

II. RELATED WORK

In WSN data communication has been done using various approaches that are related to communication. Line based routing, leader based routing, pegasus protocol, Cluster based routing[4] are mostly used approaches for data transmission. Cluster based routing protocols have proven to be energy efficient and LEACH is one of most popular cluster based routing protocol for WSN. But, LEACH suffers from several drawbacks such as possibility of choosing a low energy node as Cluster Head (CH), non-uniform distribution of CHs, etc. In this paper EiP-LEACH (Energy influenced Probability based LEACH)[5] protocol is proposed which is an enhanced version of LEACH protocol that is influenced by the energy parameter for CH selection. EiP-LEACH helps in deciding the better CH nodes and thereby contributes towards network life prolongation. In wireless sensor networks, the limitation of energy and cache space of nodes around the base station. To address this problem, a data collection mechanism by using mobile base station is proposed. Firstly, a new clustering algorithm-Time High-Overflow-Based Dominating (THD)[6] is proposed that the sensor network is divided into several clusters based on sample rate and cache of nodes. Secondly, temporary caching mechanism (TCM) is proposed to further resolve the buffer overflow problem. Finally, Dominating-Based Minimum Weighted Sum (DMWS) protocol is proposed in order to design the optimal path of the mobile base stations. Clustering is an efficient technique to minimize the energy consumption of the sensor nodes. But, the clustering algorithms for WSNs with a static sink frequently suffers from uneven energy consumption problems; where cluster heads (CHs) further away from sink consume more energy in a single hop communication[7], with the CHs sending its data directly to the sink. The proposed clustering algorithm, binds each sensor node with a CH via single or multi-hop communication, where a CH transmit its data packet to the sink when distance between them is minimal. A variety of wireless sensor network (WSN) applications have been proposed. However, the efficiency of WSNs, as well as their ability to interact with different environments, varies. In WSNs with Mobile Elements (MEs) [8], the task is first to find an effective way to minimize the length of the tour that the ME follows for data gathering. However, the minimized tour length should still offer access to all nodes in the networks for data collection from the sensor nodes. In this paper, we propose a protocol that results in a shorter ME tour length than previously proposed protocols, using closest rendezvous points (CRPs) distributed throughout the network. Sensor nodes are often clustered and cluster heads (CH) are used to route data to the BS. We have also reviewed constraints-based routing algorithms which select a routing path satisfying administrative-oriented or Quality of Service-oriented [9] (QoS-oriented) constraints. The algorithms minimize costs, balance network load, or increase security. The scope of wireless sensor network (WSN) optimization from single objective to multi objective optimization. It introduces a WSN's energy-aware and coverage preserve hierarchical clustering and routing model based on multi-objective bat

swarm optimization algorithm[10]. Two objectives are taken into consideration; coverage and nodes residual energies. The proposed model optimizes the WSN by selecting the best fitting set of nodes as cluster heads. It works to maximize the WSN's coverage and to minimize the nodes' consumed energy. This minimizes the number of active cluster heads while preserving a higher percentage of the covered nodes in WSN. It extends the longevity of the WSN's lifetime and achieves good functioning reliability.

III. PROPOSED WORK

Wireless sensor network is used for sensing information from the sensing environment that can be used for sensing information from the environment and transmit this information to base station for decision-making process in the purposed work WSN network has been deployed that utilizes energy for energy sensing, transmission, receiving information from the sensed environment. In the process of WSN the nodes have been deployed over the sensing region using the air deployment and base station has been established at a point. A signal has been transmitted from the base station to all the sensor nodes so that nodes can estimate the location of other sensor nodes as well as information about the location of the base station.

In this paper various approaches have been used for wireless network communication. These approaches are DEEC, Fuzzy based Routing and Energy influenced Leach protocol.

DEEC

DEEC is an energy efficient routing protocol that has been used for heterogeneous wireless sensor networks. In this protocol whole network has been divided into number of clusters. A cluster comprises a set of sensor nodes and a single cluster head. Cluster head has been selected on the basis of probability function. Probability function has computed the ratio of the residual energy of the node to average energy of the whole network. This value has been computed for all the nodes available in the cluster and the node having the high probability value than the other nodes has many chances to be elected as cluster head. After selection of the cluster head all the nodes sense the information and transmit this information to base station. After each completion of round residual energy of each node in a cluster has been computed and again probability to elect as a cluster head for the cluster nodes has been computed. After each successful completion of the round new cluster head has been elected and data transmission has been done.

LEACH

LEACH is the protocol that has been used in WSN for sensing and transmission of the information by using sensor nodes. LEACH is the dynamic clustering approach that has been used for cluster formation and selection of cluster head based on the probability function. In this type of cluster formation dynamic clustering based approach has been used that provide cluster to be re-established in each single round. Random probability value has been assigned to each node of the cluster that has been used for computation of ratio of the probability value to average energy of the network. On the basis of these values a node with high probability value has been elected as cluster head. All nodes available in the single cluster respond to cluster head and transfer all information to cluster head. Cluster head has been transmitted collected information to other cluster head or direct to base station, where this information has been processed for decision making process. Cluster head election has been done after completion of single round of communication for all nodes available in the network.

Fuzzy Based WSN

In this type of routing Fuzzy based rule based engine has been used that use input parameters for evaluation of the rules so that decision for data transmission can be made and energy consumption for data transmission can be reduced. In this various parameters have been evaluated for the process of route establishment for data transmission over the network. Cluster head Energy, Distance from CH to nodes, Distance between BS and Ch and Degree of CH has been given as input variable to FIS engine that use set of "if-else" rules so that decision for data transmission route can be established and used for communication process. Fuzzy based rule engine use various Neurons based rule manager for creation of

rules and on the basis of these rules fitness of each route from a cluster head has been evaluated. The route with maximum fitness has been used for communication.

EIP-LEACH

EIP-LEACH is the advanced version of the LEACH protocol. This is the energy influenced Protocol that has been used nodes residual energy with LEACH protocol to compute probability for selection of cluster head. The use of residual energy of the node for selection of cluster head confirms the low chances of a node with low amount of energy to be elected as cluster head for a cluster. If a node with low amount of energy in a cluster has been elected as CH then there must be chances of the CH to be in the state of dead state that causes loss of the information. So EIP-LEACH enhanced the performance of the WSN in terms of data transmission and network lifetime.

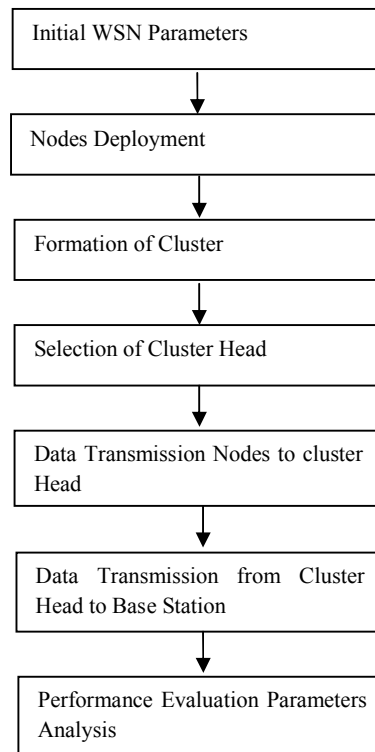


Figure 2 flow of proposed work

Flow chart represent in the figure 2 represents flow of the proposed work that must be carried out for achievement of desired objectives. In this flow various steps have been explained that must be followed by the user for development of congestion control wireless sensor network. On the basis of this scenario WSN initial parameters have been defined and on the basis of these parameters deployment of the nodes has been done.

Sensor nodes working module

In the purposed work wireless scenario has been designed by using different simulation parameters that have been used for sensing and transmitting information. Antenna, MAC, LL, QUEUE and routing protocol has been defined for generation of wireless sensor network scenario. After generation of wireless sensor network nodes have been deployed at different locations in the sensing area for sensing the information. These nodes have been provided a battery source for lifetime of the nodes so that data can be sensed and transmitted over the network to the base station.

Initialization of WSN

This is the first phase of WSN for sensing information from the environment. In this phase various parameters have been initialized for deployment of sensor nodes. In this phase area of sensing, nodes location, link layer type, queue

type, queue length and routing protocol has been defined. On the basis of these parameters network has been deployed over the network for sensing information from environment area.

Cluster Formation

In this phase clustering in WSN has been done to divide whole network into different clusters. In the process of clustering nodes has been divided into clusters on the basis of nodes properties. The total number of nodes available in the network has been divided into 5 different clusters that will transmit sensed information to base station.

Selection of cluster head

After division of system into different groups choices of cluster head have been done as such that nodes inside a cluster will transmit information to other head of group. Determination of group head has been done on the premise of vitality accessible to nodes in a system. Node that contains most extreme remaining energy in a solitary round has been chosen as a group head. Node accessible in the group that contains second most noteworthy residual energy in group has been chosen as a group head. Hubs lingering vitality after a round has been figured by characterized recipe.

Energy Calculation of Node

In WSN node have energy to sense information and transmit information from source to destination. The nodes available in network consume sensing, data aggregation, transmission and receiving energy.

E = Energy given to a node, E_r = Energy Dissipated in receiving data, E_t = Energy Dissipated in Transmission, E_{da} = Energy dissipated during data collection, E_{res} = Remaining Energy and D denotes the distance.

$$E_{res} = E - (E_r + E_t + E_{da}) * D^2 \quad (1)$$

If the nodes are note in the communication range, then the residual energy has been accounted on the basis of equation (2)

$$E_{res} = E - (E_r + E_t + E_{da}) * D^4 \quad (2)$$

After selection of cluster head and sub cluster head sensor nodes available in the network transmit data to cluster head or sub cluster head on the basis of distance. Nodes that are at minimum distance from sub cluster head than that of cluster head will transmit information to sub cluster head or vice versa.

Distance between two different node having position (x_1, y_1) and (x_2, y_2) has been computed using distance formula that works as follow

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (3)$$

On the basis of these energy and distance computation formulas energy of a single node and distance of a node from all the nodes have been computed and cluster head has been selected in the network so that reliable communication can be achieved.

IV. RESULTS

In the process of WSN various nodes have been utilized for sensing information and data transmission to base station for processing of sensed information. Nodes have been deployed in the region for sensing information so that information can be aggregated and used for transmission for meaning full purposes. In this processing of data transmission nodes have been empaneled with battery source to performance various operations. On the basis of these different operations nodes have been deployed over the network so that various parameters can be analyzed and performance for the proposed work can be measured.

Performance evaluation metrics

Network Lifetime

Network lifetime of the parameter that computes the total time network has been worked for the collection of the information from the non-approachable area. Due to nodes can't be recharged the whole energy available in a node can be utilized and node goes into the dead state. Network lifetime is measured in terms of no. of rounds. A round is computed as to be completed when each and every node available in the network has transmitted its collected information from the environment to base station. After completion of each single round new formation of the clusters

has been done and again data has been transmitted. As high number of rounds the network performs that makes it's a cost effective wireless network.

Network Stability Period

This is second parameter that has been observed in WSN to find the overall time in which whole network remain in stable mode. Stability has been measured that in which all the nodes that has been participated in the network has been in alive state. In a particular round when first node gets in dead state is known as the stability period of the network.

Throughput

Throughput is the parameter that has been evaluated on the basis of the total number of bytes that has been transmitted in particular interval of the time.

Packet Delivery Ratio

Packet delivery Ratio is the ratio of the total successfully delivered packets to the total number of packets transmitted over the network. These provide information about the loss of the information in transmission over the network.

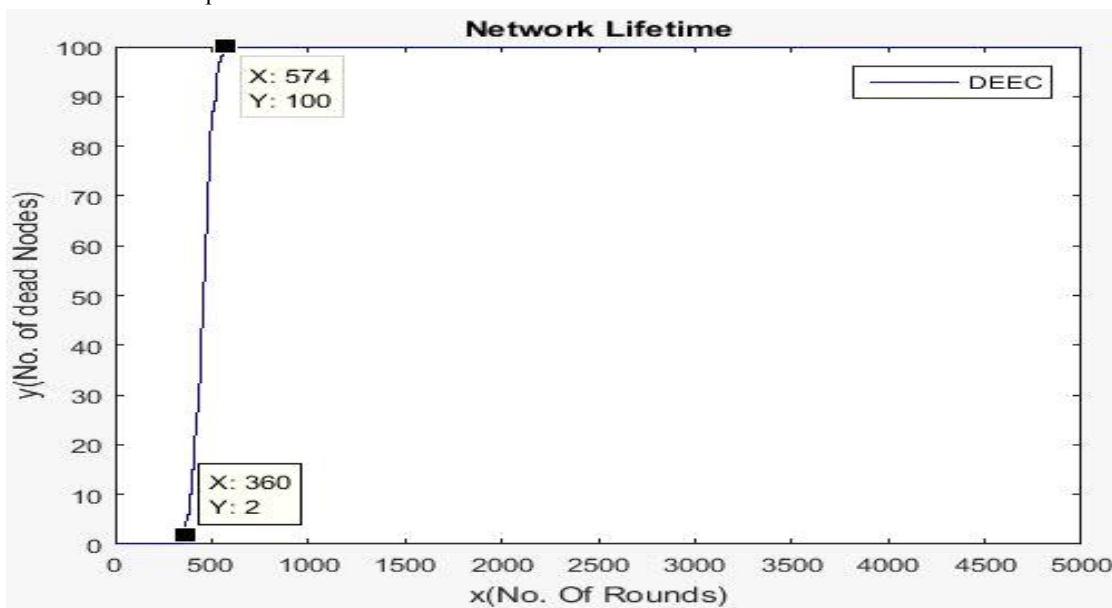


Figure 3 Network Lifetime Using DEEC

Figure 3 represents Network lifetime that has been simulated on the basis DEEC (Distributed Energy-Efficient Clustering) protocol has been represented. Nodes energy has been consumed in various purposes of sensing and data transmission. In the proposed work simulation has been done for 5000 rounds using 0.2 Joules of energy. This figure represents network lifetime of the network in terms of no. of round with no. of nodes that dead after completion of the round. Two data points has been highlighted on the figure 3 that denotes value for (x, y) coordinates on x-axis and y-axis. Data points marked on x-axis represents value of x-coordinate as 360 and y-coordinate as 2, that represents in the 360th round of the simulation 2 nodes has been gone into dead state and the network was stabled till 359th round. Where on the upper part x-coordinate represents the value as 574 and y-coordinate represents the value as 100, this represents that till 574th round of the network simulation all the 100 nodes available in the nodes lose their amount of energy and goes into dead state.

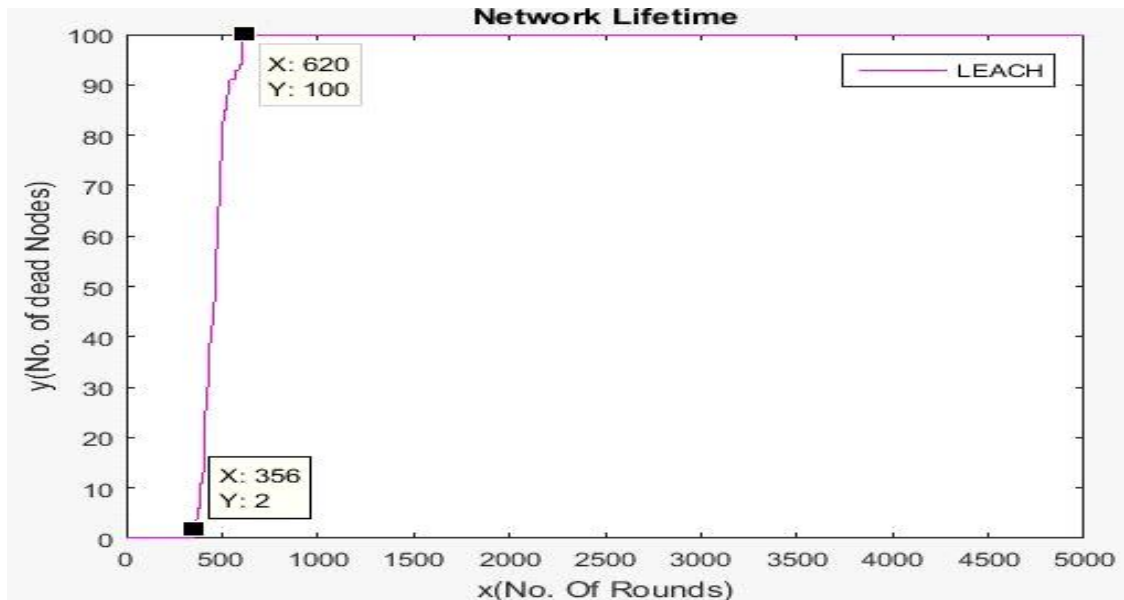


Figure 4 Network Lifetime Using LEACH

Figure 3 represents Network lifetime that has been simulated on the basis LEACH (Low Energy Adaptive Clustering Hierarchy) protocol has been represented. Nodes energy has been consumed in various purposes of sensing and data transmission. In the proposed work simulation has been done for 5000 rounds using 0.2 Joules of energy. LEACH protocol is based on dynamic clustering that enhances the network lifetime and makes it as cost effective. This figure represents network lifetime of the network in terms of no. of round with no. of nodes that dead after completion of the round. Two data points has been highlighted on the figure 4 that denotes value for (x, y) coordinates on x-axis and y-axis. Data points marked on x-axis represents value of x-coordinate as 356 and y-coordinate as 2, that represents in the 356th round of the simulation 2 nodes has been gone into dead state and the network was stabled till 355th round. Where on the upper part x-coordinate represents the value as 620 and y-coordinate represents the value as 100, this represents that till 620th round of the network simulation all the 100 nodes available in the nodes lose their amount of energy and goes into dead state.

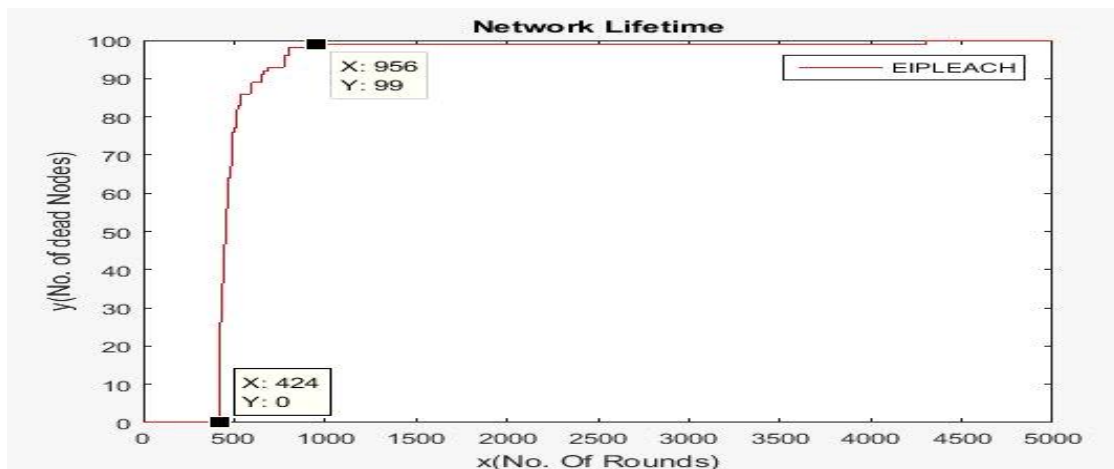


Figure 5 Network Lifetime Using EIP-LEACH

Figure 3 represents Network lifetime that has been simulated on the basis EIP-LEACH protocol has been represented. Nodes energy has been consumed in various purposes of sensing and data transmission. In the proposed work simulation has been done for 5000 rounds using 0.2 Joules of energy.

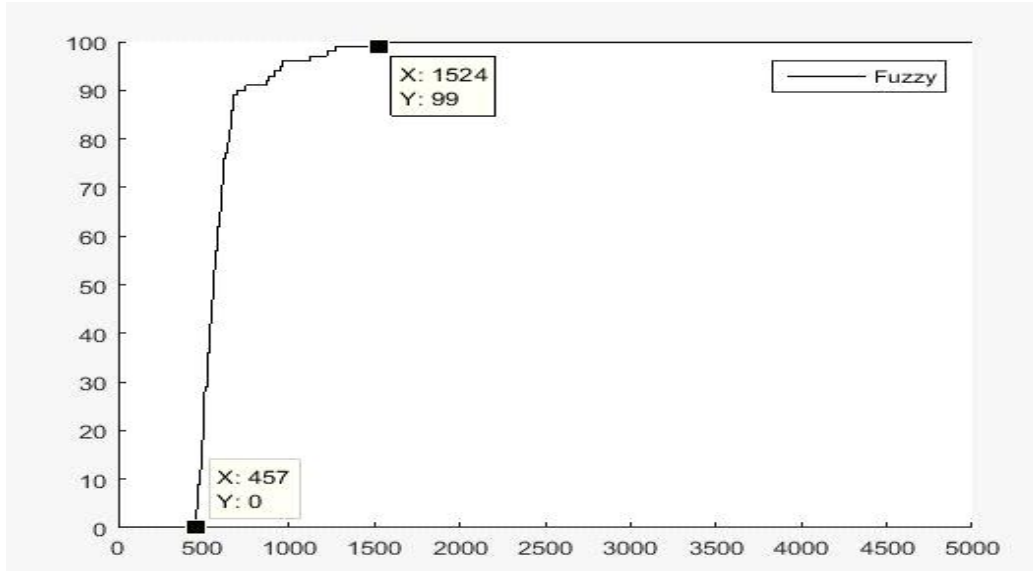


Figure 6 Network Lifetimes Using Fuzzy

Figure 6 represents Network lifetime that has been simulated on the basis FUZZY based protocol has been represented. Nodes energy has been consumed in various purposes of sensing and data transmission. In the proposed work simulation has been done for 5000 rounds using 0.2 Joules of energy. Fuzzy used a set of rules and rule based engine has been used the use various input variables and based on the variable output for selection of cluster head has been made that makes the network to be cost effective in terms of network lifetime and stable in terms of network stability period. This figure represents network lifetime of the network in terms of no. of round with no. of nodes that dead after completion of the round. Two data points has been highlighted on the figure 5 that denotes value for (x, y) coordinates on x-axis and y-axis. Data points marked on x-axis represents value of x-coordinate as 457 and y-coordinate as 0, that represents in the 458th round of the simulation first nodes has been gone into dead state and the network was stabled till 457th round. Where on the upper part x-coordinate represents the value as 1524 and y-coordinate represents the value as 100, this represents that till 1524th round of the network simulation all the 100 nodes available in the nodes lose their amount of energy and goes into dead state.

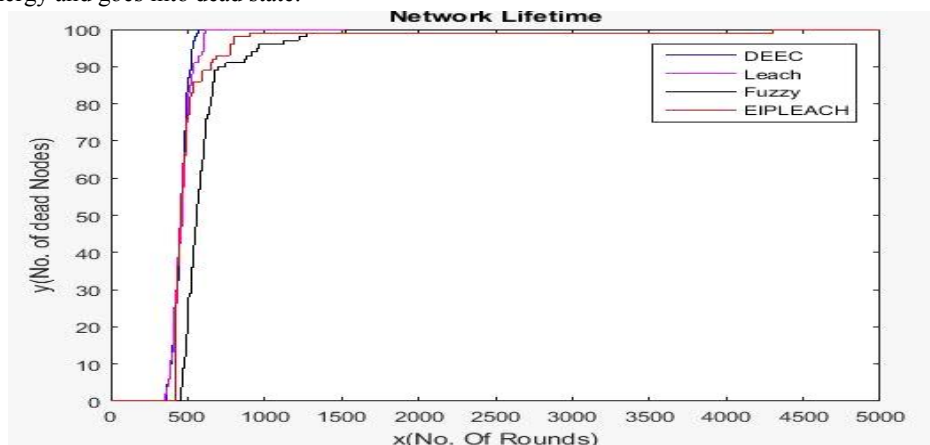


Figure 7 Network Lifetime Based Various Approaches

Figure 7 represents Network lifetime that has been simulated on the basis of different approaches has been represented in the proposed work. Nodes energy has been consumed in various purposes of sensing and data transmission. In the proposed work simulation has been done for 5000 rounds using 0.2 Joules of energy. In this proposed work proposed method has been compared with leach, DEEC, LEACH, EIPLEACH and fuzzy based WSN. On the basis of network lifetime parameter comparison Fuzzy based approach provides better network lifetime over the other approaches. This has been presented that DEEC, LEACH, EIPLEACH and Fuzzy has been stable for 359 rounds, 355 rounds, 424 rounds and 457 rounds respectively. Whereas in the proposed protocol network lifetime is goes over 5000 rounds.

Table 1 Performance Chart

Parameters	DEEC	LEACH	EIP-LEACH	FUZZY
Stability Period (In Rounds)	359	355	424	457
Network Lifetime (In Rounds)	574	620	956	1524
Packet Delivery Ratio	67%	70%	76%	81%

V. CONCLUSION

In the latest researches various approaches had been proposed for energy conservation in wireless sensor network so that network can be utilized for maximum lifetime. In this process chain based routing, cluster based routing and rendezvous point based routing had been initialized. In the proposed work wireless sensor network has been used for minimize energy consumption and avoid congestion over the network so that data loss to be minimum. To avoid congestion in WSN dynamic clustering based approach has been utilized that computes cluster head dynamically on the basis of energy available at a particular node. In the proposed work cluster head selection has been done so that data can be divided and avoid the congestion occurred in the network. On the basis of dynamic clustering the major advantages is that network each node has the chance to be a cluster head and whole energy of all the nodes consumed in predict manner. By analyzing the above defined results in WSN one can conclude that fuzzy rule based WSN used for sensing information provides better results as compare to existing approaches that are DEEC, LEACH and EIPLEACH

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