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Energy Efficient LEACH by Threshold: Wireless Sensor Network

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Abstract: ***Wireless sensor nodes are a popular resolution when it is hard or impossible to operate a mains supply to the sensor node. Therefore, because the wireless sensor node is frequently placed in location that is out of reach, to alter the battery frequently can be expensive and inconvenient. An important point in the growth of a wireless sensor node is guarantee that there is always sufficient energy accessible to power the system. Low Energy Adaptive Clustering Hierarchy ("LEACH") is a protocol based on TDMA- MAC protocol which is linked with clustering and a uncomplicated routing protocol in wireless sensor networks (WSNs). The aim of LEACH is to lesser the energy utilization needed to create and preserve clusters for improving the life time of a wireless sensor network. Proposed work will work on energy used in packet delivery, Packet Delivery Ratio and Packet Drop.***

I. INTRODUCTION

The simple equation on which wireless sensor networks is based is as follows:

Sensing + Processor machine + Radio = Millions of potential applications

There is a vast exponential growth in Wireless communications continue in the area of cellular telephony, wireless internet, and ground of wireless home networking. Development in wireless communication made it achievable to extend wireless sensor networks (WSN) that consists of small devices, which collect data by assisting each other. All these tiny devices that can sense are called nodes and contain CPU for processing of data, use memory for storing data and battery for consumption of energy and also for transmitting and receiving data from one point to another they make use of transceiver. There are different sizes of sensor nodes for different applications. For instance, in some armed or inspection applications it might be microscopically small. Its price based on its parameters like memory size, processing speed and battery [1].

As with traditional wireless devices, there is no need in wireless sensor nodes to communicate straightly with the closest high-power control tower or pedestal station, except with their neighboring peers. As an alternative, of trusting on a pre-deployed infrastructure, every individual sensor or actuator develops into part of the overall infrastructure. Mesh-like interconnect is possible through Peer-to-peer networking protocols that transport data between the number of tiny entrenched devices in a multi-hop fashion. The supple mesh architectures imagined dynamically adapt to maintain introduction of new nodes or enlarge to wrap a larger geographic region. In addition, the system can automatically change to recompense for node failures [2].

Features of Wireless Sensor Networks

» It builds a connection between the actual physical and virtual worlds

» It permits the skill to watch the previously unobservable with a very well resolution over large patio-temporal scales.

» It consists of a wide range of talented applications for production, science, transportation, civil road and rail network, and safety [3].

The Wireless Applications can also be summarized as follows:-

» Monitoring of Habitat and Ecology

» Seismic Monitoring

» Monitoring of health of Civil Structural

» Monitoring of Groundwater Contagion

» Quick Emergency Reply

» Industrial development Monitoring

» Edge Security and Observation

» Managing of Automatic Building Climate

II. Low Energy Adaptive Clustering Hierarchy- Leach

W.R.Heinzelman, proposed a hierarchical clustering algorithm for wireless sensor networks, called Low Energy Adaptive Cluster Hierarchy protocol (LEACH) which is one of the popular hierarchical routing algorithm. The plan is to group of the sensor nodes based on the accepted signal force and use local group heads (CHs) as routers to the sink. This will accumulate energy because the transmissions will only be done by CHs instead of all sensor nodes. Optimal number of CHs is probable to be 5% of the total number of nodes. All the processing of data such as data union and aggregation are local to the cluster. CHs modify randomly over time for balancing the energy dissipation of nodes[4] .There are various key features of LEACH are:

» Coordinated locally and manage for cluster set-up and operation.

» Cluster"base stations" or" Cluster-heads" rotated randomly and the Corresponding clusters.

» Local firmness to reduce global communication.

In LEACH, the procedure is separated into fixed-length rounds, everywhere each round starts with a setup phase after that a steady-state phase. LEACH is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station (sink). Each node uses a stochastic algorithm at each round to determine whether it will become a cluster head in this round. LEACH assumes that each node has a radio powerful enough to directly reach the base station or the nearest cluster head, but that using this radio at full power all the time would waste energy.

Nodes that have been cluster heads cannot become cluster heads again for P rounds, where P is the desired percentage of cluster heads. Thereafter, each node has a 1/Probability of becoming a cluster head in each round. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data.

All nodes that are not cluster heads only communicate with the cluster head in a TDMA fashion, according to the schedule created by the cluster head. They do so using the minimum energy needed to reach the cluster head, and only need to keep their radios on during their time slot.

III. Various Energy Efficient LEACHs Techniques

Wireless sensor networks (WSNs) have transformed many sections of our economy as well as our existences. A variety of present devices need sensory data from the actual world around them. This data is offered by WSNs, which contains of quite a few tiny sensor nodes. Different routing protocols rule the association of this data. Energy efficiency is one of the main plan

goal for these sensor networks. Low-Energy Adaptive Clustering Hierarchy (LEACH) is defined as a classical cluster based routing protocol for WSNs that offers good performance. Here in this section we have presented different variants of LEACH that has proposed different routing protocols for WSNs and emphasize their features

LEACH-C – LEACH-C version of LEACH protocol is an upgraded protocol over the LEACH protocol. This protocol utilizes the central clustering algorithm, and the phase named as steady-state that is used by LEACH. In this protocol every node transmits their current location data and remaining energy level to the sink [4]. As applying the central control algorithm to structure the clusters may generate better clusters by scattering the cluster head nodes all through the network. This is the main aim for LEACH-centralized (LEACH-C), a protocol that makes use of a centralized clustering algorithm and the similar steady-state protocol as LEACH. Through the set-up phase of LEACH-C, every node transmits information about its present location (to the receiver) and energy level to the Base Station. Also to find good clusters, the Base Station needs to make sure that the energy load is consistently distributed amongst all the nodes. For this, the Base Station evaluates the average node energy, and either nodes have energy under this average can't be cluster heads for the present round. By means of the left over nodes as possible cluster heads, the Base Station discovers clusters with the help of simulated annealing algorithm to resolve the NP-hard problem of discovering optimal clusters. This algorithm efforts to lessen the quantity of energy for the non-cluster head nodes to broadcast their data to the cluster head, by reducing the total sum of four-sided figure distances among all the non-cluster head nodes and the closest cluster head[7].

LEACH-E - LEACH-E protocol named as Energy LEACH is the version of LEACH protocol where the selection of cluster head is based on the remaining energy level of the nodes. The remaining energy level chooses that whether the node will develop into a cluster head or not after the first step. Here all nodes have equal chances to become the cluster head in the first round. The outstanding energy level in the second step is dissimilar for each node since the first step communication. In this protocol the nodes that have a additional energy level will develop into the cluster head relatively than the nodes having low energy level. Thus, this protocol gets better the cluster head selection method. The difficulty with LEACH protocol may happen when the cluster head is at distant from the base station. The cluster head that is distant from base station need more energy to transfer the data to the base station and thus it will die soon [4]. Energy-LEACH protocol enhances the CH choice procedure. It makes remaining energy of node as the major metric that selects whether the nodes will become CH or not after the first step. Similar to LEACH protocol, E-LEACH is partitioned into rounds, where the first round, every node has the same chances to become CH, that signify nodes are arbitrarily selected as CHs, in the another rounds, the left over energy of each node is diverse after first round communication and taken into explanation for choosing the CHs. That indicate nodes have extra energy will become a CHs instead of nodes with less energy [6].

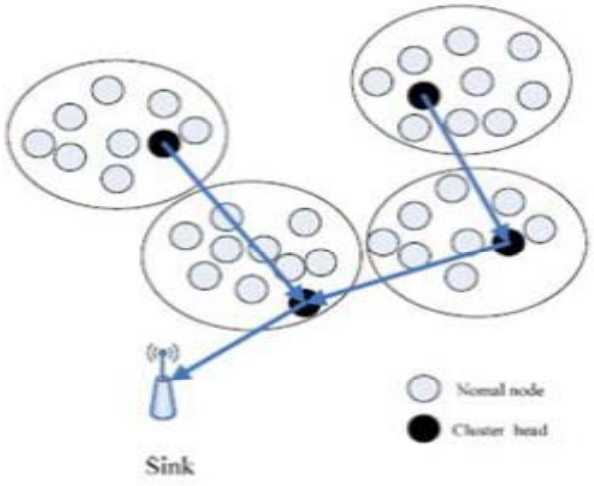


Figure 1: Structure of LEACH-E .Adapted from [7]

LEACH-H

LEACH-H stands for Hybrid Cluster Head Selection Leach and was given to defeat the defect of short endurance time and low degree of balancing the load in case of LEACH. It utilizes the benefits of LEACH and LEACH-C. Cluster head is chosen in the first round by base station in LEACH-H, which efficiently solves the problem that the number of cluster head is undecided in LEACH. In the other steps , the new cluster head utilized in the next round is chosen in their own cluster by the present cluster head in LEACH-H, which solves the matter of the reliance on the base station in LEACH-C.[8] If the cluster head is distant from base station then it may need large amount of energy to send the data to base station.

M-LEACH

M-LEACH stands for Multihop-LEACH protocol. This can be used for the cluster head that is far from base station and require large energy. It works by altering the transmission mode among cluster heads and base station from solitary hop to multi hop. This protocol selects the best potential path among the cluster head and base station by applying the other cluster heads as transmit stations to send data to base station. [8] The cluster head, in LEACH protocol is liable for receiving data from cluster members, synthesis of received data and then transmit it to the base station. If base station is distant from cluster head then cluster head will expire soon on comparing to other nodes since the energy will disperse in getting and forwarding of the data. If the cluster head expires then the data composed by the cluster head will never achieve by the base station and so the cluster will become useless. LEACH-M is been planned to conquer from the mobility matter which is a significant issue in LEACH protocol. Throughout the setup and steady state phase, LEACH-M offers mobility to the non-Cluster Head nodes all along with Cluster Head. In LEACH-M the nodes' position presumed to be increase by the GPS process along with the uniqueness of the nodes to be predicted to be uniform. The CHs are being selected on the basis of least mobility of the node and lowly reduction mode of the node. After this procedure the position of the CHs are being transmitted inside its transmission range [9]. When the network diameter is enlarged after a certain level, the displacement between the CHs and the sink node would get amplified and this is drawback of the LEACH protocol. This can be conquer with the help of MLEACH where the Cluster Head transmits the data to the sink using the other Cluster Heads as relay stations. M-LEACH is a complete dispersed clustered based routing protocol. The method can be used inside or outside the clusters.

IV. LITERATURE REVIEW

Much work has been contributed towards the LEACH protocol to improve the energy efficiency in wireless sensor networks. It is observed that there are some drawbacks in wireless sensor networks due to nodes improper energy efficiency. Therefore the LEACH protocol was suggested that has improved energy efficiency problem up to much great level. Along with this others have also proposed the variants of LEACH protocol that offers better performance than LEACH itself. Following are the some contributions of researchers that have worked towards wireless sensor networks and LEACH protocol.

Jiang et.al [1]," An Energy Balanced Algorithm of LEACH Protocol in WSN" discussed about wireless sensor networks (WSNs).They analyzed that in wireless sensor networks, because of the inadequacy of nodes' energy, energy effectiveness is a significant factor should be measured when the protocols are designing. As a usual nomination of hierarchical routing protocols, LEACH Protocol has a vital role. In reply to the not smooth energy allocation that is caused by the arbitrariness of cluster heads creation , their work suggested a new enhanced algorithm of LEACH protocol (LEACH-TLCH) that is proposed to balance the energy utilization of the entire network and expand the life of the network . The proposed algorithm is imitated by Matlab simulation platform; the simulation effects specify that both energy effectiveness and the life span of the network are far better than that of LEACH Protocol. They also stated that by choosing cluster head arbitrarily in LEACH protocol roots that the present energy of some cluster heads are fewer or their distances to source station are far, since the heavy energy weight, these cluster heads will soon expire. For this matter, they have proposed a new improved algorithm of LEACH protocol that aims at

balancing energy utilization of the whole network and expanding the network life span by balancing the energy utilization of these cluster heads.

Ralhan.R et.al, [2]" Review on Various LEACH Variants" discussed that because of insufficient battery of sensor nodes energy efficiency is the strongest point to consider in wireless sensor networks. As no substitute and charging are presented for sensor nodes, so use them in optimized manner has open explore for sensor researchers. Therefore they have discussed about the most efficient variants of LEACH protocol and conclude that from all of them Ant Colony Optimization that is based on energy efficient protocols have capable results.

Afsar et.al, [11] "A Performance and Comparative Analysis of LEACH- its Variants and Different Matrices" discussed that wireless sensor networks are restrained forced related to energy resources and thus they need efficient energy management during compilation , processing , aggregation, communication and ultimate operation of sensor's data in numerous modified applications associated to healthcare, cluster and home monitoring, security and inspection etc. They have discussed in their paper about hierarchal efficient clustering protocol and compared it on various factors for e.g lifespan of network, initial nodes energy effect and node density of network lifespan.

Poonam Shrivastava et al, [3]" Analysis of LEACH and Its Variants for Routing in Wireless Sensor Networks",discussed about LEACH protocol and how it is implemented in wireless sensor networks. They noticed that there are many devices that require sensory data from the real world which is supplied by WSN and energy efficiency is the main concern for sensor networks. Thus LEACH(Low –Energy adaptive clustering hierarchy) which is known as routing protocol for wireless sensor networks provide good results in terms of efficient energy. In their work they have analyzed LEACH performance on various factors such as energy, throughput and lifetime with the help of network simulator-2

Bakaraniya et.al, [10] " K-LEACH: An improved LEACH Protocol for Lifetime Improvement in WSN",discussed that wireless sensor network is a large group of sensor nodes and thus they are more sensitive to energy consumption as compared to wireless networks. Therefore in their study they have proposed a new algorithm for LEACH protocol known as Kmedoids-LEACH(K-LEACH) and its main aim to extend the lifespan of wireless sensor networks by balancing the energy utilization of the nodes,They have compared the results of LEACH and K-LEACH using simulation and conclude that K-LEACH gives better performance than LEACH.

V. PROPOSED WORK

In this section we are discussing the proposed work called, Energy Efficient LEACH by Threshold method. The architecture of the proposed work is shown in fig 2.

According to the proposed work EE-LEACH-T, method will select only those nodes into the consideration of Cluster head which energy level is higher than 10 Joule. Through this concept we can design a network which is not stable as compare to base LEACH work.

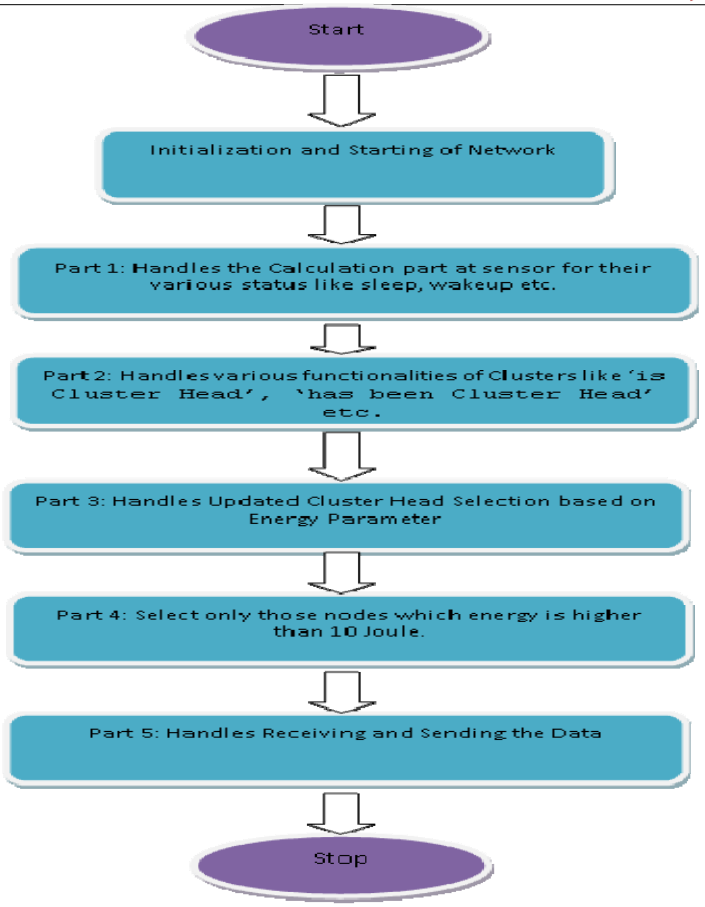


Fig 2: Architecture of EE-LEACH-T

Proposed algorithm is discuss in fig 3, which is as shown below.

```
//LEACH Application
        Step 1: Function mutargs {} {...}
        Step 2:  Function start {} {...}
// Helper Functions
        Step 3: Function getRandomNumber {} {...}
        Step 4: Function node {} {...}
        Step 5: Function nodeID {} {...}
        Step 6: Function mac {} {...}
        Step 7: Function getX {} {...}
        Step 8: Function getY {} {...}
        Step 9: Function getER {} {...}
        Step 10:FunctionGoToSleep {} {
        Step 11: Function WakeUp {} {
        Step 12: Function setCode code {} {...}
        Step 13: Function checkAlive {} {}
// Cluster Head Functions
        Step 14: Function isClusterHead? {} {...}
        Step 15: Function hasbeenClusterHead? {} {...}
        Step 16: Function hasnotbeenClusterHead {} {...}
        Step 17: Function setClusterHead {} {...}
        Step18: Function unsetClusterHead {} {...}
// Distributed Cluster Set-up Functions
        Step 20:FunctiondecideClusterHead {} {}
        Step 21: Function advertiseClusterHead {} { }
        Step 22: FunctionfindBestCluster {} { }
        Step 23: Function informClusterHead {} {}
        Step 24: FunctioncreateSchedule {} {}
// Receiving Functions
        Step 25: Function recv { } {...}
        Step 26: Function recvADV_CH { } {...}
        Step 27: Function recvJOIN_REQ { } {...}
        Step 28: Function recvADV_SCH { } { }
        Step 29: Function recvDATA { } { }
// Sending Functions
        Step 30: FunctionsendData {} {}
        Step 31: Function send {} {}
        Step 32: Function send_now {} {  }
        Step 33: FunctionSendDataToBS {} {  }
```

Fig 3: Algorithm of EE-LEACH-T

VI. SIMULATION

Simulation setup is used for modeling and analyzing the performances of network.

Modeling Wireless Network in Network Simulator (NS)

It is preferred method for deployment WLAN, MANET or custom Wireless Technology based coding methods. This method helps to build configure and deploy wireless network segments efficiently. Scenarios are designed with 100 nodes for analysis of developed algorithm (**Energy Efficient LEACH with Threshold**).

For doing analysis following parameters;

1. Energy Used in Sending Packets,
2. Packet Delivery Ratio,
3. Packet Drop

Are taken into the consideration in this dissertation. These Scenarios are designed on the bases of following parameters.

Table 1 Criteria for network designing

Simulation Time	500 seconds
Protocol	LEACH and Energy Efficient LEACH with Threshold
Area:	800 x600
Traffic	TCP/FTP
Channel	Wireless
Operation mode	MAC_802.11
Mobility	Random waypoint
Antenna	Omni directional
IFQ	Queue/DropTail/PriQueue
Nodes	100
IFQLEN	5

On the bases of table 1 network scenario is designed with 100 nodes. These Scenarios will help to see the performances of both the algorithms Original LEACH and Energy Efficient LEACH with Threshold on the bases of three parameters Energy Used in Sending Packets, Packet Delivery Ratio and Packet Drop. And by the performances of algorithm some results will drawn out. These Scenarios are designed using Network Simulator 2.34.

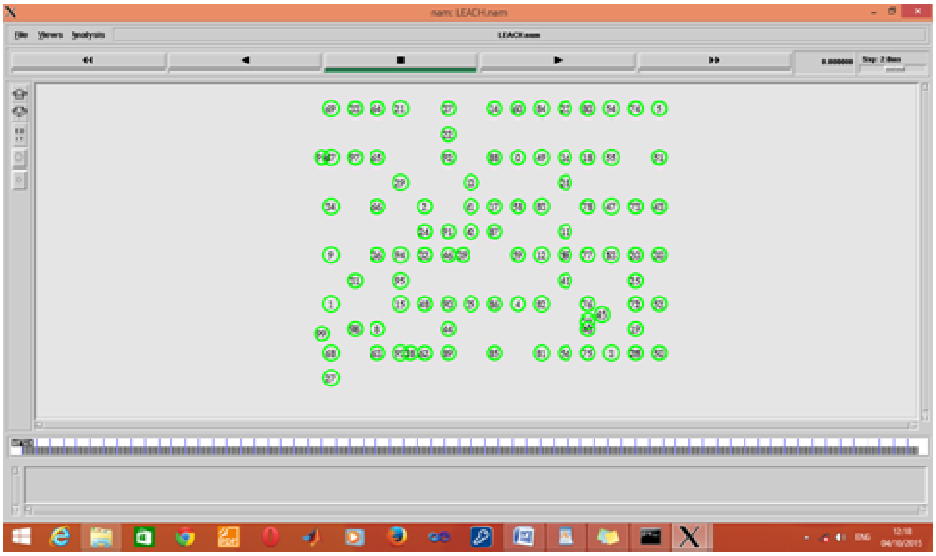


Figure 4: Scenario with 100 nodes in the network

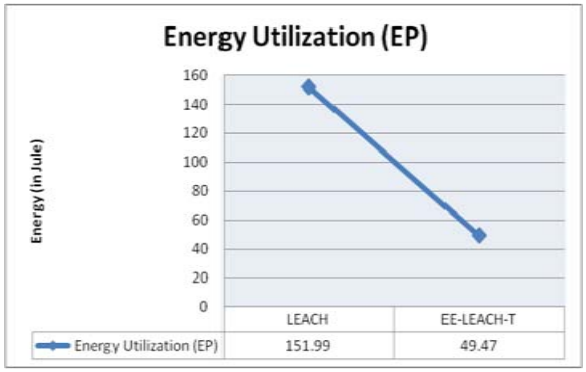
Figure 4 is showing network with 100 nodes. The network is designed on the basis of Table 4. Location of mobile nodes will be random. The movement of the nodes will within the designed scenario area.

In this dissertation, a fixed area of 800 x 600 meters is taken to deploy number of mobile nodes. Mobile nodes has wireless device to establish connection among those nodes we need wireless channel. Mobile nodes have random mobility. Operational mode is 802.11, which is selected in this network with fixed simulation time. TCP/FTP is taken which is used to send variable size of packets with fixed interval with each packet.

VII. Result Analysis

7.1 ENERGY USED IN SENDING PACKETS

Energy used is energy of the each and every node cumulative, which is used in sending the data among various nodes.



7.2 PACKET DELIVERY RATIO (PDR)

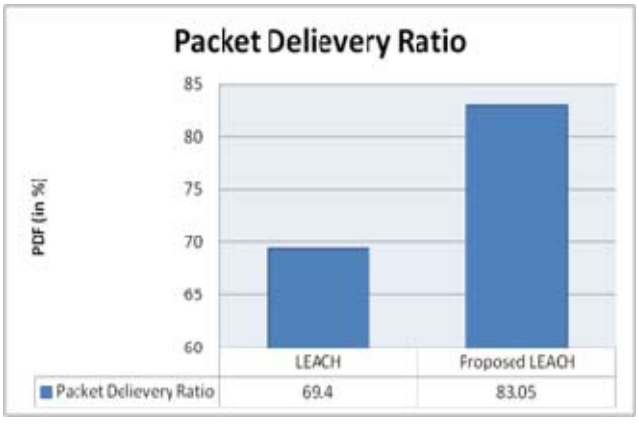
PDR is a parameter which is used for analysis the performance of algorithms in network. It is the ratio of successful packet received at destination to the packet send from source to Destination.

Table 2: Shows the Packet Delivery Ratio with respect to various number of paths and Packet Size for 100 nodes Scenario by LEACH and Energy Efficient LEACH with Threshold (EE-LEACH-T)

LEACH	Proposed LEACH	% Of Improvement
69.40	83.05	19.67%

Table 2 Shows the Packet Delivery Ratio with respect to various Packet Size for 100 nodes Scenario by LEACH and **Energy Efficient LEACH with Threshold (EE-LEACH-T).**

Simulation was done on scenarios of network 100 nodes on standard LEACH and improved **Energy Efficient LEACH with Threshold (EE-LEACH-T)** the data is shown in table 4.4 for the parameter Packet Delivery Ratio (PDR). At the same time table 2 where the comparison is done between LEACH best performance with **Energy Efficient LEACH with Threshold (EE-LEACH-T)** method's best performance.



Graph 2: Improvement in Packet Delivery Ratio with 100 nodes of **Energy Efficient LEACH with Threshold (EE-LEACH-T) as compare to LEACH**

7.3 PACKET DROP

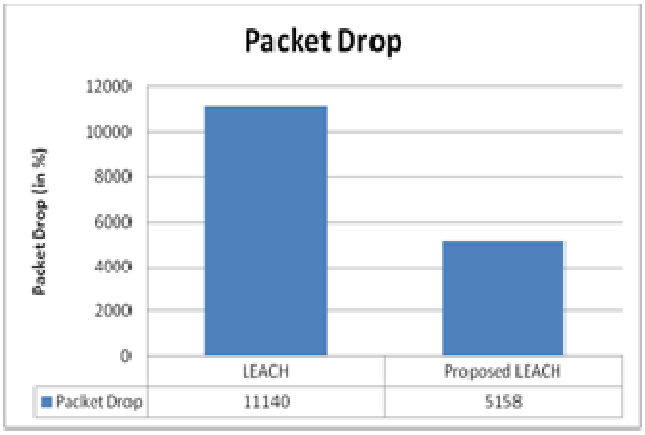
Packet drop has become a vital role of withdrawing the performance of tiny network and also it is not predictable. For any routing algorithm, packet drop should be less to give better performance.

Table 3: Packet Drop with 100 nodes network for LEACH & Energy Efficient LEACH with

LEACH	Proposed LEACH	% Of Improvement
11140	5158	53.7%

Table 3 shows packet Drop with 100 nodes network for LEACH & Energy Efficient LEACH with Threshold.

For the parameter Packet Drop a Simulation has been done on scenario of network 100 nodes on standard LEACH and Energy Efficient LEACH with Threshold (EE-LEACH-T) the data is shown in table 3. It also shows percentage enhancement has been calculated on each speed and further improvement is shown in the scenario.



Graph 3: Improvement in Packet Drop factor shows lesser no of packet dropped with 100 nodes

Graph 3 is the graphical representation of throughput of 100 nodes network. This graph shows the performance of LEACH and Energy Efficient LEACH with Threshold with 100 nodes network. An analysis by seen this graph can be drawn that Energy Efficient LEACH with Threshold provides efficient Lesser number of Packet Drop than standard LEACH algorithm.

VIII. CONCLUSION

This work has details of implementation of developed methodology. In addition, networks are developed with 100 nodes using discrete event based simulator Network Simulator 2.34. And for analyzing the performances of both the algorithm LEACH and proposed work, Energy Efficient LEACH with Threshold, is done on the bases of Table 1 ,2 and 3 on two parameters like Energy Used in Sending packets, Packet Delivery Ratio (PDR), Packet Drop and Routing Load.

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