# FUZZY BASED ENERGY EFFICIENT FOR I-LEACH PROTOCOL FOR IOT APPLICATION

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**Abstract:** Wireless sensor network comprises vast number of little, less energy, minimal effort sensing nodes with restricted memory, computational, and correspondence assets and a BS. These nodes consistently screen ecological surroundings, gather full data about the environmental condition in which they are introduced, and at that point transmits the gathered information to the BS. The BS has an expansive repository and huge information handling abilities. It paths the information it gets from sensing nodes to the server from where end-client can get to them. The idea of data is inalienably associated with idea of vulnerability. The most basic part with the association is vulnerability engaged with any critical thinking circumstance is a consequence of few data insufficiency that might be inadequate, loose, not completely dependable, dubious, opposing, or insufficient in some other way. Vulnerability might be seen as a property of data. The basic structure of fuzzy thinking permits taking care of quite a bit of this vulnerability and fuzzy frameworks can utilize type-1 fuzzy sets, which speak to vulnerability by numbers in the range. The proposed system has been more efficient compared to the base technique. The performance has been compared on various parameters like, Throughput, Dead nodes, Alive nodes etc. in all the parameters it is performing better compare to I-Leach technique.

**Keywords : WSN, Leach, Cluster, Fuzzy, Base Station**

## I. INTRODUCTION

### 1.1 Wireless Sensor Networks

Wireless sensor network comprises vast number of little, less energy, minimal effort sensing nodes with restricted memory, computational, and correspondence assets and a BS. These nodes consistently screen ecological surroundings, gather full data about the environmental condition in which they are introduced, and at that point transmits the gathered information to the BS. The BS has an expansive repository and huge information handling abilities. It paths the information it gets from sensing nodes to the server from where end-client can get to them [1].

WSN has leverage of being worked unattended in nature where nonstop human observing is unsafe, wasteful or unusable. Sensor nodes keep running on batteries and as the nodes are conveyed their batteries can't be revived, thus have small life expectancy.

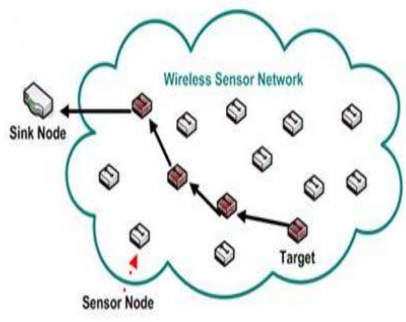


Fig.1 Wireless network containing sensor nodes [2]

There are various uses of WSN that includes environment applications and health applications like forest fire detection in perspective of temperature information it gets from considerable number of dispersed sensing nodes, landslide detection, following and checking specialists and patients, and natural disaster [2]. They are also applied in military applications like zone observation, fight harm evaluation, and so forth [3]. Home applications include home automation, smart environments.

### 1.2 Hierarchical Clustering

Hierarchical based routing is a two level routing where choosing the cluster heads in WSNs is the main level and second level includes the information transfer from sensor hubs to a BS by means of cluster heads. A broad number of groups will cover zone with minimal size bunches and few number of bunches will drain the group head with huge measure of messages to be transmitted from group individuals. To accomplish network scalability, high vitality efficiency and drag out system lifetime in substantial scale wireless sensor networks, sensor nodes are frequently gathered into non-covering groups called clustering process in wireless sensor networks [9].

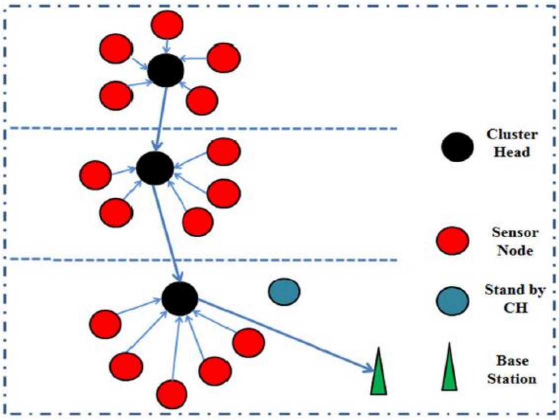


Fig.2 Hierarchical clustering in WSN [10]

### 1.3 Fuzzy Type-2 Logic Systems

The idea of data is inalienably associated with idea of vulnerability. The most basic part with the association is vulnerability engaged with any critical thinking circumstance is a consequence of few data insufficiency that might be inadequate, loose, not completely dependable, dubious, opposing, or insufficient in some other way. Vulnerability might be seen as a property of data. The basic structure of fuzzy thinking permits taking care of quite a bit of this vulnerability and fuzzy frameworks can utilize type-1 fuzzy sets, which speak to vulnerability by numbers in the range [0, 1]. At the point an element is indeterminate, it becomes hard to decide its correct membership value, and obviously type-1 fuzzy sets bode well. In any case, it isn't sensible utilizing exact membership function for something that is not certain, so for the situation we is required is other kind of fuzzy sets, those that can deal with these vulnerabilities, the supposed type-2 fuzzy sets . The measure of vulnerability in a framework can be diminished by utilizing type-2 fuzzy logic since this logic provides good capacities to deal with linguistic vulnerabilities demonstrating unclearness and inconsistency of data [12].

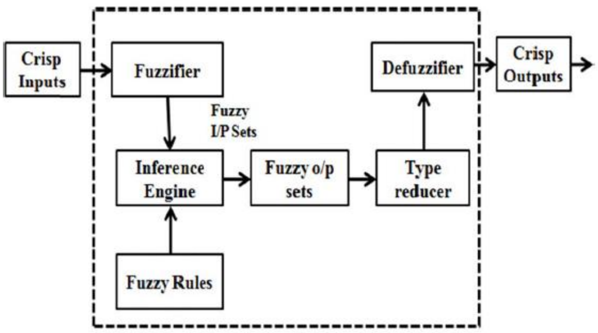


Fig.3 Type-2 fuzzy inference mechanism [10]

1. Fuzzifier- In the Fuzzifier block the fuzzy sets are generated from crisp inputs since it is fuzzy sets and not numbers that initiate the standards which are depicted as far as fuzzy sets and not numbers. Three sorts of fuzzifiers are conceivable in an interval type-2 fuzzy logic system. At the point when estimations are:
   - Perfect, they are displayed as a crisp set;
   - Noisy, yet the commotion is stationary, they are demonstrated as a type-1 fuzzy set
   - Noisy, yet the commotion is non-stationary, they are demonstrated as an interval type-2 fuzzy set.
2. Rules- Standards, that are either given by subject specialists or are extricated from numerical information, are communicated as a collection of IF-THEN explanations.
3. Inference-The Inference block maps resulting input fuzzy sets into output fuzzy sets after estimations are fuzzified. This is refined by first measuring each rule using fuzzy set theory, and by then utilizing the arithmetic of fuzzy sets to build up the yield of each rule, with the assistance of an inference system. In the event that there are M rules then the fuzzy input sets to the Inference block will initiate just a subset of those rules, where the subset contains no less than one rule and usually way less than M rules. Thus, at the yield of the Inference block, there will be at least one fired-rule fuzzy output sets.
4. Type reducer- The type reducer produces a type-1 fuzzy set output, which is then changed over in a numeric yield through running the defuzzifier.

Defuzzifier- The defuzzified output is just the average of the two end-points of this interval. Because a type-reduced set of an interval type-2 fuzzy set is always a finite interval of numbers

## II. LITERATURE SURVEY

In [15] Nayak et al. proposed an efficient technique for selecting cluster head from each cluster. The whole sensor network field is divided into levels i.e. number of clusters of equal sizes such that all these clusters are numbered sequentially. Theses cluster heads were selected based on type-2 fuzzy logic. Type-2 fuzzy logic is a decision making algorithm that handles uncertainties way better than type-1 fuzzy logic. This technique was proposed to overcome the burden on cluster head so that with this technique an efficient cluster head could be selected. Remaining energy, distance to the base station and concentration were the three fuzzy descriptors that were considered for cluster head selection. Based on these three parameters an efficient cluster head is selected from each cluster. The cluster head from first cluster will send the aggregated data to the cluster head of second cluster and so on till the last level. The cluster head of the last level will send the data to the base station. A stand by cluster head is used in case of cluster head failure as well as multi hop communication was made. It was observed that type-2 fuzzy logic provided more scalability and improved network lifetime as compared to leach and type-1 fuzzy logic.

An efficient cluster head selection technique was proposed by Pal et al. in [2]. The fuzzy logic concept has been used for selecting the super cluster head. In this work three fuzzy descriptors such as remaining energy, concentration and mobility of the base station have been used for selecting the super cluster head. A super cluster head is the cluster head that is chosen form all the cluster heads. All the cluster heads instead of sending data to the base station, only one cluster head known as super cluster head will be send the whole data to the base station. With this technique, energy consumption will be less as the preserving the battery power of the nodes in wireless sensor networks is a challenging issue. To elect the chance to be the super cluster head, the fuzzy inference engine is used. Performance parameters like first node dies, half node alive were calculated and it was observed this proposed technique provides better lifetime and scalability as compared to LEACH.

Lee et al. in [17] used a fuzzy logic based technique for wireless sensor networks in light of LEACH architecture with an expansion to the vitality predication. . The primary goal of this approach is to draw out the lifetime of the WSN by equitably appropriating the workload. To accomplish this objective, author has generally centered on choosing appropriate cluster heads from existent sensor nodes. The simulation results demonstrate that the proposed LEACH-ERE is more effective than other distributed techniques, for example, LEACH and CHEF. In this paper, the proposed LEACH-ERE approach is intended for the WSNs that have stationary sensor nodes. It is trusted that the procedure displayed in this paper could be additionally connected to extensive scale remote sensor systems.

In [22] Bagci et al. introduced a fuzzy energy-aware unequal clustering algorithm (EAUCF). As the chances of cluster heads that is closer to the base station to die earlier is more, so this unequal clustering technique was introduced. This EAUCF algorithm solves this problem of hot spots. EAUCF intends to diminish the intra-cluster work of the cluster heads that are either near the base station or have low residual battery control. EAUCF expects to disseminate the workload among all sensor nodes equitably. Keeping in mind the end goal to accomplish this objective, it for the most part centers on relegating suitable cluster head rivalry reaches to the sensor nodes. By taking their residual vitality and separation to the base station, EAUCF the competition radius values of tentative cluster heads. Various clustering algorithms were compared with this proposed technique; it was observed that this technique performs far better than previously designed techniques. As a outcome of these observations, it is concluded that the proposed algorithm is a stable and power-efficient clustering algorithm for wireless sensor networks. EAUCF is designed for WSNs that have stationary sensor nodes.

Sharma et al. proposed in [23] a uniform algorithm known as F-MCHEL. In this algorithm cluster heads are chosen using fuzzy logic. Two fuzzy descriptors such as power and distance were used. Out of all the cluster heads, one master cluster head is chosen. This master cluster head is selected on the basis of power, i.e. the cluster head with maximum residual power is chosen as the master cluster head. All the cluster heads instead of sending data to the base station, only one cluster head known as master cluster head will be send the whole data to the base station. With this technique, energy consumption will be less as the preserving the battery power of the nodes in wireless sensor networks is a challenging issue. Reenactment comes about on MATLAB demonstrates that the proposed convention gives higher vitality productivity, better stability interval and lower unsteadiness period when contrasted with LEACH convention regardless of overhead of decision of master cluster head. Results got demonstrate that a suitable master cluster head decision can radically lessen the vitality utilization and improve the lifetime of the system. F-MCHEL is an augmentation of CHEF which brings about better strength of various hierarchical systems when contrasted with LEACH and CHEF.

## III. ALGORITHM

**StepI:** Build a network

1. net_len=350;

2. net_width=350;

3. num_clust_x=1;

4. num_clust_y=8;

5. clust_width=net_len/num_clust_x;

6. clust_height=net_width/num_clust_y;

7. total_clust=num_clust_x*num_clust_y;

8. left_x=0;

9. right_x=left_x+clust_width;

10. left_y=0;

11. uy=left_y+clust_height;

12. b=1;

13. num_sens_per_clust=12;

14. n=num_sens_per_clust*total_clust;

These steps will build a cluster architecture. The cluster building process is vertically done.

**Step II:** if Step 1 to Step 14 is completed then

Calculate Remaining_Energy = ETx (k, d) = Eelec * k + €amp *k * d2, d>1

ERx (k) = Eelec * k

Energy Consumption= mean(Remaining_Energy)+Em

and Size of the packet= abs ((abc) +Em)*packet

Transmission time =datatxperiod*10

Throughput= (Size of the packet / Transmission time)

End

## IV. FLOWCHART

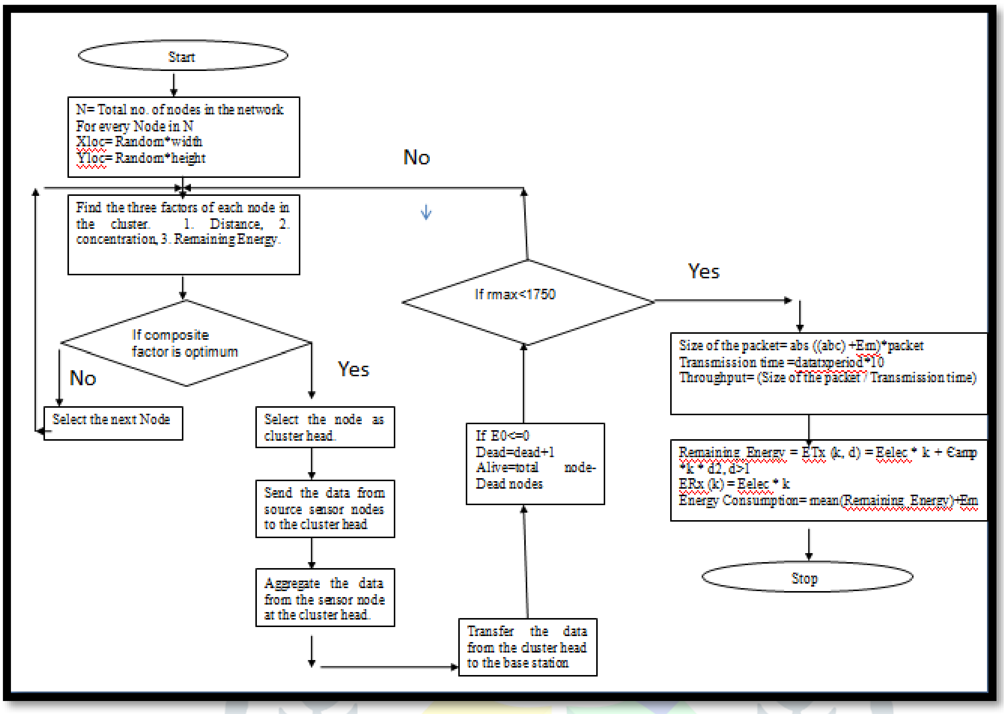


Fig. 4 Flowchart

## V. RESUTLS AND DISCUSSIONS

### 5.1 Simulation Parameters

| Parameter Name | Parameter Value |
|---|---|
| Area Along x-axis | 100m |
| Area Along y-axis | 100m |
| Sink position along x-axis | 50m |
| Sink position along y-axis | 50m. |
| Number of nodes | 150 |
| $E_{mp}$ | 0.0013pJ/bit/m$^4$ |
| $E_{fs}$ | 10pJ/bit/m$^2$ |
| Initial Energy | 0.5J |
| Transmission Power | 50nJ/bit |
| Receiving Power | 50nJ/bit |
| Number of clusters | 8 |
| Node Distribution | Random, Uniform |

Table 1 Network Configuration

### 5.2 Performance Parameters

Performance of work through the following parameters:

1. Remaining Energy.
2. Number of dead nodes.
3. Number of alive nodes.

Remaining Energy: It is the amount of energy that is being left while making the communication between the source node and then to the head of the cluster and lastly to the base station. On each communication, there will be receiving energy, transmission energy, and aggregating energy etc utilized. Remaining energy can be calculated by subtracting the total energy that is consumed during the communication from the total initial energy of the nodes as shown in the following equation.

Remaining Energy=total_initial_energy - total_energy_consumed

Dead Nodes Count: As the sensor nodes have limited energy and it is next to impossible to replace or recharge their batteries so these sensor nodes become dead i.e. their energy gets totally consumed while making communication. So dead node count is the count of number of nodes that have been dead while their energy becomes zero and their activity has been dormant. Dead nodes can be counted by subtracting alive nodes (the nodes that have some energy for communication) from the total number of sensor nodes present as shown in equation.

Dead node count= total_nodes - alive_nodes

Alive Nodes Count: It is the count of number of nodes that still have some energy for communications. It is calculated by subtracting the dead nodes from the total number of nodes as given in the equation.

Alive node count= total_nodes - dead_nodes

### 5.3 Alive Nodes

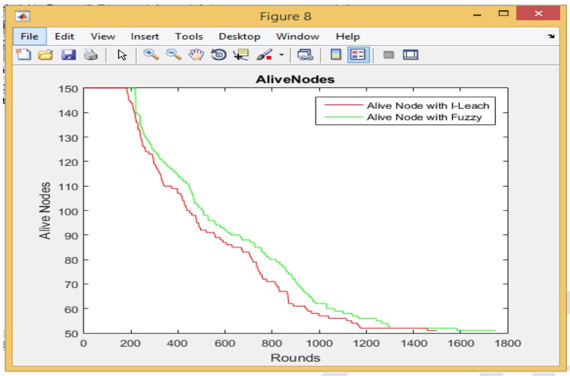


Fig. 5 Alive nodes

Alive nodes Comparison of both I-Leach and the Fuzzy on 1750 rotations has been done. This figure shows the better performance of the fuzzy based system

### 5.4 Dead Nodes

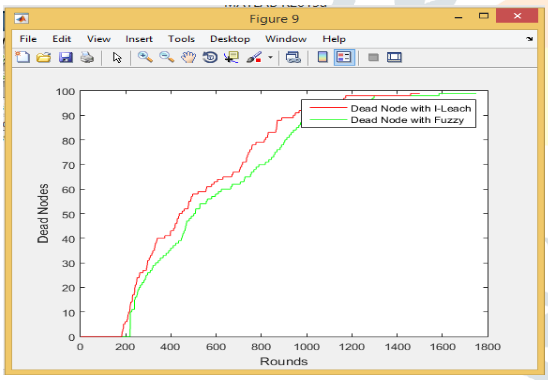


Fig. 6 Dead Nodes

Comparison of the Dead nodes count for both I-Leach and the Fuzzy has been done. This performance comparison has been done on 1750 rotations. Performance of the Fuzzy has been better compared to the I-Leach.

### 5.5 Energy Dissipation

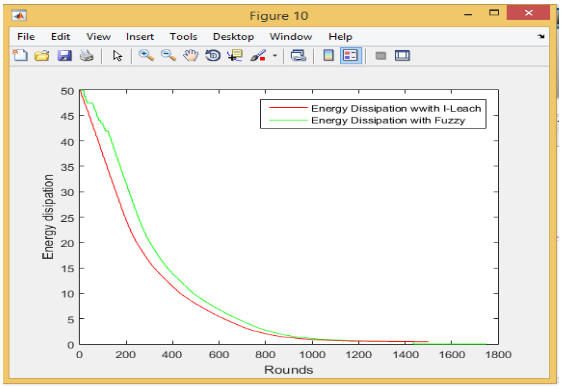


Fig. 7 Energy Dissipation

Energy dissipation has been compared on 1750 rotations on two different techniques like I-Leach and the Fuzzy based system. The performance of the Fuzzy based system is better compared to the I-Leach.

### 5.6 Throughput

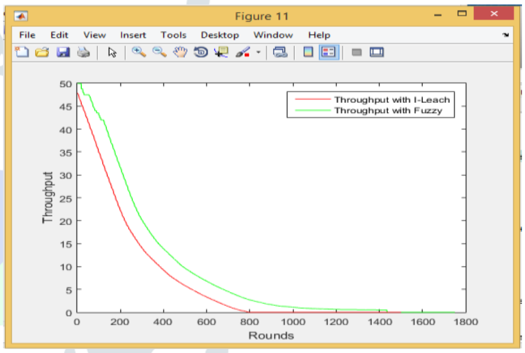


Fig. 8 Throughput

The throughput has been compared on two techniques like I-Leach and the Fuzzy based system. The performance of the Fuzzy based system is better compared to the I-Leach.

### 5.7 Comparison of First Dead Node and Last dead node for I-Leach and Fuzzy

Table 2 Dead Nodes Comparison

| | | | | I-leach | | Fuzzy Leach |
|---|---|---|---|---|---|---|
| Nodes | **Energy** | **Area** | **FDN** | **LDN** | **FDN** | **LDN** |
| 100 | 0.5 | 100 | 1050 | 1700 | 1072 | 1732 |
| | | 200 | 850 | 1450 | 900 | 1500 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 400 | 98 | 1700 | 110 | 1710 |
| 400 | 0.5 | 100 | 1100 | 1700 | 1130 | 1712 |
| | | 200 | 900 | 1700 | 950 | 1718 |
| | | 400 | 100 | 1600 | 200 | 1668 |
| 1000 | 1 | 100 | 2000 | 2700 | 2090 | 2745 |
| | | 200 | 1700 | 2650 | 1790 | 2730 |
| | | 400 | 300 | 2700 | 400 | 2739 |

The performance of the I-Leach and the Fuzzy system on 100,400 and 1000 nodes has been compared.

### 5.8 Throughput comparison

Table 3 Throughput comparison

| No Of nodes | Throughput using I-Leach | Throughput using Fuzzy |
|---|---|---|
| 100 | 47.85905 | 49.95905 |
| 400 | 47.63835 | 49.15906 |
| 1000 | 47.22601 | 48.17907 |

**Throughput = (Size of the packet / Transmission time)**

### 5.9 Remaining Energy

Table 4 Remaining energy comparison

| No Of nodes | Remaining Energy using I-Leach | Remaining Energy using Fuzzy |
|---|---|---|
| 100 | 0.334 | 0.4 |
| 400 | 0.354 | 0.37 |
| 1000 | 0.19 | 0.23 |

Energy Consumption

ETx (k, d) = Eelec * k + Єamp *k * d2, d>1

ERx (k) = Eelec * k

Total consumed energy of each cluster = Σ ERx + Σ ETx

= Total consumed energy of data receiving + total consumed energy of data transmitting

## VI. CONCLUSION

WSN is the wireless sensor network having various sensor nodes inter communicate to each other. Each node has limited power. This power is battery power. Various energy efficient protocols are being used for communication between source node to the base station while have least energy utilization. The objective is always a energy efficiency. I-Leach uses enhancement of the existing Leach protocol. Such that the threshold on the cluster head is being applied. Also there their is shift in the energy amongst the nodes. The performance on the front of Dead node count, Alive Nodes count, Throughput and the energy efficiency. In proposed approach Fuzzy based system is applied for enhancing the efficiency further. Fuzzyfication of three parameters like Density, Distance and the Residual energy is being used. Based on these basic parameters cluster head is selected. This will select the node as cluster head which at highest density, least distance and highest residual energy. While doing this the enhancement of the network for increasing the life time of the network is done. The performance on four parameters like throughput, residual energy, dead nodes count and alive nodes count has being done in comparison to the I-Leach protocol. In all the parameters the network performance has been improved.

## VII. FUTURE WORK

In current research Fuzzyfication of three parameters like residual energy, Distance, Density has been done over to the I-Leach. The performance for energy efficiency has been improved. This reach can further be enhanced by using Genetic based approach. With optimization technique the performance of the network can be improved further.

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