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Enhanced Lifetime of the WSN Network using Fuzzy - Based Clustering Algorithm

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Abstract
Wireless sensor network (WSNs) attends a new criterion of real-time embedded system with determinate computation, memory, communication, and energy resources which are vitality used for huge vicinity of applications where mostly habitual networking framework is basically infeasible. These little sensor nodes are accomplished by battery power and the battery accomplished sensor nodes cannot be instantly recharge or recovered. So, depreciation of energy depletion is an important matter to increase the lifetime of network. For the purpose of this matter, cluster based routing protocol is one effective scheme used, where sensor nodes are split in to number of bundles and each bundle is called as cluster. In each cluster, selected a chief node that is called as Cluster Head. All sensor nodes sense the environment, when diagnose any action, they send the notification to the corresponding cluster heads. After this the cluster heads send the notification to the Base station. So, selection of suitable cluster head can decline significant extent of energy dissipation. But in this entrance, a super cluster head (SCH) is selected among the CHs who can only obligated for send the data to the Base station. In this paper, we propose both CHs from clusters and SCH among the CHs are selected by choosing applicable fuzzy legend, such as remaining battery power, mobility of BS, Centrality, Base station Route. If a network is randomly deployed with uneven load on CHs, then having single SCH is not an efficient approach. If load more on Super Cluster Head, then select one more appropriate SCH for increase the throughput and prolong the lifetime of network.

Keywords: *WSN, Fuzzy logic, CH, SCH.*

1. Introduction

WIRELESS Sensor Network examined as actual time embedded system disposed in a distinct field to sense several types of environmental criterions like as temperature, pressure, gas, humidity etc. The giant applications of WSN like habitant observing, forest fire detection, surveillances etc. have composed a lot of concern among the researcher association in latest prior.

Generally, WSNs are dimply disposed in difficult regions where battery recovered is closely unattainable and human tracking plan is mighty tricky. There are many general matter like as power violence, reserved computing quantity, wide environment; radio affinity makes the sensor nodes defective various times[2]. Once the network is entrenched, all nodes preserve on observing the data and the battery power life goes exponentially. At any time the nodes catch any action, they send the notification to another nodes or to the base station. Persistently it expose that the identical obtained information by the neighboring sensor nodes and can be obtained identical information by the base station that propagate the defective of the network. Data duplication is the dominant issue in the WSN, to avoid this data iteration and make reliable network using various routing protocols with distinct schemes have been proposed in literature [3]. Cluster based routing protocol is one of these effective scheme, where sensor nodes are split into number of bundles and each bundle is called as a cluster. In each cluster, selected a chief node that is called as Cluster Head. All sensor nodes sense the environment, when diagnose any action, they send the notification to the corresponding cluster heads. After this the cluster heads send the message to the Base station. So, selection of suitable cluster head can decline significant extent of energy dissipation. Figure 1 shows the general system model for clustering based WSN.

The possessing sectors investigate the protocol in detail. The rest of the paper is restricted as follows. Section 2 considers the related work. Section 3 represents the proposed protocol. Simulation results

and analysis in section 4. Discusses the conclusion in section 5.

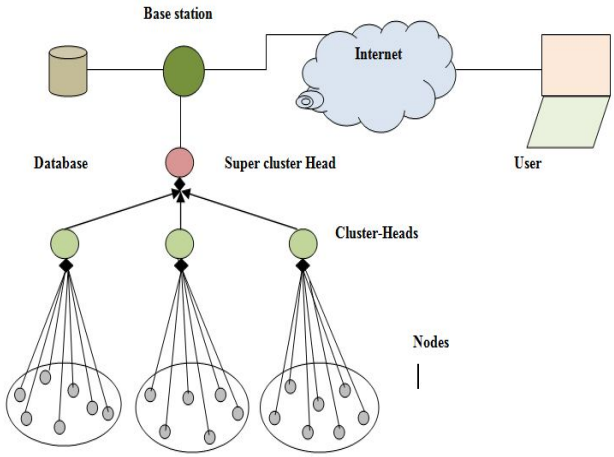

Fig. 1 WSN architecture

2. Related Work

In clustering based protocol, each cluster head is susceptive to send the data to the base station. In this portion, greatest of glorious clustered based routing protocols are examined. We have split conservatives I two sections. In first portion, some protocols where cluster heads are elected in a stochastic model are examined and in the second portion, few of the fuzzy logic based clustering protocols are examined.

2.1 Hierarchical Routing Protocols based on clustering

1) LEACH: Leach [1] [3] is a glorious hierarchical routing protocol which elects CH based on stochastic model and each sensor node gets equal chance to become a CH. Leach protocol operates in two phases: first is a setup phase and second is a steady state phase. In setup phase clusters are formed and actual data is transformed in the steady state phase. Every node selects a random number between 0 and 1 to be the CH. If the number is less than the threshold value T (n), the node obtain the fortunate to become the CH for present round. The threshold value is defined in an equation (1).

$$T(n) = \begin{cases} \frac{p}{1-p*\left(r \bmod \frac{1}{p}\right)}, if\ n \in G \\ 0, otherwise \end{cases} \quad \ldots\ldots (1)$$

Where r is the round, p is the probability of nodes to be cluster head, G is the set of nodes which have never been CH in the end 1/p rounds. Even though in LEACH allocated equally load on each cluster head, fixed there are few limitations that need to the explained here.

- LEACH is a stochastic model so there is a chance that two cluster heads are selected closed to each other, that leads to consume accomplished all energy in the WSN network.
- In each round one random number is created and threshold value is computed so more CPU cycles are utilized.
- If the selected node situated near to edge of the network, other nodes consume more energy message transfer to the CH.

2) LEACH-C: In LEACH-C [2] BS using centralized algorithm to elect the CH. By using centralized algorithm BS knows the locus data and energy of each node. The main limitation of LEACH-C is that the location of the entire nodes essential known to BS. In [3], various clustering protocols have been explained.

2.2 Fuzzy Based Clustering Protocol

Fuzzy logic Model holds vagueness and real time doubts in a bigger process compared to stochastic model. Several authors have put the effort how Fuzzy logic (FL) can be exploiting to select the effective CH so that consequential life time can be accomplished. Here, few of the FL Type-1 based clustering algorithms have been explained.

1) CHEF: In CHEF [5] CH is selected by using two criterions like as contiguity distance and energy. This accession selects CH with high energy and regionally superlative node. Simulation result demonstrates that the CHEF operated 22.7% better than LEACH. In [2] author has deliberated three fuzzy criterions like as energy, concentration and centrality to measure the chance to become the CH and that can boost lifetime of the network. All the nodes are not appointed with GPS receivers and the nodes without GPS cannot supply position information.

2) F-MCHEL: In F-MCHEL [7] CH is selected by promoting fuzzy logic based on energy and contiguity distance. The node which has highest

residual energy from the cluster heads is selected as Master Cluster Head (MCH) and only responsible to sends the assembled data to the Base station. F-MCHEL is betterment than CHEF.

3. Proposed Protocol

The proposed protocol is described as Enhanced Fuzzy logic-based clustering protocol, its achievement is determine using distinctive benched appreciable criterions such as First node dies over time, Half node dies over time, End to End delay, Last node dies, Network Stability. The main purpose of the proposed protocol to select suitable Cluster Heads from the clusters and select tentative Super cluster Head among the CHs. In [14] selected the CHs by using Leach Protocol and selected SCH among CHs using three Fuzzy descriptors such as remaining battery power, mobility of BS and centrality of the clusters. But the Leach protocol have many limitations, So the proposed protocol to select both CHs from the clusters and a SCH among the CHs using Fuzzy descriptors such as remaining battery power, mobility of BS and centrality of the clusters, BS route. If a network is randomly deployed with uneven load on CHs, then having single SCH is not a efficient approach. If load more on Super Cluster Head, then elect one more appropriate SCH for increase the throughput and prolong the lifetime of network. As a result it demonstrates that our proposed technique results are much better than existing approach. After the results we are comparing the proposed technique versus the existing approach.

3.1 System Assumption

In proposed model, sensor nodes are deliberated to be randomly disposed to monitor the continuously environment, in the proposed model. All nodes in the network has following properties

- All the sensor nods are static, except the base station, once the nodes disposed in the network there is no moving of nodes.
- In the starting point all nodes have the same initial energy because homogenous network have been examined such that all nodes are same.
- Mobile is the moving Base station.
- Nodes do not posses any GPS mechanism so the distance between the node and the base station can be measured the based on received strength of the signal.

3.2 Network Model

For demonstration if there are N nodes randomly allocated over M × M region and K clusters are assumed, then there are N⁄K nodes per cluster (one CH and (N⁄K)-1) Non cluster Head nodes. In proposed model, it is pretended that the sensor nodes are deliberated to be randomly disposed in a square area to monitor the environment continuously. The proposed model is represents in Figure 2.

3.2.1 ***The Proposed Algorithm***

1. BS Route:
   1. Get nod energies and locations
   2. Sort nodes based on energy, then location
   3. Define BS route on energy and location
2. CH Selection procedure:
   1. Initialize Network
   2. Get BS route
   3. Get all node energy, mobility, centrality and BS Route
   4. Feed Fuzzy system with values of energy, Mobility, centrality and BS route
   5. Obtain CH chance chart of the nodes
   6. Update node with strongest chance as CH
3. SCH Selection procedure:
   1. Select CH based on algorithm 2
   2. Select optimal CHs in each round
   3. Select SCH based on fuzzy-if then rules among the CHs using node energy, mobility, Centrality and BS route
   4. All CHs send the aggregated to SCH
   5. BS collect the information from BS

3.3 *Fuzzy Logic Model*

The Fuzzy logic model subsists of four subjects: a fuzzifier, fuzzy inference engine, fuzzy rule and a defuzzifier. Fuzzy inference engine e (Mamdani's rule) is used to elect the chance to be the CHs as well as SCH from CHs. In figure 3. Shows the block diagram of fuzzy inference system

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There are four steps to necessary to exhaustive the process:

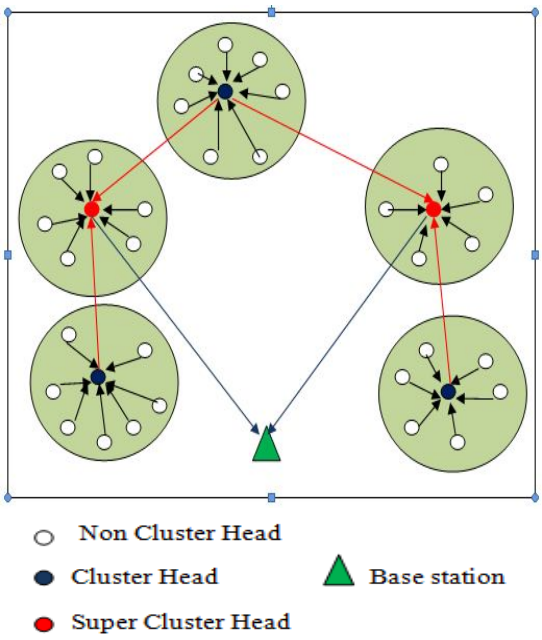

Fig. 2 Proposed Model

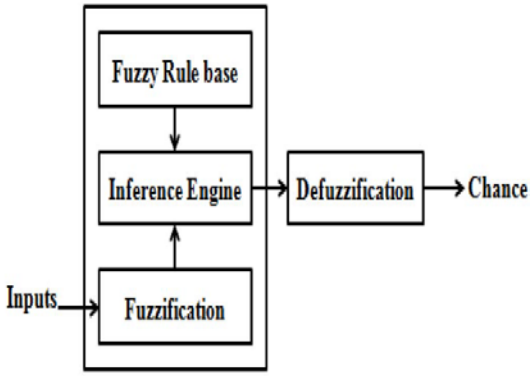

Fig. 3 Block diagram of Fuzzy Inference System.

1) Fuzzification: Fuzzification is the first step in the fuzzy inference process. This includes a power conversion where crisp inputs are converted in to fuzzy inputs. Crisp values are identical inputs sensed by sensor nodes and crossed to the control system for preparing lie as temp, pressure etc. In our proposed protocol, Mamdani's Method Fuzzy inference Technique is used to select CHs from the clusters and SCH among the CHs. In our proposed system used fuzzy system and inference techniques are given in figure 4. We have taken four Fuzzy input variables to select suitable CHs from clusters and tentative SCH among the CHs. All the four variables each have three membership functions. Table 1depicts the Membership functions of input variables.

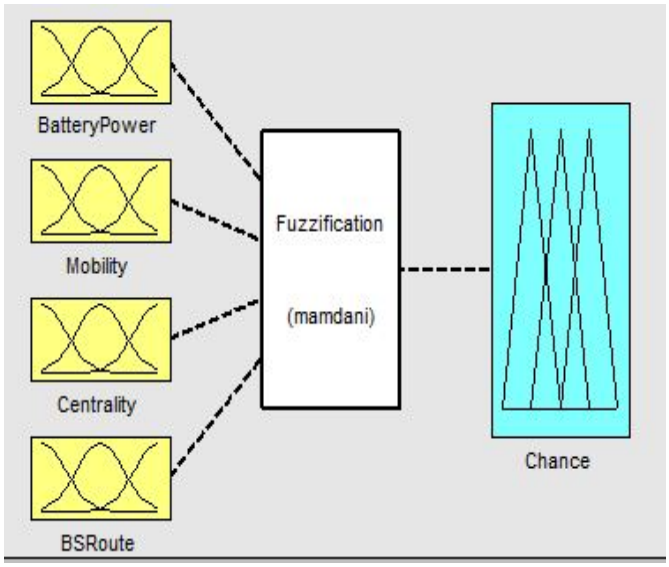

Fig. 4 Fuzzy system for Proposed Model

Table 1. MEMBERSHIP FUNCTIONS FOR INPUT VARIABLES.

Membership Function			
Remaining Battery Power	Mobility	Centrality	BS Route
Less(0)	Low(0)	Close(0)	OFF(0)
Medium(1)	Moderate(1)	Adequate(1)	ON(1)
High(2)	Frequency(2)	Far(2)	Always(2)

2) Rule Base and inference engine: It stores the IF-THEN rules. The fuzzy inference system (FIS) is a process that uses the set theory to mapping from given inputs to outputs. It takes both input values and IF-THEN rules for simulate the process. In our system, we have 27 rule used in fuzzy interference. The rules in the form is if W,X,Y,Z then C. W means remaining battery power, X means mobility, Y means the centrality, Z means BS Route and C means the chance. The rules are borrowed from the formula given in fuzzy equation 1.

Chance = (Battery Power – 1) + Mobility + Centrality
+ BS Route …… (1)

In this equation we have checked remaining battery power as (Battery Power – 1) because in every round there will be consume few energy at each node. So, after preparing of each round, the remaining energy is checked for the next round. Mobility, Centrality and BS Route is deliberated to be saving factor. The output chance hooked of 7 membership functions *very weak, weak, lower medium, medium, higher medium, strong, very strong*. The membership function for output variable chance is shown in Table 2. The fuzzy rules and value of chance is depicted in Table 3.

3) Deffuzzification: It converts fuzzy set I to crisp values.

Table 2.MEMBERSHIP FUNCTIONS FOR OUTPUT VARIABLES

Membership Function
Chance
Very weak (-1), weak (0), lower medium (1), medium (2), higher medium (3), strong (4), very strong (5)

Table 3. FUZZY RULES AND VALUE OF CHANCE

4. Simulation Results

In this section, we represent the simulation results for FIS system. The perception of fuzzy logic is being performed in MATLAB software. To compare the attainment metrics of our interest with Leach with Fuzzy descriptors which confirm that the proposed protocol enlarged lifetime of the Network.

Figure 5 demonstrates the extent of time when the first node dies, because the lifetime of the network depends on the lifetime of respective nodes. It is seen from Figure 5 that first node dies in Leach with Fuzzy very fast while it persist approximately double time in the proposed model. The simulation results shows

4.4×10^{7}. It has been clearly seen that the Existing approach get less time for first node dead than Enhanced proposed approach.

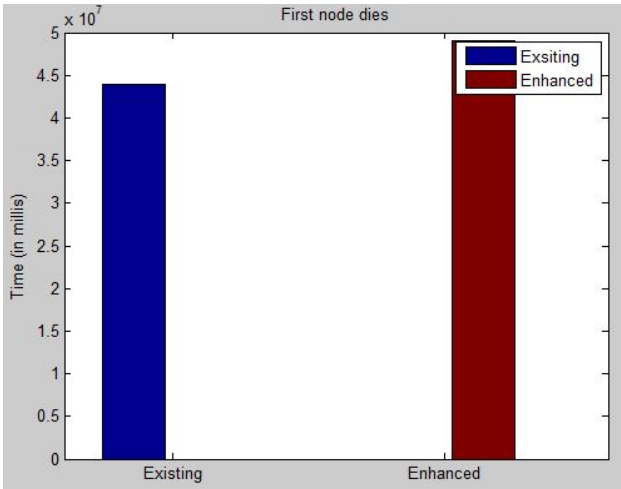

Fig 5.First node dies over time

It is seen from Figure 6 that half of the nodes die first in Leach with fuzzy and persist for extended period of time in the proposed protocol.

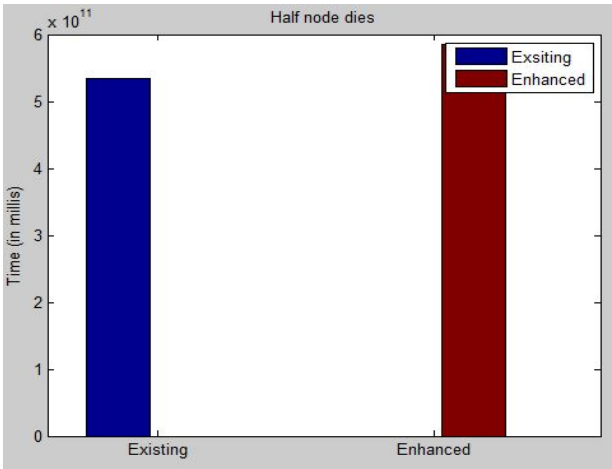

Fig. 6 Half node dies over time

The proposed (Enhanced Leach with Fuzzy descriptors), Half node dies is found to be time 5.9×10^{11} and Existing approach is found Half node dead time 5.6×10^{11} . It has been clearly seen that the Enhanced proposed approach get more time for half node dies than Existing approach. Figure 7 depict about end to end delay. End to End delay is defined as the largest time taken by the travel the packets from source to BS. It is clearly from Figure 7 that end to end delay is decreased in the proposed protocol as compared to Leach with fuzzy. The time extent between the death of first node and half of the nodes essentially illustrate the stability period of the network.

Remaining Battery power	Mobility	Centrality	BS Route	Chance
Less(0)	Low(0)	Close(0)	Off (0)	Very Weak(-1)
Less(0)	Low(0)	Adequate(1)	ON (1)	Weak (0)
Less(0)	Low(0)	Far(2)	Always (1)	Lower Medium (1)
Less(0)	Moderate(1)	Close(0)	Off (0)	Weak (0)
Less(0)	Moderate(1)	Adequate(1)	ON (1)	Lower Medium (1)
Less(0)	Moderate(1)	Far(2)	Always (1)	Medium (2)
Less(0)	Frequent(2)	Close(0)	Off (0)	Lower Medium (1)
Less(0)	Frequent(2)	Adequate(1)	ON (1)	Medium (2)
Less(0)	Frequent(2)	Far(2)	Always (1)	Higher Medium (3)
Medium(1	Low(0)	Close(0)	Off (0)	Weak (0)
Medium(1)	Low(0)	Adequate(1)	ON (1)	Lower Medium (1)
Medium(1)	Low(0)	Far(2)	Always (1)	Medium (2)
Medium(1)	Moderate(1)	Close(0)	Off (0)	Lower Medium (1)
Medium(1)	Moderate(1)	Adequate(1)	ON (1)	Medium (2)
Medium(1)	Moderate(1)	Far(2)	Always (1)	Higher Medium (3)
Medium(1)	Frequent(2)	Close(0)	Off (0)	Medium (2)
Medium(1)	Frequent(2)	Adequate(1)	ON (1)	Higher Medium (3)
Medium(1)	Frequent(2)	Far(2)	Always (1)	Strong (4)
High(2)	Low(0)	Close(0)	Off (0)	Lower Medium (1)
High(2)	Low(0)	Adequate(1)	ON (1)	Medium (2)
High(2)	Low(0)	Far(2)	Always (1)	Higher Medium (3)
High(2)	Moderate(1)	Close(0)	Off (0)	Medium (2)
High(2)	Moderate(1)	Adequate(1)	ON (1)	Higher Medium (3)
High(2)	Moderate(1)	Far(2)	Always (1)	Strong (4)
High(2)	Frequent(2)	Close(0)	Off (0)	Higher Medium (3)
High(2)	Frequent(2)	Adequate(1)	ON (1)	Strong (4)
High(2)	Frequent(2)	Far(2)	Always (1)	Very Strong (5)

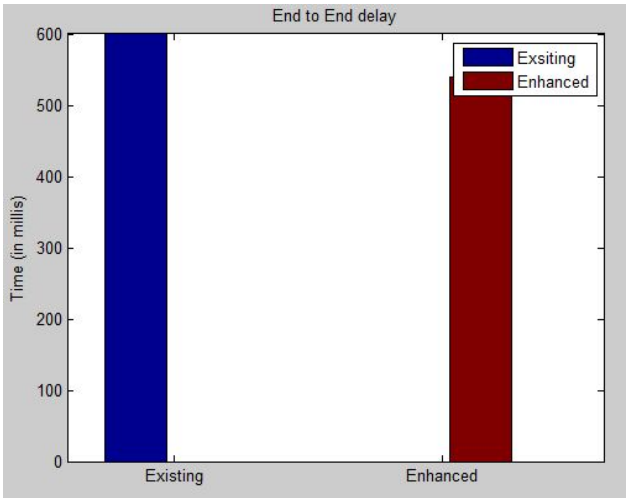

Fig. 7 End to end delay

The simulation results show that Last node dead time for Enhanced proposed improved than Existing technique in Figure 9. The proposed (Enhanced Leach with Fuzzy descriptors), Last node dies is found to be time 18×10^{13} and Existing approach is found Last node dies time 16×10^{13}. It has been clearly seen from Figure 9 that last node dies in Leach with fuzzy much before than proposed approach.

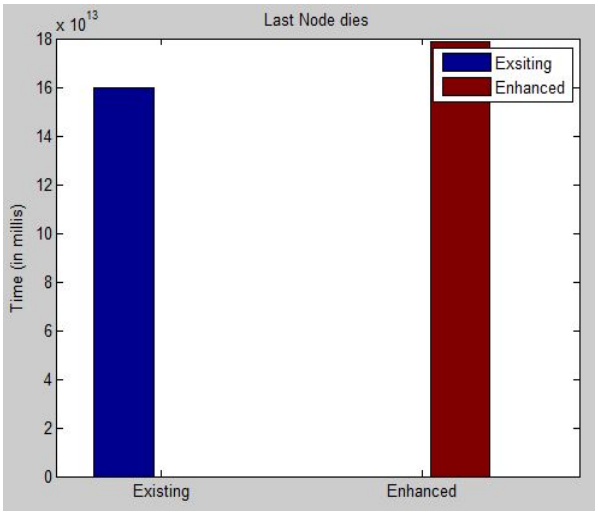

Fig. 8 Last node dies

When the sensor nodes are densely desposed, this metric is very useful. It is clearly seen from Figure 8 that half of the nodes die in Leach with Fuzzy and persist for extended period of time in the proposed protocol. So, the network is higher stable between the time periods of first node dying to half of the node alive. Figure 9 evidence that the proposed protocol is higher stable than Leach with Fuzzy descriptors.

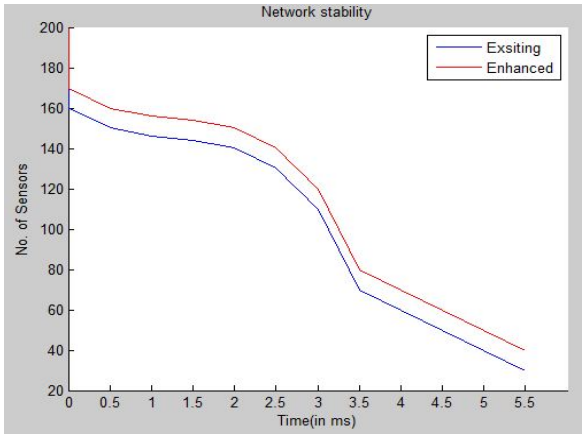

Fig. 9 Network stability

4.2 Result in Tabular

Table 4. Comparison

Protocol	First Node dies	Half Node dies	Last Node dies
Leach with Fuzzy descriptors	4.4×10^{7}	5.6×10^{11}	16×10^{13}
Enhanced Leach with Fuzzy descriptors	4.9×10^{7}	5.9×10^{11}	18×10^{13}
Improved Percentage	11%	5%	12%

6. Conclusions

In this paper, energy effective clustering algorithm has been proposed for WSN Network. The proposed protocol selected the suitable CHs from clusters and one tentative Super Cluster Head among the Cluster Heads using fuzzy descriptors such as Remaining Battery power, Mobility, Centrality and BS Route,

who is only hampered for sending the message to mobile Base station. If a network is randomly deployed with uneven load on CHs, then having single SCH is not a efficient approach. If load more on Super Cluster Head, then select one more appropriate SCH for increase the throughput and prolong the lifetime of network. Simulation result shows that the proposed perform better than Leach with Fuzzy descriptors in terms of First node dies, Half node dies, End to end delay, Last node dies, Network stability.

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