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FUZZY LOGIC BASED CLUSTERING ALGORITHM WITH MINIMUM SPANNING TREE IN WIRELESS SENSOR NETWORK

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ABSTRACT

Wireless Sensor Network (WSN) comprises of the resource constrained sensor nodes that are predictable to work autonomously for long-period of time. Because of the restricted accessibility of the power supply, the main worry in the WSN is energy preservation. Usually, the Minimum Spanning Tree (MST) utilized the optimum data aggregation tree for an energy-efficient routing. Earlier the consumption of energy condensed through the hop basis data transmission includes the help of the Prim's Algorithm. In this article, Fuzzy Logic clustering based algorithm utilized to create clusters & then tree creation to enhance the effectiveness of network. Simulation has been done on the NS-2 & outcome display that the proposed work shows better results than existing algorithms.

Keywords: Wireless Sensor Network, Energy, MST, Prim's Algorithm, Optimal Route.

1. INTRODUCTION

WSNs are free-standing & self-controlling systems that consist a massive number of tiny, inexpensive and affordable battery-powered sensor-radio systems (devices) called by sensor nodes or motes serriedly deployed across the distant places. WSN's have been diffused on the basis of largely amount across the geographical remote areas to watch the physical entities and environmental conditions, such as pressure, light, temperature, humidity, chemical level and fire detection and vice-versa. The sensor nodes procure the data, process and pass to the base station Sink directly or via other sensor nodes to the base station for further operations.

The sensor node might be either smaller one or larger one in terms of size. WSN should have sink that communicates its neighbour nodes on the basis of its application. Basically, A huge number of sensor nodes will communicate and co-ordinate among themselves wirelessly and further with the base station that may be directly or indirectly, and actually they would have the abilities to capture the data which is around them, afterwards make stored the data, forward that captured data to the neighbor nodes or sink and accomplish some of the quantifications over the captured data.

Actually, on WSN's, the energy will be the vital key factor, and then the applications show a stipulated set of features. So, the need and an opportunity make emphasized for optimizing the N/W architecture for the applications in order to lessen the resources to be consumed & increasing energy efficiency. Basically, the WSN's requirements and limitations towards architecture and protocols are so distant and it's being challenged & diversified as compared to the conventional Internet architecture, i.e., in terms of needs. Nowadays, one of the prominent and vital researches in WSN is Energy Efficient Routing Protocol. Routing Protocols for WSN utterly and totally dependent on the routing protocols. Hence, designing based Energy-Aware Algorithms become a main factor for enhancing the lifespan of the sensors & its network as comprehensively.

The application which is based on sensor extend an extensive range of the region, with the remote monitoring of the seismic events, the ecological aspects, smart-spaces, the condition-based maintenance, the soldierly shadowing, the exactness farming, transport, the factory instrumentation, & the inventory tracing [1]. The WSNs has various small, lower cost hubs equipped with the sensor, microchips, wireless transceivers, memory, & battery-operated. They examine a physical, ecological condition & collect & transmit the data at one / more

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of the base-station. WSN consumes energy throughout the collection of data. Because of this there are various types of applications in different areas. The WSN is a co-operative gathering of the sensor hubs, every sensor hub has the dispensation capacity. The routing in the WSN is various as of the conservative fixed network routing through the numerous ways. The WSNs infrastructure is low, incredible wireless links, there are sensor hubs that can fail, & its routing protocols face the harsh energy reserves necessities. In contrast, the WSNs are wireless schemes with the incomplete power, are reserved in dynamism ingesting, & with dynamism have the actual time with the different sources [2].

Heinzelman W.R. et.al has proposed LEACH which has been a distributed and a single hop clustering algorithm [3]. Cluster formation and communication are the two important and prominent phases of this algorithm. The main issue of this algorithm is that it supports single hop clustering, hence paving the way for increased number of cluster formations. Lee J.S. and B.A have presented their perspectives of LEACH in [4, 5].

In [6] article, the protocol termed as Tier Based Minimum Spanning Tree Protocol also named as (TBMSTP) is implemented. This approach is on the basis of Tier idea that is dividing a n/w into the portions based on the hubs distance from a BS & MST building. We are utilized 2 level MST idea that is, a MST on the level of hub include the tier & the another on level of cluster-head among the various tiers to decrease load & intensification a WSN network life-time.

In [7] research paper, the algorithm based on networking-associated termed as local minimum spanning tree named as (LMST) working where as cooperating at the problems of energy balance, which is leading the network for brief life- time, & implement the algorithm of energy-balance. The algorithm examines the energy usage completely to connect the remaining energy of data communiqué and communication nodes, to obtain balanced energy and to avoid complications related to excessive consumption of energy once intermediate node functions forwarding function, like this. Expand the network life cycle. Simulated investigational results displayed the large capacity of the implemented algorithm which could capably extend the lifetime of the n/w & ensure a long-term performance of network, whereas another n/w's ensure act gauges, like the throughput & rate of delivery.

In[8] research paper, we join the routing features which is based on cluster for the cluster creation & the selection CH & the usage the (MST) for the communication of intra-cluster. The proposed method is based on optimizing MST using the Simulated Annealing named as (SA). In given research, mobility standards which is normalized, delay & residual energy are measured for discovering the optimum MST. The outcome which is given by simulation, determine the efficiency of implemented technique to improve package distribution proportion & reducing end-to-end delay.

In given article [9], for WSN, the optimized routing protocol is implemented. We are attentive in building the effective routing spanning tree which reduces energy ingesting amongst all of the hubs in n/w & fit to WSN include decreased energy to attain the extended life-time. Key concept of such algorithm arises as of MST theory of graph. Such method attentions over minimum hop sum of every node to grasp target (basin-node) include the optimum pathway.

In [10] proposed by Azad P. and Sharma V, states that cluster heads have been chosen by a fuzzy decision making approach. In this approach, to select apt CHs and employing three different features including residual energy, number of neighbours and distance from the BS of the nodes.

D.K. [11] have been proposed a Particle Swarm Optimization (PSO) approach for creating energy aware clusters by optimal cluster head selection. KC, G. [12] BFO technique facilitates the positions of multiple base stations randomly in a network to enhance the likelihood of sensor node packets reaching at least one base station (BS) due to the presence of large black hole regions, thereby ensuring high-success.

The rest of the paper has various sections which are: in section II, Routing Techniques of WSN are explained and Minimum Spanning Tree has been described with some detailed explanation and section III described Prim's Algorithm. Section IV Proposed Methodology discussed. In section V and VI, Result Analysis and Conclusion and future enhancement has been described respectively.

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2. ROUTING TECHNIQ UES IN WSN

Routing is a procedure for structuring route amongst destination as well as destination to send information to request. This involves transmission of info after nodes, which assists as well as analyzes this info to BS to assist in decision-making process. There are numerous types of constructions to route information after nodes to BS, which are designated as surveys:

➢ **Single Hop Routing:**

First & easiest method was an instant broadcast of data. Inside the given method every sensor hub will find & move its data directly to BS except the help of any middle hub. The form of BS is located on a distance as of sensor nodes named as (SN), this tell about the extended transmission expenditure of the info, because of which nodes energy reduces rapidly & thus the lifetime of SN's is small.

➢ **Multi-Hop Routing**:

In it, every SN's conveys their data to their instant neighbor, & include the many hops data of neighboring nodes is moved to BS. In the multi-hop networks, each of the hub devours the fewer energy to transmit its data than the Single-hop. The Multi-hop WSN is most efficient then the single-hop types network. Inside the actual world annotations, the single-hop system is most effective if multi-hop network is in single-hop less package for future. This architecture present the hubs located near the BS have higher load, so they expedite its dynamism faster than new nodes, that effect lifetime of network [6].

➢ **Minimum spanning tree [MST]**

The spanning tree of particular graph will be sub-graph which joins altogether of vertices of tree. There may be several spanning trees in a single graph. If every weight is allocated some weight / numbers, then MST is a lower weight tree compared to the any other spanning tree in that particular graph. Each branch has been entrusted with weights. As has been seen, tinted tree is recognized spanning-tree. Several other spanning trees could too be made through joining vertices of this figure into various ways [13]. The edge-weighted graph is a diagram that we connect with weight as well as cost at every end. An MST of edge-weighted graph is a comprehensive tree whose weight is no more than some other spanning tree.

✓ The graph is associated. Tree conditions in our definition show that graph must be connected to presence of MST. Uncertainty no graph is connected, then we can optimize our algorithm to calculate MST of each associated component, which is composed known as minimum spanning tree.

✓ Edge's weight is not far. Geometric awareness is sometimes valuable, nonetheless weight of side may be arbitrary

✓ Edge weight may be zero or negative, as well as if age weight is all positive, then subtract MST with minimum total weight connecting all verticals is enough.

✓ Edge Weight is dissimilar condition edges of ends are equal, then incomplete spanning trees are not single. Creation this assumption makes our evidence informal, nonetheless all of our algorithms work well in presence of equal weight.

3. PRIM'S ALGORITHM

Prim's algorithm is paramount concept in theory of graph which looks aimed at minimum spanning tree toward an associated weight graph. Prim's algorithm extends the minimum spanning tree increasing subtrees sequence. In this sequence, the primary sub-tree contains a solo vertex chosen randomly from set V of the vertices of graphs. Inside following iterations, recent tree increases greedily, easily not connecting it to that tree with the adjacent vertex to the top. Afterward being included in the creation of graph, the algorithm stops after adding vertices of all the graphs. However, algorithm extends a tree through just a vertex over its each iteration, overall numeral of their iterations is n-1, here n represent sum of vertices in graph. Tree created through algorithm is attained because edges set utilized to the development of tree. The algorithm of Prim's nature create it required to offer each of the vertex not in recent tree include the info around a smallest edge joining vertex to the vertex of tree. Info is given through joining the 2-labels on the vertex: adjacent vertex of tree name & related edge weight. The vertices which aren't nearest to any vertices of tree could be provided ∞ tag indicative of its "infinite" distance to the vertices of tree & null tag to adjacent vertex of tree name. include these tags, verdict subsequent vertex to be added to recent tree represent as T = (VT, ET) turn out to be easy challenge of verdict the vertex includes minimum distance tag in set V – VT [14].

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4. PROPOSED METHODOLOGY

The main focus is to form a cluster and selecting a CH for every cluster. The CH chooses on the basis of (i) Residual Battery Power, (ii) Distance to Base Station and (iii) Concentration with the help of Fuzzy logic mechanism. Actually, we are used 27 rules in Fuzzy Inference Technique (FIT) at our paramount system. These rules are applied over 3 fuzzy input variables like (i) Residual Battery Power, (ii) Distance to Base Station and (iii) Concentration, and the output variable is Fitness-Value. CH is selects based on the Fitness-Value, by using Mamdani's Fuzzy rule. The value of Fitness and the rules of Fuzzy are illustrated in below equation1.

$$Fitness - Value = \sum_{0}^{500} (RBP, Distance\ to\ BS, Concentration) \quad (1)$$

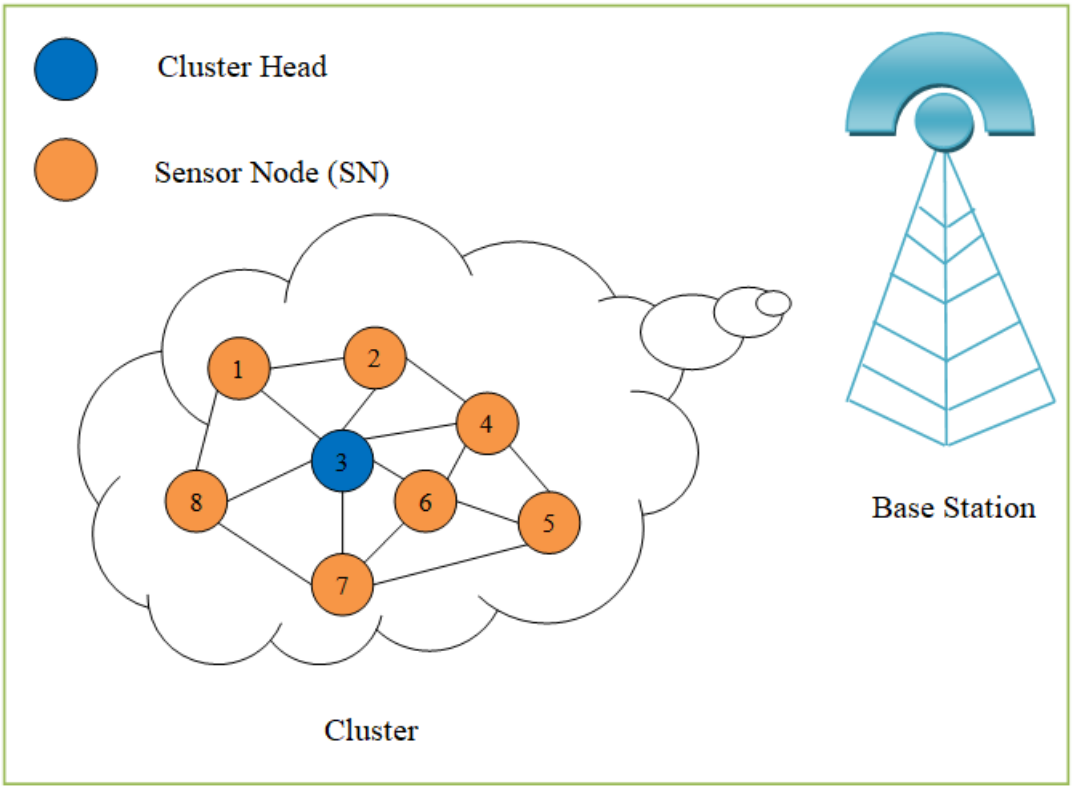

Figure1: Cluster Head Selection

In above figure1, it can be noted that the node 3 is declared as the CH. The decision is made by taking the current fitness value of the node into account and is calculated by the equation1. The fitness value is calculated on the basis of 3 parameters like (i) Residual Battery Power, (ii) Distance to Base Station and (iii) Concentration with the help of fuzzy logic mechanism.

In Fuzzy logic approach, Fuzzy Inference Technique (FIT) [15] employs to select the CH because it is one of the most commonly and regularly using technique. We would take 3 fuzzy input variables to elect the CH. The 3 input variables would have 3 membership functions.

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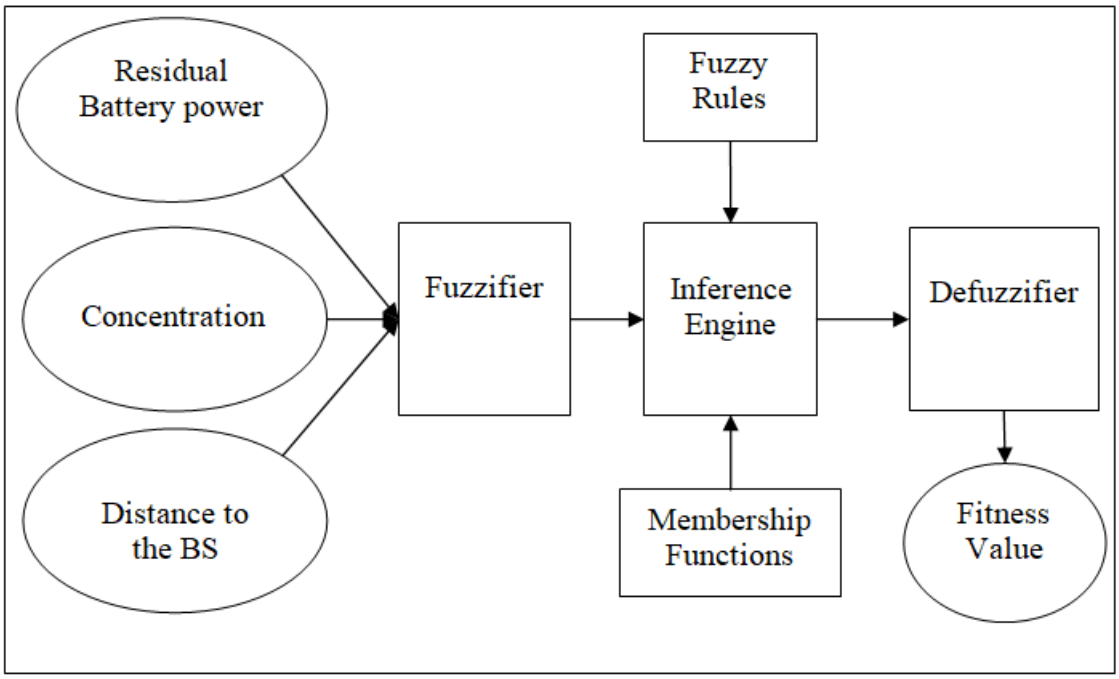

Figure 2: Fuzzy Logic Control System of EECFP-FL

In figure2 the fuzzifier holds 3 kinds of input factors for each sensor node that have been (i) Residual Battery Power, (ii) Distance to Base Station and (iii) Concentration. The input with fuzzy rules and membership functions are being assessed by the Inference Engine. Fuzzy Rules have been processed the conditions which selects Fitness-Value for every node that become the best CH which can be behave as Mediator. Functions of Membership provide the sets of each input factors like high, medium, low.

The fuzzy set which shows an initial variable, i.e. Residual Battery Power. The linguistic variables for the fuzzy set defined as high, medium and low. Trapezoidal membership function deliberates for low and high. For medium, triangular membership function has been considered. The Distance to the BS has been derived as second fuzzy input variable. The linguistic values of Distance to the BS are derived as farthest, far, and near. The Concentration is third fuzzy input variable. The linguistic values for concentration have been defined as low, medium, and high which refers linguistic variables as well.

On Inference Engine and Rule Base, we use 27 rules over fuzzy inference. The form of the rules, if RBP, Dis_BS, CON then FV.

RBP represents Residual Battery Power
Dis_BS represents Distance to the BS
CON represents the Concentration, and
FV represents the Fitness-Value

The rules have been defined from the formula that represented in equation1.

The output variable's Fitness-Value of sensor node to choose as a getting elected as a CH is calculated using Residual Battery Power, Distance to the BS and Concentration of concern clusters. The output Fitness-Value is derived from 7 membership functions, they are: (i) Very Weak (VW), (ii) Little Weak (LW), (iii) Weak, (iv) Little Medium (LM), (v) Medium (vi) High Medium (HM), (vii) Little Strong (LS), (viii) Strong, (ix) Very Strong (VS).

The Fitness-Value to be the CH is reckoned deliberating 3 input factors like as (i) Residual Battery Power, (ii) Distance to the Base Station and (iii) Concentration employing Fuzzy rules.

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Consider the whole network in which the sink node is placed at (0, 0) coordinate and others are deployed randomly. Firstly, the network is divided into small groups known as clusters. This step is performed by Fuzzy Logic mechanism to form optimal clusters. Now perform the minimum spanning tree formation using Prim's Algorithm by considering sink node as an input. Lastly, the data transmission performed through cluster heads of each clusters instead of each nodes which makes them more efficient then earlier.

Proposed Algorithm:

Step 1: Initialization

As Randomly N sensor-nodes are being scattered over the field of MxM region.

Step 2: Divide the network into clusters

Step 3: Apply Fuzzy Logic Mechanism

Step 4: Involve the network graph G (V, E), "k" clusters are presumed, where V as well as E is the nodes also wireless links respectively

Step 5: Cluster Head (CH) Selection

- Elect the CH on the basis of RBP, over the Distance from BS and Concentration over the Fuzzy logic Model.
- Make Apply Fuzzy if-then-else rule and then get Fitness-Values.

Step 6: Cluster Formation

- if (is Node CH?) then
- send advertisement or Announce CH status and await for join_req_msg
- Establish TDMA schedule and to be sent to CM. otherwise

[1] Await CH advertisement and to be forwarded join_req_msg to selected CH

[2] Await scheduling from CH

Step 7: Formation of Minimum Spanning Tree by connecting the cluster heads

Step 8: Transfer Data

- All the CH collects the data from various cluster nodes which comes under the zone of concern Cluster and aggregate the collected data.
- Transfer the information from 1 CH to another CH until it arrives into the BS or SINK but information must come from the upper level.
- A Sensor-Node that has greater energy is chosen as stand-alone CH (SB-CH) Near the BS to restart the connectivity when any failure happens at last CH.
- Compute the Neighbour Cluster Heads, if any CH dies, Re-elect CH from Neighbour Cluster Heads.

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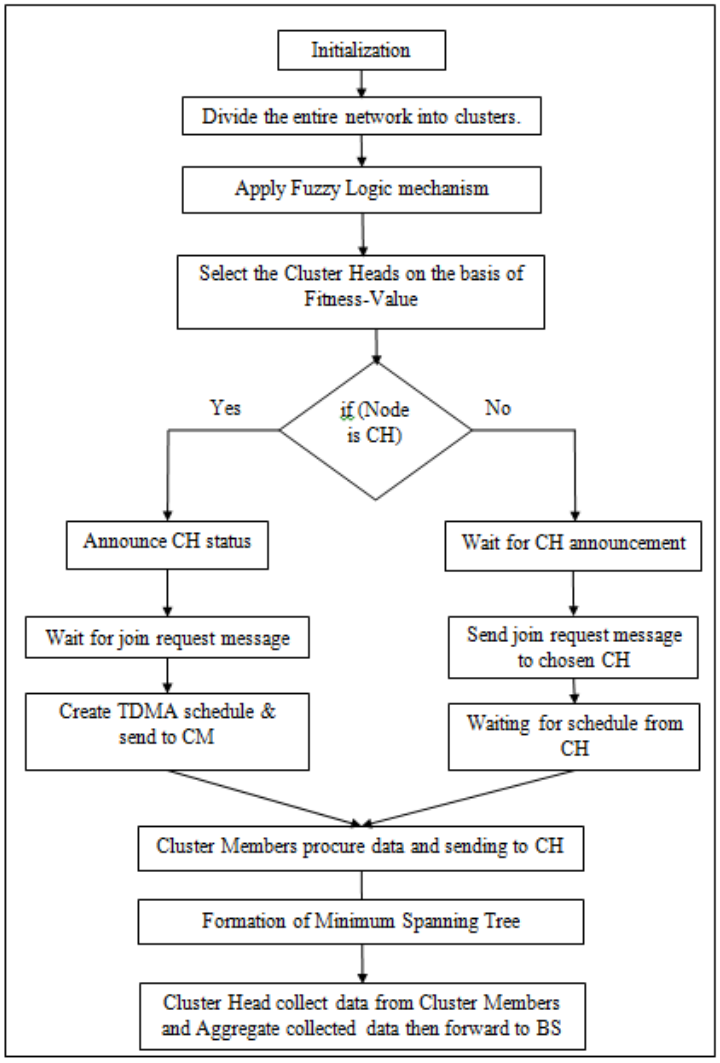

Figure 3: Proposed Algorithm Flowchart

5. RESULT ANALYSIS

The simulation performed to illustrate the proposed work by using NS-2 simulator. The sensor network is organized in a 1000×1000 square area. Randomly 500 nodes are deployed. The results of the proposed work are compared with the existing protocol. Deliberately the comparison took place on the parameters known as (i) Average Residual Energy, (ii) Average Energy Consumption, (iii) Number of Nodes Alive and (iv) Number of CHs elected. The comparative analysis of existing protocols along with the proposed protocol is observed and the betterment of each protocol is explained. It is also presented the comparison of the above said parameters with number of nodes.

Average Residual Energy versus Number of Nodes

Table1: Average Residual Energy versus Number of Nodes

Number of Nodes	LEACH	PSO	PSO- BFA	FL-MST
	Average Residual Energy (J)			
100	2.35	2.65	2.75	2.88
150	2.25	2.50	2.60	2.85

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200	2.10	2.45	2.78	2.84
250	2.00	2.35	2.65	2.80
300	2.00	2.35	2.65	2.76
350	2.00	2.35	2.65	2.74
400	2.00	2.35	2.65	2.72
450	1.80	2.30	2.55	2.65
500	1.60	2.00	2.35	2.45

The table1 represents Average Residual Energy versus Number of Nodes of each protocol and the same comparison is graphically presented to analyse the betterment of each protocol.

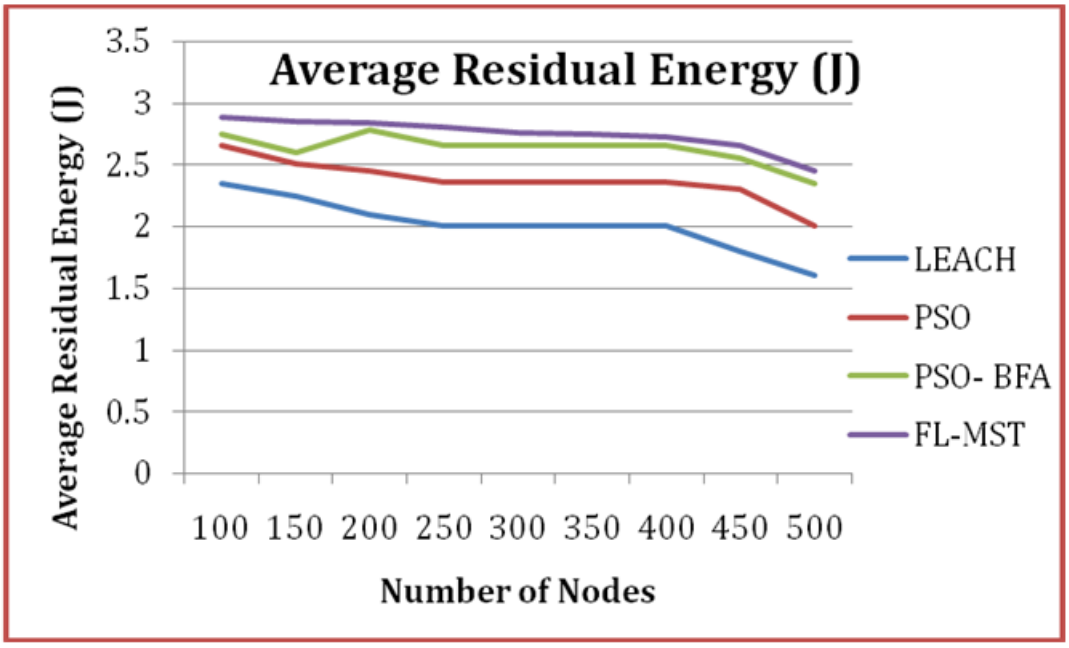

Figure 4: Average Residual Energy versus Number of Nodes

In figure 4, X-axis represents Number of Nodes and Y-axis represents Average Residual Energy. The increase of Average Residual Energy is clearly observed as the number of nodes is increased. The proposed protocol FL-MST Average Residual Energy growth is clearly observed at each stage of enhancement of number of nodes. At the stage where number of nodes is 100, the Average Residual Energy of FL-MST is 2.88 joules whereas the Average Residual Energy of other protocols at the same number of nodes is less than proposed protocol. It clearly represents the better performance of proposed protocol. The same observation is noted up to 500 nodes.

Average Energy Consumption versus Number of Nodes

The table 2 represents Average Energy Consumption versus Number of Nodes of each protocol and the same comparison is graphically presented to analyse the betterment of each protocol.

Table 2: Average Energy Consumption versus Number of Nodes

Number of Nodes	**LEACH**	**PSO**	**PSO- BFA**	**FL-MST**
	Average Energy Consumption(J)			
100	0.27	0.17	0.16	0.16
150	0.45	0.27	0.26	0.22
200	0.57	0.39	0.35	0.28

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250	0.82	0.42	0.37	0.32
300	0.82	0.42	0.42	0.38
350	0.82	0.52	0.45	0.40
400	0.82	0.62	0.52	0.48
450	0.88	0.72	0.65	0.50
500	0.90	0.86	0.75	0.58

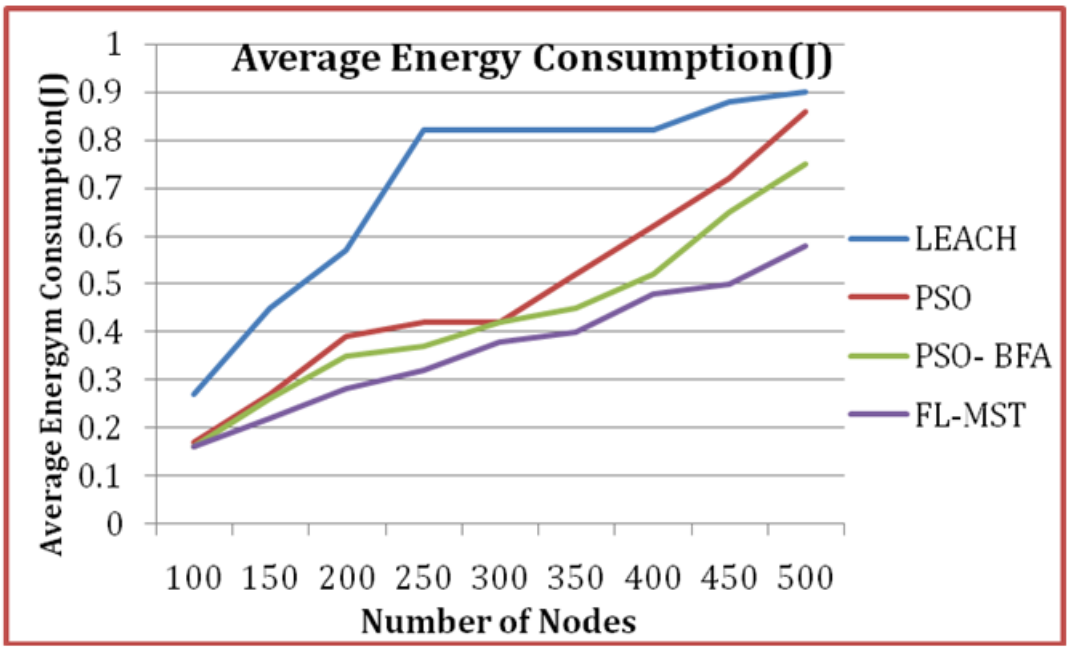

Figure 5: Average Energy Consumption versus Number of Nodes

In Figure 5, X-axis represents Number of Nodes and Y-axis represents Average Energy Consumption. The decrease of Average Energy Consumption of each node is observed clearly as the Number of Nodes are increased. The proposed protocol FL-MST optimization of Average Energy Consumption rate is clearly observed at each stage of enhancement of number of nodes. At the stage where number of nodes is 100, the Average Energy Consumption of FL-MST is 0.16 joules whereas the Average Energy Consumption of other protocols at the same number of nodes is greater than proposed protocol. It clearly represents the better performance of proposed protocol. The same observation is noticed up to 500 nodes.

Number of Nodes Alive versus Simulation Time (Sec)

The table 3 represents Number of Nodes Alive versus Simulation Time of each protocol and the same comparison is graphically presented to analyse the betterment of each protocol.

Table 3 Number of Nodes Alive versus Simulation Time (Sec)

Simulation Time(Sec)	**LEACH**	**PSO**	**PSO- BFA**	**FL-MST**
	Number of Nodes Alive			
25	250	350	360	430
50	180	280	320	380

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75	120	150	280	310
100	90	120	230	260
125	75	90	190	210
150	45	75	120	160
175	25	55	90	120
200	10	35	55	100

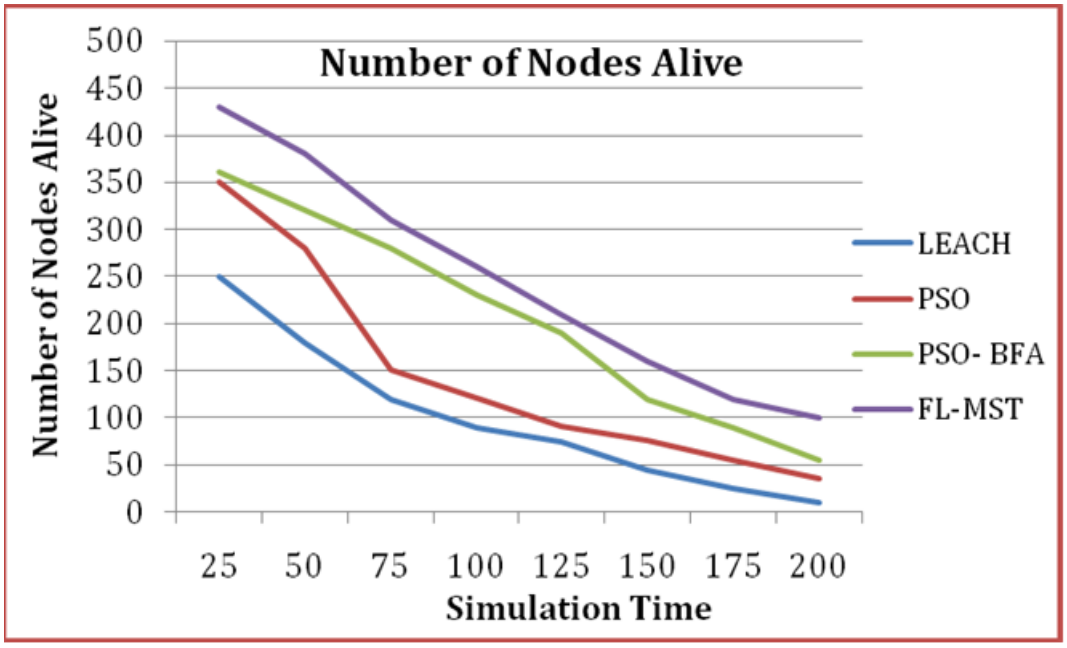

Figure 6 Simulation Time versus Number of Nodes Alive

In figure 6, X-axis represents Simulation Time and Y-axis represents Number of Nodes Alive. The increase of Alive Nodes is clearly observed as the Simulation Time is increased. The proposed protocol FL-MST Alive Nodes growth is clearly observed at each stage of enhancement of Simulation Time. At the stage where Simulation Time is 25 seconds, the Number of Alive Nodes of FL-MST is 430 whereas the Number of Alive Nodes of other protocols at the same number of nodes is less than proposed protocol. It represents the better performance of proposed protocol.

Number of CHs elected versus Simulation Time (Seconds)

The table 4 represents Number of CHs elected versus Simulation Time of each protocol and the same comparison is graphically presented to analyse the betterment of each protocol.

Table 4: Number of CHs elected versus Simulation Time (Sec)

Simulation Time(Sec)	**LEACH**	**PSO**	**PSO- BFA**	**FL-MST**
	Number of CHs elected			
25	40	25	22	18
50	32	20	20	18
75	25	18	18	18

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100	20	16	16	17
125	18	14	14	17
150	16	12	14	16
175	14	10	12	16
200	12	08	08	16

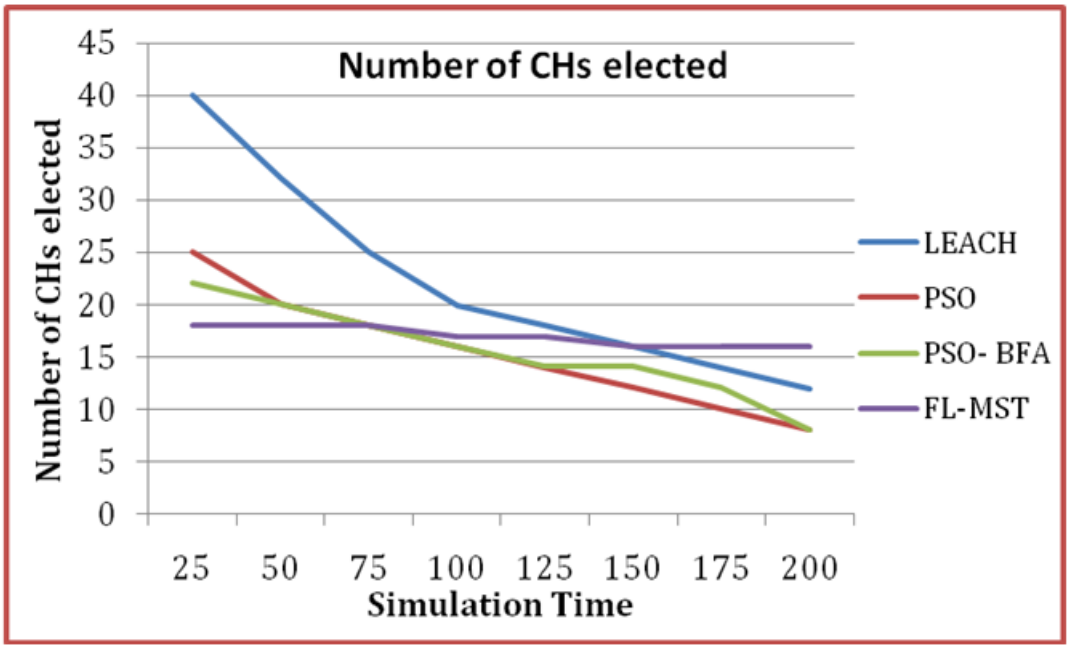

Figure 7 Simulation Time versus Number of CHs elected

In figure 7, X-axis represents Simulation Time and Y-axis represents Number of CHs elected. The optimized number of CHs elected is balanced as the Simulation Time is increased. The proposed protocol FL-MST CHs elected mechanism is balanced at each stage as Simulation Time is enhanced. At the stage where Simulation Time is 25 seconds, the Number of CHs elected is balanced through the proposed protocol FL-MST at each and every stage. It clearly represents the balancing of Cluster Heads election is well maintained rather than other existing protocol.

6. CONCLUSION AND FUTURE ENHANCEMENT

In this paper, the proposed protocol FL-MST relies on a cluster based model. The main emphasis in this paper is select CH by implementing fuzzy logic model and CH alone it can forward collected data of all cluster members to the BS. The whole sensor networking system is divided into a range of clusters and in every cluster, using Fuzzy LOGIC model the Cluster head is selected by using fuzzy logic descriptors. In the proposed model Cluster head re-electing method is implemented such that it saves sufficient energy in turn it increases life span of WSN. The proposed protocol FL-MST provides better functionality such as residual energy, energy consumption, alive nodes, number of CHs elected, and life-time enhancement of the network than existing protocols

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