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RESEARCH ARTICLE

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Fire Fly Hybrid Approach for Energy Efficient Routing

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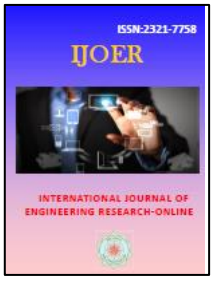

ABSTRACT

Energy consideration is the most important aspect for the configuration of the efficient performance of the network. Various researches takes place in order to propose a reliable method for developing an energy efficient network but was not enough capable to achieve the goal due to various reasons like less number of parameters were considered for implementing the work which leads to the downfall of the proposal. Later on some optimization mechanism were also collaborated with cluster head selection techniques but gets failed. This study provides proposal on the basis hybridization of intelligence technique and natural behavior optimization algorithm i.e. fuzzy and firefly algorithm respectively. The major aim of the proposed work is to select the cluster head on the basis of individual parameters as well as the evaluation parameter of the whole system. First of all three parameters are given to the fuzzy interface which leads to an output of single parameter, the fuzzy will evaluate the network on the basis of individual parameters and then firefly implies the evaluation of the system or network on the basis of average distance, average energy and fuzzy fitness value to calculate the fuzzy cost value. The results are done by performing the simulation in MATLAB.

Keywords—fuzzy cost value, average mead distance, density, average residual energy, fuzzy interface, firefly optimization

I. INTRODUCTION

Most of the fields make the use of WSN in order to sense the sensitive data from its ambiance and then make that data reachable to the base station [1]. The WSN is a network that is comprises of diminutive, low powered, low-priced sensors which are deployed in the network randomly. Then these sensor nodes perform the process of data collection and sending it to the base station by following specific route [2]. Before routing, the main step is to implement the cluster formation. Clustering scheme is a kind of addition in order to achieve the goals like energy efficient operations like declining the number of nodes which can link up with the base station by commencing the concept of cluster heads [3]. Hence, to make a WSN an energy efficient network is a vital criterion. In order to implement the energy efficient operations it is mandatory to implicate the optimal cluster formation [4]. Lot of research work had been focused on the concept of cluster head selection on the basis of less number of parameters [5][6]. Many cluster head selection techniques are available to select the cluster head node efficiently on the basis

of some parameters [8]. In various cluster head selection protocols such as LEACH, DEEC etc, the process of cluster head selection relies upon the nodes because the cluster are created by the nodes on the basis of the distance covered by them [9][10]. This mechanisms emphasizes on the factor of distance whereas the other factors are ignored which can also effect the lifetime of the network and energy consumption [11]. We proposed a hybrid energy efficient protocol by implementing the concept of fuzzy logics along with the optimized firefly algorithm. And the comparison is done with LEACH and QLEACH in the result section of this paper. Further this study also provides an overview to the work that had been done clustering by using advanced mechanism like fuzzy or firefly etc in section 2, section 3 provides the brief introduction to the mechanism that is used for commencing the proposal, section 4 portrays the concept of motivation behind conducting this work, section 5 depicts the flow and the procedure that is followed to implement the proposed hybrid cluster head selection mechanism.

II. RELATED WORK

Reza Khoshkangini et al, 2013. Proposed a technique that focuses on reduction of energy consumption and growing the life time of network using a fuzzy logic approach. The method was based on two factors, namely, energy level and centrality, and used a controller that a verts uninvited attention of cluster heads in a specific section. The simulation results show a substantial amount of rise in energy conservation and extended network life time as compared to other proposed techniques. Komal Bhoite et al, 2015. Developed a new energy efficient routing protocol for WSNs in this paper and that was Extended Distributed Weight-based Energy efficient Hierarchical Clustering protocol (EDWEHC). Each node initially detects its neighbors (in its enclosure region) and then calculates its weight. The leading weight node in a neighborhood may become a cluster head. Then the cluster head hierarchy will be joined by the neighboring nodes. The clustering procedure ended in O (1) iterations, and does not depend on network topology. Fuzzy logic procedures were integrated in DWEHC to enhance the energy consumption performance..Golden Julie et al, 2012 proposed a Neuro Fuzzy energy aware clustering scheme (NFEACS) to form optimum energy aware clusters. NFEACS involves two fragments: fuzzy subsystem and neural network system NFEACS used neural network that delivers effective training set related to energy and received signal strength of all nodes to evaluate the predicted energy for tentative cluster heads. The high energy sensor nodes are proficient with center location of base station to select energy aware cluster heads. In fuzzy logic part, fuzzy instruction was used that inputs to form clusters. NFEACS was designed for WSN handling mobility of node. The proposed scheme NFEACS was compared with associated clustering schemes, cluster head election mechanism, and energy aware fuzzy unequal clustering. It was noticed from the compared results that NFEACS performs well than other related techniques. Kaushik Gotefode et al, 2016 Proposed a Fuzzy rule based General Self-Organized Tree-Based Energy-Balance routing protocol (FGSTEB) which was based on the GSTEB, in this work a routing tree for data transmission by selecting the appropriate routing path and relay node using fuzzy rules, fuzzy rules finds relaying node depending on their residual energy and the load on the node. Due to the dynamic nature of the FGSTEB protocol and performs the simulation according to different parameter in consideration. The central objective of the work was to enhance the performance of GSTEB protocols by balancing energy consumption which extending the lifetime of WSN. Osama Mohd Alia et al, 2014proposed a Decentralized Fuzzy Clustering Protocol, named DCFP, which reduces total network energy dissipation to promote maximum lifetime of network. The procedure of creating the infrastructure for a given WSN was performed only once at the commencement of the protocol at a base station, which remains unaffected throughout the network's lifetime. In this initial construction step, a fuzzy C-means algorithm was adopted to distribute sensor nodes into their most suitable clusters. Consequently, the protocol runs its rounds where each round was separated into a CH-Election phase and a Data Transmission phase. In the CH-Election phase, the election of new cluster heads was locally done in each cluster where to enhance the quality of elected cluster heads, a new multi-criteria objective function was proposed. The

sensing and data transmission from each sensor node to their corresponding cluster head was performed in the Data Transmission phase and cluster heads in turn combine and send the sensed data to the base station. The results of simulation prove that the proposed protocol improved network lifetime, data delivery, and energy consumption as compared to other energy-efficient protocols that are well-known.

I. TECHNIQUES USED

Fuzzy Logics: Fuzzy is applied in various fields such as engineering, studies, medical etc in order to derive a decision. Fuzzy system is easy as well as simple to understand and implements. Fuzzy system is a logical system which is in the form of many-valued logic. The truth table of these values lies between the range of 0 and 1, since Boolean logic supports the 0 and 1 only and considers the result either 0 or 1. It also supports the elements which are surrounded by the set may either have partial degree of membership means either element belongs to a set or not. These degrees are managed by any particular functions when applied with the linguistic variables. Fuzzy use linguistic variables in addition to quantitative variables in order to present vague concept. Membership function defines mapping of a membership value between 0 and 1 in the given input space. Universe of discourse is another term used for input space [13].

Following figure 1 explains the working process of fuzzy system in brief. Firstly a crisp value is added to the fuzzy system as an input. Then Fuzzification process is applied to the crisp fuzzy values. Fuzzification is a process which converts the crisp values into fuzzy sets.

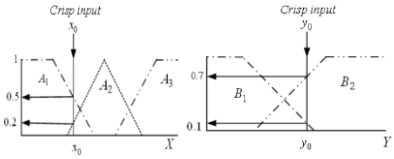

Figure1. Fuzzification [13]

Then defined rules are applied to the fuzzy input set driven by applying fuzzification. On the basis of rules an intelligent decision is taken and then the fuzzy sets are converted to the crisp values back by applying the Defuzzification.

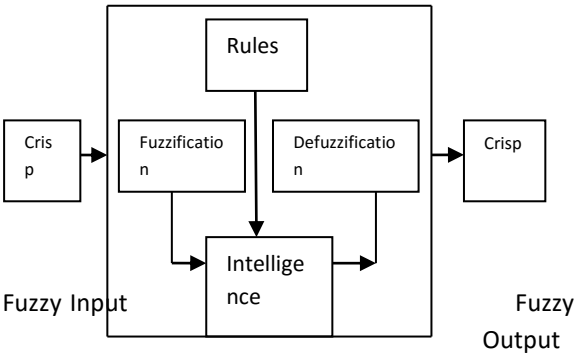

Figure2. Working of Fuzzy Logic Based System

FUZZY RULES

Fuzzy logics have dual core nature on one hand it act as a rule based system and on other side it is also a non linear mapping. In order to understand the transformation of IF-THEN rules into non linear mapping let's consider the example that we have a collection of IF-THEN rules:

$R^{(1)}: IF x_1 is F_1^l and x_n is F_n^l THEN y is G^l$ (1)

In equation (1) $x = (x_1, \ldots., \ldots, x_n) \in R^n and y \in R$ belongs to the input and output of the fuzzy logics. $F_1^l and G_l$ are considered as the labels of fuzzy sets represented by R and $l \leq M$.

With respect to fuzzy logics, each rule defines a fuzzy set as follows:

$$F_1^l \times \ldots. \times F_n^l \rightarrow G^l$$

FIREFLY: The algorithms which are based natural behavior of particular living thing is referred as Met heuristic algorithm. These algorithms are meant for designing a high level solution to a problem by combining science and mathematics by selecting efficient optimization algorithms. Met heuristic algorithm is a combination of up to date optimization algorithms, soft computing and computational intelligence in order solve particular problem. Swarm Intelligence is considered as a sub part of Met heuristic techniques. Because the algorithm is based on the nature swarms like birds, fishes. Similarly Firefly algorithm is based upon the flashing pattern of tropical fireflies. It was developed by Xin-She Yang in 2007.

ALGORITHM: In the firefly algorithm, the optimization process depends on the brightness of the fireflies and the movement of fireflies towards their brighter counterparts. Every firefly is attracted to the other depending on brightness because the fireflies are all unisexual according to the first

assumption about artificial fireflies. The firefly algorithm is as follows:

1. Define an initialize benchmark function$f(x), x = (x1, x2, \dots\dots\dots xd)$
2. Generate initial population of fireflies x_i $(i = 1,2,3 \dots\dots\dots, n)$
3. Determine light intensity for xi by calculating $f(x_i)$
4. Define light absorption coefficient γ
5. While t < Maximum Generation
6. Make a copy of the generated firefly Population for move function
7. For $i = 1{:}n$ $all\ n\ fireflies$
8. For $j = 1{:}n$ $all\ n\ fireflies$
9. If $(I_j > I_i)$
10. Move fireflies i and j according to attractiveness
11. Evaluating new solutions and updating light intensity for next iteration
12. End if
13. End for j
14. End for i
15. Sorting the fireflies to find the present best
16. End while
17. Begin post process on best results obtained

APPLICATION OF FA: Firefly algorithm has attracted much attention and has been applied to many applications. Firefly algorithm is mainly applied for following applications:

1. For Digital image compression.
2. For feature selection in digital images.
3. For solving the engineering design problems.
4. For classification.
5. For clustering.
6. For route optimization

ADVANTAGES: The advantages of firefly algorithm are; it has the capability of dealing or handling the multimodality. It can perform sub division of the modules automatically without any interruption, Because it is based on the attraction and attractiveness decrease with distance. It is applicable to highly non linear, multimodal optimization problems efficiently.

III. PROBLEM FORMULATION

An energy efficient protocol in wireless sensor networks, nodes have limited energy resources and, consequently, protocols designed for sensor networks should be energy-efficient. Various energy efficient techniques were combined with optimization algorithms to achieve high level performance. But old routing protocol and energy efficient protocol find route from source to destination on the basis of direct energy and distance of the nodes from overall system, which makes it less robust, versatile and efficient. The other loop hole was related to the concept of parameters that were considered for the purpose of cluster head selection.

After studying the previous work that had been done in the field of wireless sensor network in order to make it an energy efficient network, we came to know the various problems or issues related to those works. None of the mechanism is sufficient to achieve the high network stability and are also very time consuming. We need to design a protocol which provides the less power consumption in sensor network for transferring the data from source to destination and also must capable to perform cluster head selection on the basis of various parameters which are mandatory to consider.

IV. PROPOSED WORK

As previous section describes the issues that comes in the way to achieve the energy efficient wireless sensor network. It is observed that there were many routing or energy efficient protocols available. But the important parameters were evaded while implementing the mechanisms, which can affect the overall performance of the system or network.

Hence we provide a hybrid technique which is comprises of fuzzy and firefly optimization algorithm. First of the fuzzy will be implemented in order to evaluate the performance of individual nodes on the basis of following parameters

1. Energy of nodes.
2. Distance from adjacent nodes
3. Density(Connection of particular node with its adjacent nodes)

After measuring various parameters corresponding to the individual nodes, next the firefly will be applied to select the best node on the basis of three functions i.e.

1. Average Cluster Head Energy
2. Minimum Average Distance

3. Fuzzy Fitness

$$f1 = E_{avgCH} = \frac{E_{all\ nodes}}{E_{CH}} \quad (1)$$

$$f2 = minimum\ average\ distance = d = \frac{distance_{CH}}{Nodes\ Count} \quad (2)$$

$$f3 = fuzzy\ cost\ value\ of\ cluster\ heads$$

$$final\ fitness\ value = (.61 * f1) + (.2 * f2) + \sum f3 \quad (3)$$

The firefly will process on the basis of three parameters one of the parameter is the output that is received by implementing the fuzzy system and the firefly will add two more parameters such as Average CH energy and Minimum average distance in order to evaluate the performance of the whole network.

The proposed technique is multi fitness oriented mechanism in which the focus is derived on multi fitness to achieve the final fitness value which is as per the user's requirement which can vary over the time. The hybrid technique is capable to evaluate the network on the basis of individual node and as well as whole system. The steps to follow in order to implement the propose work are as below:

1. First step is to enter the various parameters such as energy, number of nodes, and area for the network in order to create a network.
2. Second step is to deploy the nodes in the given area of the network and by considering other parameters such as energy etc.
3. Initialization of the fuzzy interface on the basis of three parameters such as energy, distance and density. Here energy refers to the energy that is allotted to the nodes initially, distance depicts the distance between particular node to the sink node and density refers to the connection of the particular node to its adjacent nodes.
4. In this step the evaluation of fuzzy cost value of individual node will done.
5. Then the firefly optimization algorithm will be applied in this phase of the implementation to evaluate the fuzzy cost value. It takes the output of the fuzzy system as an input and also add two parameters to measure the cost value.
6. On the basis of evaluated cost value, the best scored node is selected to play the role of cluster head in the process of communication.
7. Next step is to initialize the communication among sink node and cluster heads so that the performance of the system get measured after implementing the hybrid mechanism for CH selection.
8. Last step is to make a comparison of the results that are obtained from current implementation with the traditional LEACH and QLEACH.

The methodology of the proposed work is as follows:

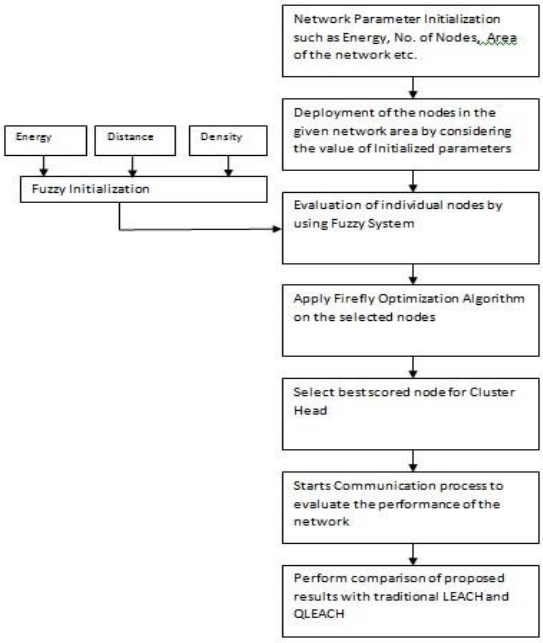

Figure3. Frame Work of the Hybrid Method

V. RESULTS AND EXPERIMENTS

This segment of this paper portrays the results that are observed after implementing the proposed hybrid mechanism to select the cluster heads on the basis of necessary parameters.

The table below represents the network configuration for the simulation of the proposed work.

Parameters	Values
Area	100*100
Number of nodes	100
E_{node}	0.5j
E_{tx}	50 nj
E_{Rx}	50nj
E_{mp}	0.0013pj

E_{fs}	0pj
EDA	50nj

E_{node}: refers to the initial energy allotted to the nodes at the initialization of the network;
E_{Tx}: Energy consumed for the transmission process;
E_{Rx}: Energy consumed for receiving the data packets while communication.
E_{mp} : stands for amplified energy
EDA: defines the data aggregation energy.
Area: defines the area considered for the deployment of the nodes. .
Number of Node: The total number of nodes deployed in the network.

The figure4, 5 and 6 shows the graphs of the memberships functions that are used or defined by fuzzy system. Figure4 depicts the membership function of residual energy of the nodes, figure5 explains the graph corresponding to the distance membership function, and similarly the figure6is related to the graph of density membership function. These three membership functions led the fuzzy system to generate a fuzzy output on the basis of list of predefined rules.

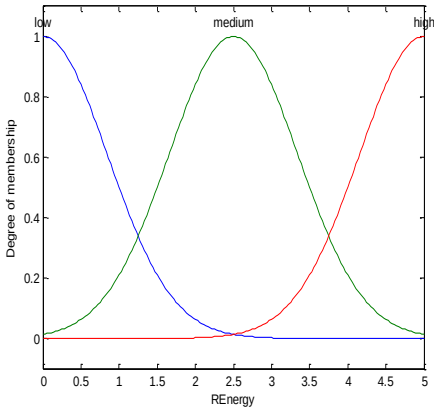

Figure 4 membership function of residual energy

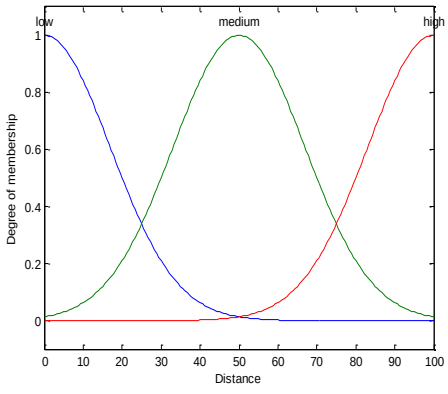

Figure5 membership function of Distance

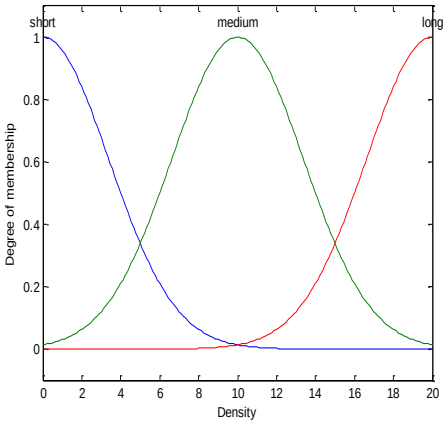

Figure6 membership function of residual energy

The graph given in figure7 depicts the amount of average residual energy of the network with respect to the 3500 rounds. Average residual energy refers to the average amount of the energy that remains on the network after performing the communication process within 3500 rounds. From the graph given below it is observed that the residual energy of the network did not get exhausted even when the communication is done in 2000 to 2500 rounds.

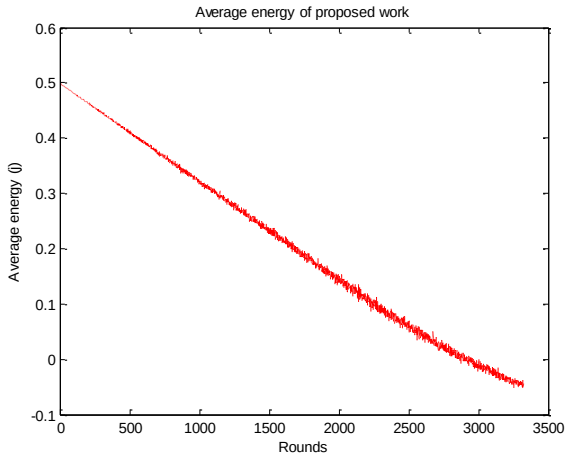

Figure7Average Residual Energy of the network

The graph below(figure8) represents the comparison of the proposed work with existing protocols such as LEACH and QLEACH. The comparison is done on the basis of number of dead nodes in the network. Dead nodes refer to the nodes that do not have the sufficient amount of energy to perform the communication and hence are not capable to work. From the graph below it is extracted that the dead nodes exist in the proposed work on a later stage as compare to the LEACH and QLEACH where the nodes started losing their energy at the initial phase of the communication.

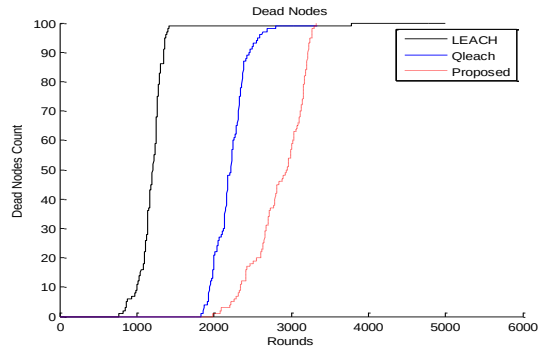

Figure8 Comparison with LEACH and QLEACH on the basis of dead nodes

The figure9 introduces the comparison graph on the basis of alive nodes in the network while implementing the communication process. Alive nodes stands for the nodes that remains alive or capable to perform the communication. The node that has a specific amount of residual energy to communicate with the sink node falls in the category of alive nodes. The graph below defines that the proposed work has the number of alive nodes till the end of 3000 number of rounds which is more than the LEACH and QLEACH.

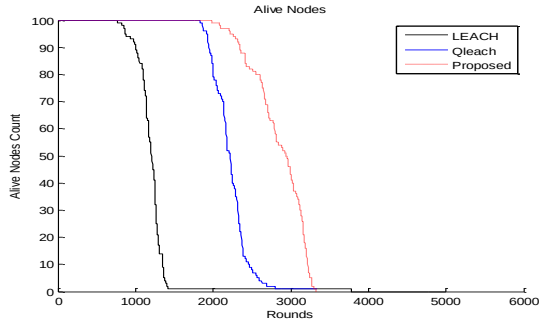

Figure9 Comparison with LEACH and QLEACH on the basis of alive nodes

The table below represents the comparison on the basis of exact values derived from the resultant graphs that is obtained after implementing the proposed hybrid technique of cluster head selection.

Table1 Comparison table on the basis of resultant parameters

S.No	Techniques	First Dead Node (number of rounds)	Last Dead Node (number of rounds)
1.	Proposed Hybrid Method	1911	3299
2.	LEACH	760	1410
3.	QLEACH	1830	2800

VI. CONCLUSION

The focus of this study is to perform the cluster head selection by using the most prominent techniques i.e. Fuzzy and firefly. The proposal is represented by performing the hybridization of fuzzy and firefly optimization algorithm. The cluster head selection is done by evaluating the various parameters on the basis of individual node as well as full fledge network. The results show that the proposed work is most capable to enhance the energy efficiency of the network.

For further enhancements can be done by considering the load balancing and the concept of mobile nodes in the network

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