Enhancement of Fuzzy Logic Controller Using The Meta-Heuristic Algorithm for Energy-Efficient Cluster Head Selection in WSN

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Abstract

Power administration is the key factor to recover the lifespan of the sensor network in WSN. Cluster is one of the mainly commanding strategies to organize a network to attend to the scalability of the network, use of remaining energy, and enhance the lifetime. In most of the proposed algorithms, difficult thing is to select the cluster head (CH) throughout the process. To handle such types of problems, the fuzzy logic approach is the best solution with adoptive, elastic, and intellectual modes for taking the decision that improves the life span of the network.

Here, We proposed the most favorable power management approach to progress the power efficiency in WSN with a fuzzy approach. Optimal FLC means to maintain the alive nodes, boost the residual energy stages, reduce Packet Loss rate, and reduced the delay in-between process, Hence to improve FLC, some meta-heuristic algorithms such as PSO, GA are used. Simulation results are conducted for LEACH, FLC, FLC-GA, FLC- PSO using MatLab. As per model outcomes, the FLC-PSO strategy is efficiently managing the energy in WSN that can enhance the lifespan of WSNs.

Keywords: Cluster Head (CH), Fuzzy Logic Control (FLC), Genetic Algorithm (GA), Low Energy Adaptive Clustering Hierarchy (LEACH), Particle Swarm Optimization (PSO)

I. INTRODUCTION

Energy Management plays an important reassuring role in the WSN process. The nodes are set with restricted batteries. It is very difficult to change or recharge a battery, hence some nodes are operated with renewable power, but, their high cost is not economical. Power use is managed at a different level to a low sense of duty cycles, reduce delay, information redundancy, and implementation of short-range for transmission. In the network layer, power-efficient routing protocols are formed to extend the network life span. The nodes within each cluster can intercommunicate, and the leader of a group called Cluster Head (CH). cluster head (CH) is trusted to collect data from all nodes and transfer them to a seating, synchronized base station.[1-3,5]

LEACH is one of the traditional methods, that select nodes arbitrarily and energy provided to every member node .but some drawback is fixed probability for choice of CHs with the continuous changing environment and no prediction for the position of nodes as per their remaining energy. To overcome this limitation of LEACH, Fuzzy logic Control is proposed with some meta-heuristic algorithms are used. We proposed The fuzzy logic control approach that introduced for power management of WSN for enhancement of lifetime, based on the no. of dead nodes, remaining energy, packet loss ratio, and reduction of delay with the size of the network,

Fuzzy logic control has different rules, regulations, and parameters, for optimization, for good results in the part of the lifetime of the network, different meta-heuristic methods like GA, PSO, etc. Hence, we are proposed to enhance the progress of a predictable Fuzzy Logic Control system with meta-heuristic algorithms. [12]

In this proposed work, we concentration on Section 2 that reviews meta-heuristic Algorithms for optimization of FLC. Section 3 focused on the model to optimize FLC using PSO, and GA. Section 4 that Simulation Results in MatLab with different algorithms and Section 5 gives deals with the result conclusion.

II. METAHEURISTIC ALGORITHMS

A. *Genetic Algorithm*

GA is an arbitrarily and streamlining technique that is for the most part utilized for tackling enhancement issues. GA is work on the proceeded with the presence of the fittest data. GA starts with a bunch of a likely arrangement called early populace which is created arbitrarily. Each animal's outcome is known as genetic material. The size of every genetic material should be equivalent.

A wellness work computes the wellness estimation of every chromosome. The chromosome with high wellness esteem is nearer to the ideal stage. The transformation is applied to arbitrarily choose chromosomes that get a superior understanding of Crossover and mutation that create the following populace[10].
Here, Fitness Function is shown in Eq 1,

$$F = E_r + (N_i - CH) + \frac{TIC}{N_i} + \frac{BSD}{Ni} \quad (1)$$

Where Er: Remaining Energy, CH: No of CH, TIC: Total cluster to Cluster Distance, BSD: Distance from BS to CH.Ni: No of Nodes.

Here, a one-point hybrid strategy is utilized. The hybrid activity happens between two chromosomes with a likelihood determined by the hybrid rate. That chromosome trade parcels to isolated by the hybrid point.
One Point Crossover with Individual 1 and 2 (i,e Ind 1 and Ind 2) shown in Table 1.

Table – 1
One point Crossover

Ind 1	*1*	*1*	*1*	*0*	*0*	*1*	*1*	*1*	*0*
Ind 2	*0*	*1*	*0*	*1*	*1*	*0*	*0*	*1*	*0*

After crossover: Offspring with Individual 1 & 2 (i,e Ind1 and Ind 2) shown in Table 2.

Table – 2
Offspring

Ind 1	*1*	*1*	*1*	*0*	*1*	*0*	*0*	*1*	*0*
Ind 2	*0*	*1*	*0*	*1*	*0*	*1*	*1*	*1*	*0*

The transformation administrator is executing to each piece of a chromosome with a possibility of change rate shown in Table 3.

Table – 3
Status of Mutation

Before	*1*	*1*	*1*	*0*	*1*	*0*	*0*	*1*	*0*
After	*0*	*1*	*0*	*1*	*0*	*1*	*1*	*1*	*0*

B. Particle Swarm Optimization

This is an enhancement approach that takes into account the social behavior of natural kinds of things for mathematical calculation purposes. It is a population-based swarm optimization tool to execute the enhancement development regarding the fitness function. PSO approach uses a huge scale to find every particle and maintain the fitness value of each particle. Hence each particle is connected at the same speed. This helps to get the field in the right place, keeping in mind the cost of improved fitness work. All about local intelligence particles, and Global Optimal position to locate the cluster heads and reduce overall performance energy. PSO algorithms are more efficient as compare to other mathematical and heuristic approaches.[11]

Proper descriptions of PSO in the mathematical form are in Eq 2 and 3.

$$Vi(t+1) = vi(t) + c1r1\big(pbes1t(t) - xi(t)\big) + c2r2(gbest1(t) - xi(t)) \quad (2)$$

$$xi(t+1) = xi(t) + vi(t+1) \quad (3)$$

Here, vi(t) and xi(t) are the distance and location opposite the motion of the i^{th} particle on the t^{th} step, respectively, r1 and r2 are arbitrary nos, pbest1(t) is the best solution of the i^{th} particle at the t^{th} step, and gbest1(t) is the best global result at the t^{th} step.

III. OPTIMAL FUZZY LOGIC CONTROL

For better results in cluster head selection with optimal fuzzy approach, Input parameters to FLC are No of lifeless nodes (D) and residual energy (E). Membership functions (MFs) for lifeless nodes (dead nodes) are implemented as small, Medium, High. Five membership functions for residual energy are implemented as like Very small, small, Medium, High, Very High.

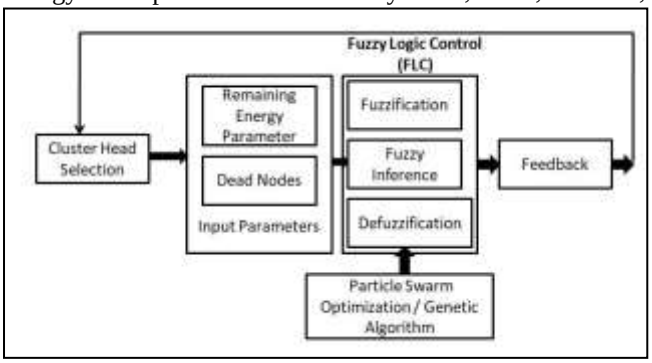

Fig. 1: Optimal FLC Model

Total eight membership functions and fifteen rules are required to optimize the FLC [7,8]. The optimal FLC proposed structure is shown in fig 1.

IV. SIMULATION RESULTS

We performed the simulation in Matlab2018a. The experimental simulation of the network along with special cluster head selection algorithms such as LEACH, Simple FLC, optimized FLCs with PSO and GA[6-10]. On the performance of simulation results, network performance parameters are considered like residual energy, nodes with high energy level, average end-to-end delay, packet loss rate, No of Cluster formation regarding the size of the network are discussed. In the particular simulation, 100 energy nodes are arbitrarily spread over the size of the WSN in the square size of 100m X 100m to 500m X 500m. Simulation performance of the network for different network parameters shown in Fig 2,3,4,5 and 6.

In fig 2, It is measured that no of CHs formed with the size of the network, When the size of the network increases, the no of CHs increases. FLC-PSO generated a better no of CHs than Conventional FLC and FLC-GA.

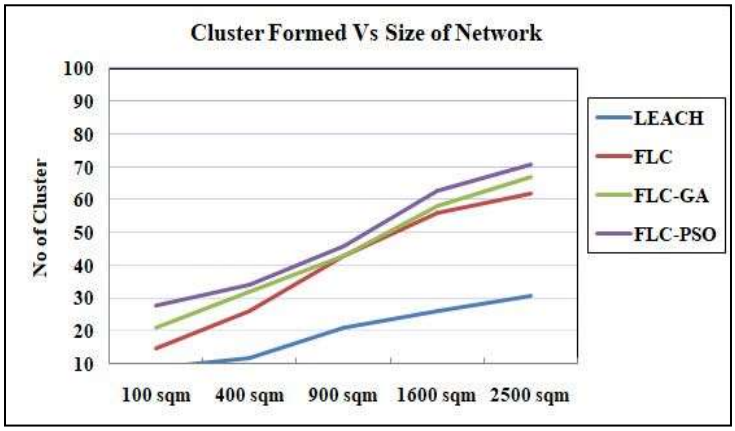

Fig. 2: Cluster Formed Vs Size of Network simulation

In Fig 3, It is measured that normal end-to-end delay regarding the size of the network, FLC-PSO performs better by reducing delay than FLC Cluster Head Selector, FLC-GA. When the size of the network increases, the delay gets reduced.

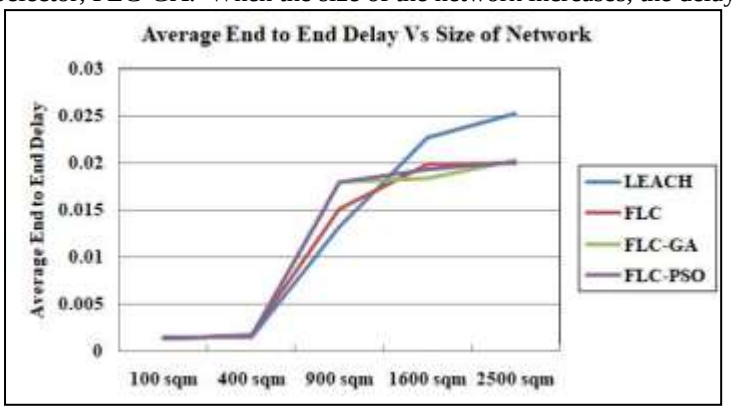

Fig. 3: Average End to End Delay Vs Size of Network

In Fig 4, It is measured that packet loss rate regarding the size of Network, FLC-PSO performs better by reducing loss rate than FLC Cluster Head Selector and FLC-GA. The packet loss gets reduced regarding the size of the network.

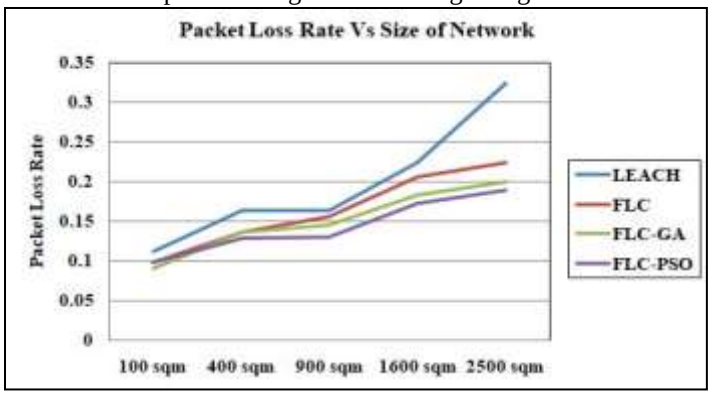

Fig. 4: Packet Loss Rate Vs Size of Network

In Fig 5, It is measured that percentage of lifetime of network with no of round generated. FLC- PSO is a more optimized technique that enhanced the lifespan of nodes and networks better than LEACH, conventional FLC, FLC-GA.

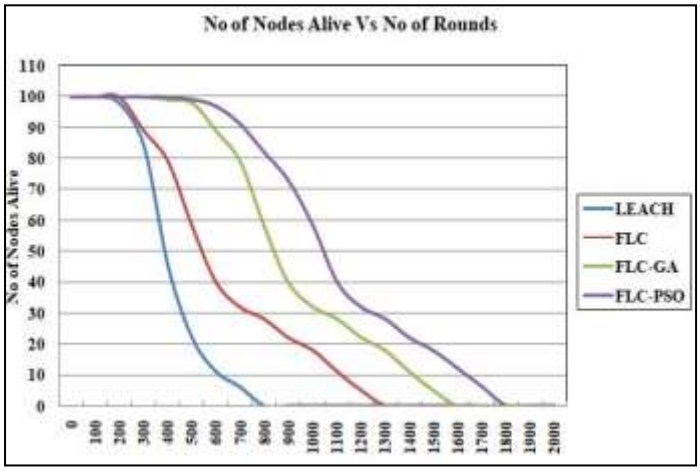

Fig. 5: No of Nodes Alive Vs No of Rounds

In Fig 6, The remaining energy of the Network decreases with rounds and it decides the lifetime of the network.. As per the simulation, The lifetime performance of the network is efficiently improved by FLC-PSO better as compare to LEACH, Conventional FLC, FLC-GA.

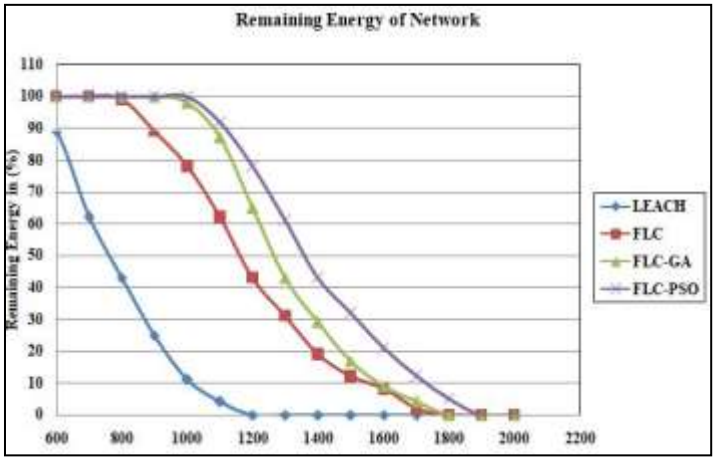

Fig. 6: Remaining Energy of the Network Vs No of rounds

V. CONCLUSION

We found some conclusions from the comparison of various algorithms for the optimal solution of the FLC. LEACH selects CHs depending on scattered clustering data and the Fuzzy system selects the CHs based on the fuzzy significance, existing power of nodes, mobility, and the space between nodes.

For Optimal FLC, different rules should be optimized for better results. Hence, some meta-heuristic algorithms are proposed to enhance the conventional FLC system. To improves node residual energy and effective clustering mechanism, PSO with a fuzzy approach can find high-class optimized results in less execution time. In future research, Hybrid model PSO-GA, PSO-ACO, GA-ACO will be the better solutions for better optimization in cluster head selection in WSNs for Lifetime enhancement.

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