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Fuzzy Based Energy Competent Cluster Head Selection in Wireless Sensor Networks

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Abstract: Wireless Sensor Network (WSN) is a wireless communication System based on embedded system and sensor system, which is equipped with lots of low-cost micro low-power sensor nodes. Nowadays, WSN has been widely applied in various fields for their merits, such as smart home, environmental monitoring, and military surveillance, disaster relief operations etc .The wireless sensor network checks physical and environmental status, data is collected and sent to the base station via network. Clustering combines several sensor nodes to form a cluster and elects a head for the clusters formed. Cluster formation and cluster head selection plays major role in Wireless Sensor Networks (WSNs).In order to select a Cluster Head various parameter such as residual energy, centrality, number of neighbors, distance to base station etc., can be considered. . This paper focuses on coordination of sensor nodes in a network and selection of best node which keeps information of affiliated sensor node for communication with cluster head of other clusters using fuzzy logic.BFO algorithm also used for optimization .This model improves the network lifetime and efficiency of the Cluster Head.
Keywords—cluster head,fuzzy logic and BFO

I.INTRODUCTION

WSN is an autonomous sensor used to monitor environmental conditions such as sound, pressure, etc. It helps to transfer the data via the networks to the destination. It is build-up of many nodes where each one of the nodes connected to one another. A common application of WSN is area monitoring, environmental/earth sensing, air pollution monitoring etc. The main characteristics of WSN are ease of use, mobility of nodes, energy harvesting, resilience.WSN use LAN or WAN for communication via gateway. Major issue in WSN is the nodes are not in similar size ,the data transferring efficiency may be vary, for this purpose clustering method is adopted and particular node can be selected as cluster head(CH).Cluster is the process of grouping the objects which are similar among them and are dissimilar to the other cluster. Its main aim is to determine the unlabeled data in intrinsic group. Clustering technique can be performed by using many different methods. In this system, Fuzzy logic is used for clustering process and to evaluate true or false, yes or no, high or low etc. The reason for using fuzzy logic is decision making purpose. It is mainly designed for reduce the development cycle. It can provide more user-friendly and efficient performance. In this paper four parameters are used for applying fuzzy logic, they are residual energy, centrality, distance to base station and number of nodes.

By using this fuzzy logic fitness of each node can be found and analyze all the fitness value for select the cluster head among all the nodes by implementing the BFO algorithm. It is a global optimization algorithm for distributed optimization and control over the nodes .It is used to find the best solutions for difficult problem. For cluster head selection in our paper, BFO algorithm is used. This algorithm chooses the energetic nodes and eliminates the weakest nodes. As a result of this system improves the network life time and efficiency of the cluster head.

II.LITERATURE

WSN has several nodes that are able to sense the environmental condition and process it. These nodes are used to collect various environment information. These nodes use a large amount of energy for transmission of data. Grouping of these nodes is called clustering .Cluster Head is selected for each of the clusters in the network. The work of this CH is to collect data, process it, filter it and then transmit .One cluster can transmit data to another through gateway or CH. Selection of CH involves overhead on the network as more energy is spent. Clustering is focused in improving quality of service in WSN which also has some limitations. One of which is there is energy consumption between various nodes and its CH's. Some of the technique used in Cluster Head selection are LEACH,CHEF,LEACH-ERC.LEACH(Low Energy Adaptive Clustering Hierarchy) is clustering based routing protocol and involves rotation of Cluster Head to distribute energy load evenly[1]. Time factor is added to the LEACH algorithm and elect CH by setting a counter to number of candidates. The node which has shortest time interval gets selected. In existing literature [1-2], it has revealed that LEACH protocol select CH of insufficient energy. To eliminate the disadvantage of LEACH algorithm, fuzzy logic algorithm has been used. In this proposed system, fuzzy logic is used which has less computational heavy load and used for clustering purpose. Mamdani was the first parameter used for fuzzy logic along with LEACH and it considered the centrality, energy and concentration to find candidate for CH election process. The main drawback with LEACH is , it does not consider energy of the nodes in selecting CH. This might lead to insufficient energy. So to enhance residual energy, scalability, and usability, etc. and clustering purpose fuzzy logic is used. CHEF (Cluster Head Election Mechanism using Fuzzy logic) algorithm uses fuzzy if-then rule for expansion or enlargement of network lifetime [2].It provide only 22.7% more efficiency than LEACH. But only with this percentage network lifetime cannot be increased. With above stated information it clearly portraits that LEACH, CHEF are not providing good result. In [1], author has used fuzzy logic for clustering with two parameter namely, optimal degree centrality and expected residual energy as a parameter to find fitness node. Clustering with the help of degree of centrality and residual energy will not form the best cluster and hence it lead to elect CH with insufficient energy. To overcome this problem, here in our proposed system four parameters are included they are centrality, residual energy, distance to base station and number of neighbor's. These parameters are helps to group the sensor node effectively .After the formation of cluster, cluster head has to be selected. The proposed system use BFO algorithm for selecting Cluster Head. Bacterial Foraging Optimization algorithm is an nature-inspired optimization algorithm [3].In existing paper [3], it has revealed about BFO run-length unit parameter which control the exploitation and exploration. They have implemented or developed new algorithm, Adaptive Bacterial Foraging Optimization (ABFO).This ABFO [3], further applies two foraging algorithm namely, the Producer Scrounger Foraging (PSF) and the Area Concentrated Search (ACS) to the BFO. These two algorithms were implemented to improve the BFO performance. It also compared with the PSO and GA [7].

Genetic Algorithm(GA)is an algorithm that selects CH based on fitness condition of node which survive in the environment.GA selects the Cluster Head which is nearest to base station is the major drawback.GA has four steps namely, Crossover, Mutation Operation, Selection and Fitness Function. In crossover phase, it assume node as CH which is selected after interchanging two parents chromosome. As the parent chromosome deliver new chromosome the base chromosome has been chosen as Cluster Head. If the chosen cluster head becomes a regular node (normal node which resides in network).Then the member of that Cluster Head will find new CH. This may lead to loss of data. In Mutation Operation, there is the chance of regular node to become a Cluster Head and vice versa. If this happen then selecting a best Cluster Head becomes more complex and create confusion in selecting CH among others. The Selection phase is selecting CH by only considering the higher Fitness valve. This section tends to loss CH which has medium fitness but result good efficiency. Fitness functions will checks fitness by considering the residual energy and required energy to transfer data. With help of these two parameter energy consumption cannot be reduced. Particle Swarm Optimization (PSO) was developed by Kennedy and Eberhart in 1995 PSO [7] gives accurate result for device sizing in an analogue circuit. It is a method that optimized the problem through iteration in terms of quality by trying to enhance solution of candidate.PSO balance exploration and exploitation by combining global and local search method.PSO will not produce good result at local optimal solution. In our proposed system BFO algorithm is used along with fuzzy logic to give best fitness node through which Cluster Head is selected and it improves the efficiency of the network life by electing the efficient Cluster Head. It will reduce the energy consumption in place of more energy consumption utilized.

III.WSN ARCHITECTURE

The wireless devices like cell phones, GPS devices, laptops, RFID and other electronic devices have become more pervasive, cheaper and important in today's life. The need and large demand for communication and networking among all these wireless devices has been increased for different applications. Wireless sensor networks from this point of view are the future trend. AdHoc network is used in wireless and wired network as well. It provides self-configuration network for mobile nodes, collection of the sensor nodes leads to wireless sensor network. These networks are based on infrastructure less wireless network, If wireless network require any infrastructure, Wireless Local Area Networks (WLANs) and cellular networks are used. It is the first step for forming the clusters. The entities used more in this architecture are, Sensor nodes, Base station and the main factors are designing the protocols, algorithms, collection of data, transmission media, security and self configuration. The basic components of WSN are controller, transceiver, sensor node, external memory, power source. It use the routing protocols which enables the routers to choose the best path to route the packet and control the messages.

Functionality of Routing Protocols:

This routing protocol enables the routers to choose the best path to route the packet. The main characteristics and differences of the routing protocols and how they work for WSNs is presented in this step. This step includes that how to select the path, Control messages etc.

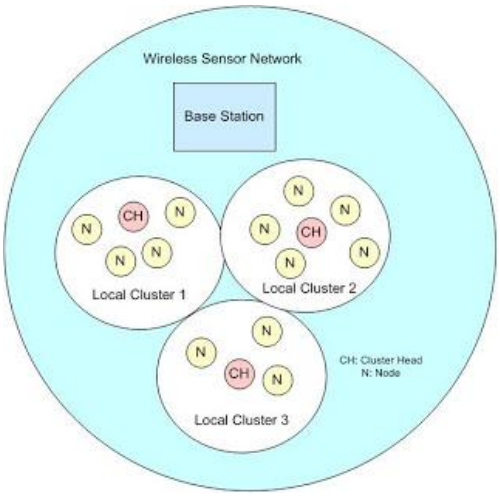


Figure 1: ***Wireless Sensor Network***

IV.BACTERIAL FORAGING OPTIMIZATION ALGORITHUM

Bacterial Foraging Optimization Algorithm was developed by Passion, it is a nature-inspired optimization algorithms. There are many more optimization algorithm such as PSO,GA and EP, which brings their inspiration from evolution and natural genetics [4-6], [14].Particle Swarm Optimization and Ant Colony Optimization portraits their way in effective manner in this domain. Using this Swarm-based Algorithms BFOA was proposed by Passion. The Key idea of BFOA is to grouping of E.coli bacteria in multi-optimal optimization. In order to maximize the energy bacteria search for nutrients per unit time. During the time of foraging the locomotion of real bacteria is obtained by a set of tensile flagella. It helps to swim and tumble; these are the two functions of bacteria during foraging time. While flagella rotate in clock wise direction, each flagellum pulls on to cells. Counter clockwise direction movement intimates the flagella to swim fast. Every bacterium communicates with each other with help of signals.

Foraging decision has been taken by bacteria ,the first phase in BFOA is Chemo taxis-search for nutrients and the important feature is to mimic the chemotactic motion, second phase is Swarming-groups the bacteria in concentric pattern to increase the density, third phase is Reproduction- less healthy bacteria die and healthier bacteria will multiply to maintain the constant size of swarm, fourth phase is Elimination and Dispersal-with the rise of high temperature and high nutrient gradients, the group of bacteria will die or move to new location. From the beginning, BFOA has revealed biological motivation and graceful structure. The major part of the research in BFOA are mathematical modeling, adaptation and algorithm modification.

COMPARING BFO ,GA AND PSO BASED ON

EVALUATION PARAMETERS

For analysis purpose, different parameters are compared to evaluate the best algorithm among BFO, GA and PSO. While comparing it has been proved that BFO gives good result [11].Hence BFO algorithm has been chosen to perform the cluster head selection process. Following table represent the comparison of BFO, GA and PSO [13] .

Table1-Comparison of BFO ,GA and PSO

Data name	Parameters	GA	PSO	BFO
Data 1	cohesion	.3079	.6850	.7120
	variance	.3910	.2910	.1634
	precision	.20	.31	.42
	recall	.29	.32	.40
Data2	cohesion	.4008	.6221	.7890
	variance	.2450	.2301	.2010
	precision	.32	.36	.39
	recall	.26	.34	.46
Data3	cohesion	.5087	.8012	.8490
	variance	.4960	.3810	.2816
	precision	.49	.52	.64
	recall	.31	.35	.40

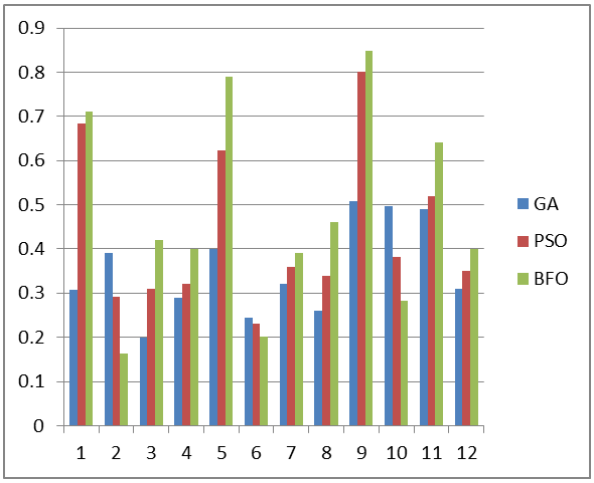


Fig 2:Graph representing comparison of BFO,GA & PSO

V.PROPOSED SYSTEM

1. FUZZY LOGIC

The proposed system has the main focus on calculating Fitness value for cluster head nodes. The fitness value of each node is varied depends upon the current value of centrality, residual energy, number of nodes, distance to the base station. The set of linguistic variables for the fuzzy logic are Low, Medium, High and Very high [1]. To minimize the computation work, number of rules is selected in these four parameters used in this logic. This system is used to calculate the cluster head competence radius. It uses mamdani inference system. The cluster head selection strategy is determined with help of clustering which is done by fuzzy logic, therefore improves network lifetime. Following explain detail about parameter used in proposed system,

TABLE 2- Fuzzy Rule for Purposed System and Graph.

Residual energy	Centrality	Number of neighbour	Distance to base station	Fitness
Low	Low	Medium	High	Low
Low	Medium	High	Low	Low
Low	High	Low	Medium	Low
Low	Low	Medium	High	Low
Medium	Medium	High	Low	Medium
Medium	High	Low	Medium	Medium
Medium	Low	Medium	High	Medium
Medium	Medium	High	Low	Medium
High	High	Low	Medium	High
High	Low	Medium	High	High
High	Medium	High	Low	High
High	High	Low	Medium	High

a) Residual Energy:

Residual energy is a remaining energy of the nodes after some work has been done. This will show the area where energy spent and from this remaining energy of each can be analyzed. Residual energy [8] helps to reduce the wastage of energy, increase speed, utilize energy efficiently to improve performance and saves energy. The formula used to represent residual energy is

$$P^{A}(e, T) = E(-e, T)$$

b) Centrality:

Centrality [8] defines the nodes role and importance in network of specified area. It provides service in fair load distribution. Data transmission between nodes will be balance correctly with help of centrality. The formula used to represent centrality is

$$\sum_{i}\sum_{j}\frac{gikj}{gij}, \qquad i \neq j \neq k$$

c) Number of neighbor:

Number of neighbor [10] reveals extends network lifetime. This parameter enlarges the area coverage to improve data delivery to base station. Numbers of neighbors were calculated by using in build operation in NS2.

d) Distance to base station:

This parameter balances the energy consumption in network and increases network throughput [10]. The formula used to represent distance is

$$D=S*T$$

Fitness formula: This the fitness formula used to evaluate the fitness of nodes [12],

$$F(k) = \eta\, e_k + \lambda / n - 1 \sum_{i=1, i \neq k}^{n} e_i / r_i + 1$$

Here, $\eta + \lambda = 1$, and $\eta, \lambda \in [0, 1]$, where e_i represent residual energy, ri represent the distance between the node and the current node k, λ represent the energy factor of the neighbor node i(i 6= k), η represent the energy factor of the current node k.

2. BFO

Bacterial Foraging Optimization Algorithm (BFOA) was developed by Kevin M.Passion (2002) is a nature-inspired optimization algorithm. BFOA is based on behavior found in nature. It mimics the search for bacterial behaviour which is in human intestine. This algorithm dictates the way of proceeding in the process and it consists of three phases namely, Chemo taxis, Reproduction and Elimination &Dispersal.

A.Chemotaxis:

The pattern generate by bacteria in presence conditions are known as chemo taxis. Two term tumble and swim involved in this process. A motion of bacteria in random direction known as tumble and a motion of bacteria in same direction is known as swim. This process, in this system utilized to check whether the node has to stay or not. This phase shows the run length of node from node to another.

B. Reproduction:

Here the least healthy bacterial die and healthiest bacteria then divided into two bacteria that are located in same place. This leads to constant bacteria population. In this paper, this phase used to determine the weak nodes and choose healthier node by considering the highest fitness of sensor node.

C. Elimination and Dispersal:

The chemo taxis phase is used for general search purpose and reproductions process used to speeds the moving object. This phase eliminates the weakest bacterial and selects the bacteria which provide high energy. This method eliminates the chemotaxis and reproduction phases since they are not enough for universal search. For our proposed system it provide service to select the best node and eliminate weakest node .It finds the weakest node and kill them then transfer it to another place inside the environment. And finally selects the high priority sensor node which is called as Cluster Head.

VI.SIMULATION

In this portion, the performance of proposed system for clustering using fuzzy logic with four parameter as inputs is presented.NS2 simulation is used for evaluating the proposed system. By using large number of sensor nodes, WSNs gives many applications. Each and every event is sensed by the sensor nodes and deployed in nearby nodes and then transmitted to the base station or remote processing unit. Main aim of using this simulation is time based approach, experiment take place in real life environment, testing process. NS2 majorly take part in validating test and make the demo for the user to use this proposed system. To provide accurate information in real time environment, WSNs is used to collect the data and process it in real time conditions. The surrounding area conditions are measured by the sensor nodes to give the exact information in order. The communication between the base station (BS) and the sensor nodes are made by the intermediate nodes. . Wireless technology provide its high potential with various application areas such as transportation, military, medical, natural disaster, seismic sensing and environmental. The main application of the Wireless sensor network is monitoring and tracking. This simulation process uses routing protocol for select the correct destination node for communication purpose. This simulation tool is used to evaluate the experiment without exposure to risk.

Simulation Tool:

NS-2.32 software is used in this study. It is mainly consists of two languages. They are OTCL and C++. NS2 use OTCL to create and configure the network, OTCL acts as the front end process and an interpreter. The use of OTCL can be broken down into four major steps. Creation of nodes (modeling) is the first step, agent creation, application for the respective agents and finish procedure. The use of C++ is the back end process which supports for packet transmission. It is used to give an executable file. It is used for large simulation.

VII.RESULT

Routing protocols for WSN and necessary implementations and analyzing its effect for critical condition monitoring application with the help of different parameters is done.

NS2 simulation is used for evaluating the system. By using large number of sensor nodes, WSNs gives many applications. Each and every event is sensed by the sensor nodes and deployed in nearby nodes and then transmitted to the base station or remote processing unit. Main aim of using this simulation is time based approach, experiment take place in real life environment, testing process.

Analysis of Results:

Figure 3: Initial step-No of nodes in environment.

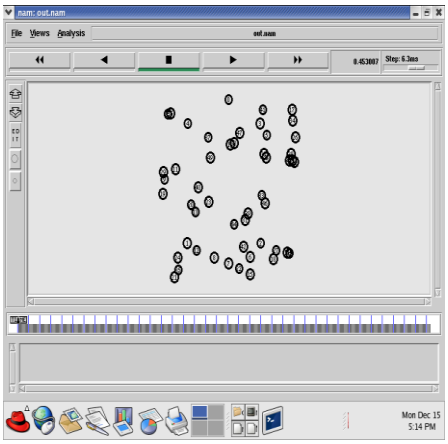


Figure 4: Cluster formation at beginning.

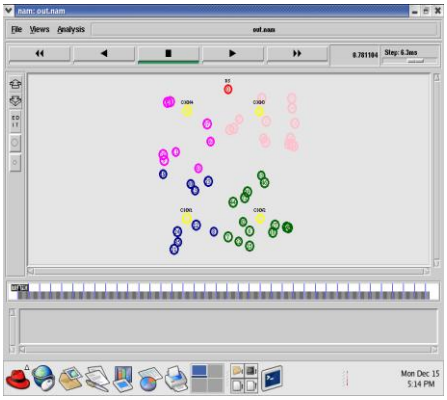
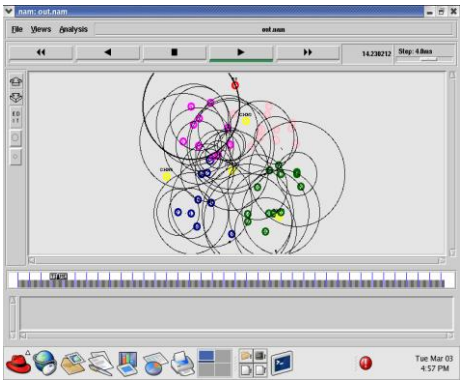


Figure 5:Data is forwarded from cluster head to base station



The result is represent that the routing protocol is selected by using different parameters and scenarios from simulation are analysed. Hence Cluster Head is selected with help of Fuzzy logic and BFO algorithm and as a result this system improves the network lifetime and efficiency of the Cluster Head.

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