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Energy Optimization in a Wireless Sensor Network based on Advanced PEGASIS using Bacterial Foraging Optimization in Chain

Gaganpreet Kaur[1], Daljeet Singh Bajwa[2]
[1]*M.tech Student, BBSBEC, Fatehgarh Sahib, Punjab, India.*
[2]*Assistant Proffesor, BBSBEC, Fatehgarh Sahib, Punjab, India.*

Abstract:- Bacterial Foraging Optimization (BFO) is a well-known biologically inspired technique for finding optimal solution to a problem. It is a heuristic search technique and a computational methodology based on mimicking the foraging behaviour of Escherichia Coli (E. Coli.) bacteria. BFO is a population based numerical optimization algorithm in which the self-adaptability of individuals in a group searching has drawn great deal of interest in researchers. The complex but organized activities exhibited in bacterial foraging patterns could inspire a new solution for optimization problems. This paper proposes an evolutionary based bacterial foraging algorithm as an energy optimization technique in a wireless sensor network for optimal utilization of energy and this is done by using Advanced Power Efficient GAthering in Sensor Information System (PEGASIS) using BFO in chain and thus reducing the distance between individual nodes. As Wireless Sensor Network's (WSN) are widely used in number of civilian and military applications. So due to limited battery life, energy conservation is a major issue to enhance network lifetime. The proposed method is evaluated in terms of performance of life time cycle by considering the energy level of the nodes and the alive nodes present in the network.

Keywords:- Sensor nodes, BFO, chain formation, network energy, number of rounds.

I. INTRODUCTION

A wireless sensor network (WSN) can be defined as a network of small embedded devices, called sensor nodes which communicate wirelessly with each other as well as with base station. Each node is a low power device that integrates sensing, computation and wireless communication capabilities [8] [11] [2]. Nodes are organized into clusters and networks and to perform an assigned monitoring task. Sensor nodes are battery driven devices and it is often inconvenient or impossible to recharge the battery as the sensor nodes can be placed in hostile environments. But on the other hand lifetime of a sensor network should be long enough to fulfill application requirements [4]. In this context of limited resources, it is necessary to design all the network components from the nodes hardware to the protocols, in order to obtain the minimum possible power consumption in an efficient way. Experimental measurements have shown that generally data transmission is very expensive in terms of energy consumption while data processing consumes significantly less.[3][4].Despite all the research attention received in the power optimization area, the problem of extending the lifetime of a WSN is still a big consideration. A number of routing protocols already exists which guarantee the minimization of energy dissipation in wireless system. Since the nodes sense data and if they are present too near to each other that redundant data is transferred to BS. Hence the algorithms try to minimize the energy by avoiding transmission of redundant information.

In this paper, we propose a new hierarchal routing protocol for stationary WSN called Advanced Power Efficient GAthering in Sensor Information System (PEGASIS) using BFO in chain for energy optimization. Chain formation is done between the sensor nodes with the help of BFO technique, as the bacteria will try to search for the nutrients and avoid noxious substances and at the same time they try to move towards other bacteria but not too close to them. In the similar way, the optimum use of energy is achieved by reducing the distance between individual sensor nodes as energy required to transmit data is directly proportional to the square of the distance [11].Due to the optimal use of energy, the network lifetime is also enhanced because now the sensor nodes can survive up to a longer time.

The rest of the paper is organized as follows: Section 2 explains related work; Section 3 explains the proposed algorithm. In section 4, we evaluate and analyze the performance of the proposed algorithm. In section 5, conclusion of the proposed algorithm is presented.

II. RELATED WORK

Energy conservation and network lifetime is a major issue in WSN. Several approaches have been proposed and developed to utilize energy and thus enhancing lifetime of a network. Some of these are discussed below:

Heinzelman et al. [13] proposes Low Energy Adaptive Clustering Hierarchy (LEACH), which is a cluster based hierarchal protocol. Energy usage is minimized by distributing the load to all the nodes in different points of time. Each node acts as a cluster head for its own cluster at different points of time and sends the aggregated information from its cluster nodes to the base station. The operation of LEACH is divided into set-up phase, in which formation of clusters takes place and steady state phase, in which data transfer, takes place. Thus distributing the energy between various sensor nodes becomes effective and therefore enhances network lifetime.

Lindsey et al. [10] works on Power Efficient GAthering in Sensor Information System (PEGASIS), which is a near optimal chain based hierarchal protocol and is an improvement over LEACH. In PEGASIS, each sensor node transmits its data to the closest neighboring sensor node by forming a chain and every node takes turn to transmit the fused data to the base station (BS). Due to which energy is balanced in the nodes and thus network lifetime is enhanced. PEGASIS is more efficient then LEACH protocol, as it eliminates the overhead of forming dynamic clusters and also only one node per round transmits aggregated data to the BS.

Kelvin M. Passino [7] proposed Bacterial Foraging Optimization Algorithm (BFOA), an evolutionary algorithm, for distributed optimization and control. BFOA is based on foraging behavior of E.Coli bacteria present in human intestine. BFOA is already been used to solve many engineering problems.

Bharathi M.A. et al. [1] presented a genetic algorithm, known as Bacterial Foraging optimization Algorithm (BFOA). BFOA is inspired by social foraging behavior of Escherichia .coli. As bacteria try to maximize their energy by searching for food and also avoid noxious substances. The energy conservation takes place by forming clusters, selecting cluster head nodes and data aggregation at cluster heads to minimize redundancy and thus enhancing network lifetime. BFOA over performs then other clustering algorithms like LEACH in terms of network lifetime and number of alive nodes etc.

III. PROPOSED ALGORITHM

The main objective of this work is to enhance the network lifetime by constructing a chain using BFO algorithm. Several optimization techniques are used nowadays in various fields of research, as these techniques provides optimized results in a few time, to the problems which cannot be solved by using mathematical calculations or hit and trial operations in longer period of time.

Network lifetime enhancement is achieved by decreasing the distance between individual nodes in a chain so that the power consumption to transmit the data is reduced and the sensor nodes can survive up to a longer lifetime.

BFO has following basic principal mechanisms:

- Chemo-taxis
- Swarming
- Reproduction
- Elimination- Dispersal

1. Chemo-taxis

The motion patterns that the bacteria will generate in the presence of chemical attractants and repellents are called chemo-taxis. For E. coli, this process was simulated by two different moving ways: run or tumble. A unit walk with the random direction represents a tumble and a unit walk in the same direction with the last step indicates a run [5]. A bacterium alternates between these two modes of operation in its entire lifetime. The bacterium sometimes tumbles after a tumble or tumbles after a run. The alteration between the modes will move the bacterium and this enables it to search for nutrients.

2. Swarming

For the bacteria to reach at the optimum food location in the search space, it is desired that the best bacterium till the point of time in the search period should try to attract other bacteria, so that together they find the best location more rapidly. Therefore, effect of swarming is to gather the bacteria into groups and move as concentric patterns with high bacterial density [9].

3. Reproduction

In the reproduction step, health status of the bacteria is determined. The least healthy bacteria die and the best set of bacteria get divided into two. The healthier half replaces the other bacteria, which gets eliminated due to their poor foraging strategies [9]. This keeps the population of bacteria constant.

4. Elimination-Dispersal

In order to avoid the stagnation (local optima) problem, elimination-dispersal event is performed after number of chemotactic and reproduction steps. In the elimination-dispersal process, individual bacterium is selected for elimination from the population and is replaced by a new bacterium located at random new location within the optimization domain [9].The best set of bacteria are moved to the another position within the environment (dispersed) and the remaining bacteria are killed (eliminated). The population of bacteria still remains constant [12].

In this proposed work, each sensor node communicates with other sensor nodes in the network by forming a chain between each other. All the sensor nodes, except the last node, will collect data from the previous neighbor node and fuses its own data with it and forwards an aggregated data to the next neighbor node. Last node will just forward data to the next neighbor node. Here, each sensor node is considered to be contained with bacteria and the parameter to be optimized represents coordinates (position) of the bacteria. Number of bacteria's is initialized (positioned) at each sensor node. Each sensor node in the network runs BFO to construct chain with the closest neighbor sensor node. After each progressive step the bacterium move to new positions (new coordinate values) and at each position fitness function is calculated and further movement of bacteria is decided with better fitness function (less cost function).This finally leads the bacteria to a position with highest fitness function.

The fitness function is taken as Euclidean distance to find out the distance between two individual sensor nodes and the health status of the bacteria.

$$\text{Fitness Function}=\sum_{i=1}^{i=n-1}\sqrt{((X_i-X_{i+1})^2+(Y_i-Y_{i+1})^2} \quad \ldots (1)$$

where, in Equation (1), n represents number of sensor nodes and X and Y are co-ordinates of sensor nodes.

In this technique, each bacterium takes steps (velocity) of some defined size in a particular direction to find its nutrient i.e. each sensor node try to find most suitable node in the chain means the node by linking with which the chain formation will be of minimum length (better fitness function).If the bacterium finds the most suitable nutrient gradient after that defined step size walk fulfilling the fitness function i.e. Euclidean distance, then it is called as a swim. If the most suitable nutrient gradient condition is not met at the immediate next step position, then the bacterium i.e. the sensor node look for the next node position to find the best neighborhood node or it will tumble i.e. bacterium will change its direction. The bacterium keeps on moving in same direction (swim) if the value of fitness function is increasing in that direction, otherwise bacterium will change its direction to search for a better fitness function (tumble). The process of swimming & tumbling of bacteria continues till all the nodes in a network get connected with optimum utilization of energy i.e. with the minimum length of entire chain covering all nodes yielding better value of fitness function. The algorithm starts constructing chain from node 1, which is nearest to the base station, till all the nodes in a network get linked with each other.

All the sensor nodes have same energy initially & the purpose of this proposed work is to optimize the energy of sensor nodes. All the sensor nodes are evaluated by their node energy. This evaluation defines the health status of the nodes present in the WSN network.

In this research, population of bacteria's is initialized in each sensor node i.e. each sensor node contains some defined bacteria, which are called parent bacteria. Each bacterium will move from one place to another for searching its food by following either swim or tumble mechanism. Fitness function is calculated after a complete chemo-taxis process. Locations of the healthier bacteria represent better sets of optimization parameters. Then, to further refine our research more number of bacteria is required to be placed at these locations, this is done in the reproduction step. Healthiest half of bacteria i.e. with minimum value of cost function/ minimum distance value, are let to survive, while the other half of them die. Each surviving bacterium splits up into two, called child bacteria and these two are placed at same location. In this way, population of bacteria remains constant. Selection of bacteria is done on the basis of better value of fitness function. Then in order to avoid the problem of local minima (assuming to be best fitness position), elimination- dispersal step is performed in which bacteria is eliminated from its present location and one bacterium is placed (dispersed) at random location in order to realize global search.

IV. PERFORMANCE EVALUATION

A. Network Environment Parameters:

In the proposed technique, 100 nodes are randomly deployed over a 1000m×1000m geographical region. MATLAB (Matrix Laboratory) software is used to evaluate the performance of this technique. The network environment parameters are illustrated in table 1.

Table I: The network environment parameters

Parameter	Value
Network Size	**1000m×1000m**
Base station location	**(995,995)**
Nodes	**100**
Initial Energy	**0.5J**
E_{elec}	**50nJ/bit**
EDA	**5nJ/bit**
Data packet size	**2000 bits**

Where, E_{elec} is the energy being dissipated to run the transmitter or receiver and EDA is energy of data aggregation [6].

B. Results

The goal of simulation is to compute network energy against the number of rounds and to determine number of alive nodes versus number of rounds.

Table II: Simulation results in terms of number of rounds against percentage of dead nodes

Percentage of dead nodes	Number of Rounds
1%	**62**
10%	**170**
25%	**258**
50%	**355**
75%	**430**

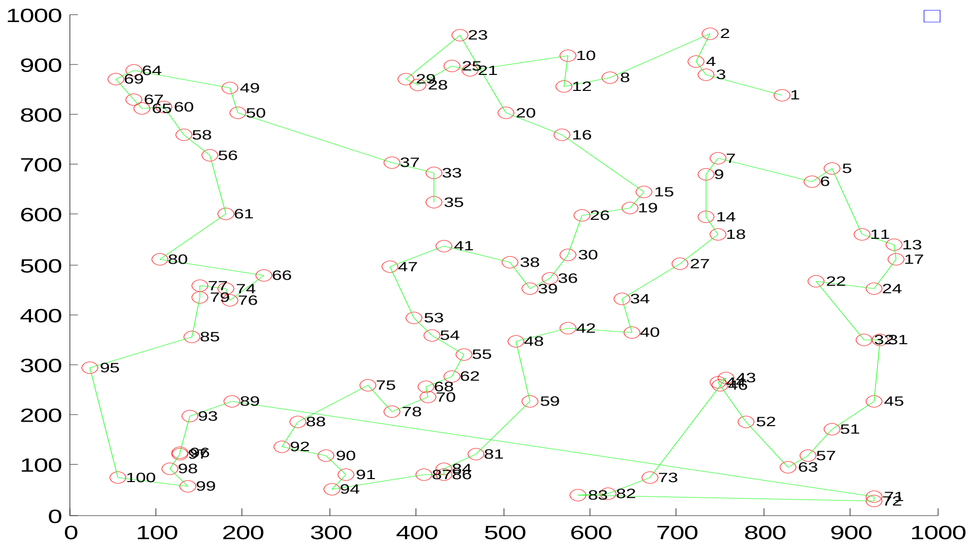

Figure1: The PEGASIS chain construction phase using Greedy Algorithm.

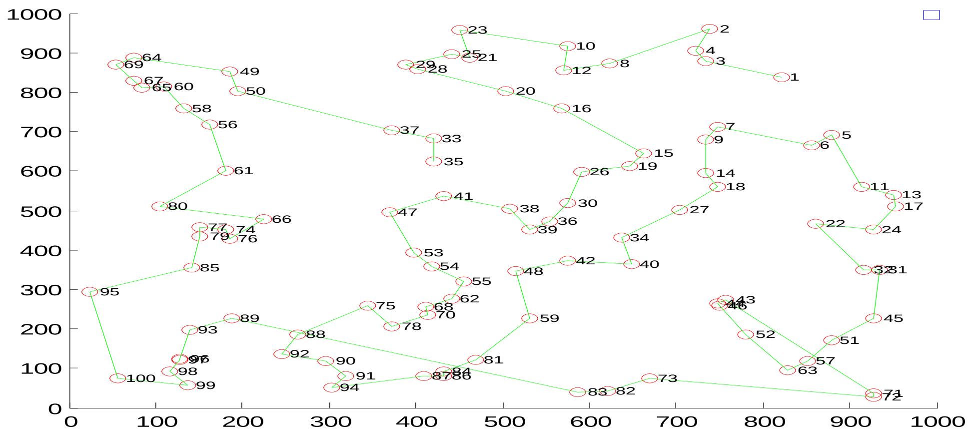

Figure2: Chain formation by Advanced PEGASIS using BFO

In Figure 1 and Figure 2, red circles represent sensor nodes and blue square represents BS. As, it is clear from Figure 1, that there exist some larger distances between various sensor nodes like 72 and 89, 72 and 82, 43 and 73 etc. Due to which energy consumption will be more and nodes can die at early stages of their operation. Therefore, these large distances are solved up to a greater extent, in Figure 2, by implementing Advanced PEGASIS using BFO in chain. Thus, building shorter chain as compared to PEGASIS and increasing lifetime of a network.

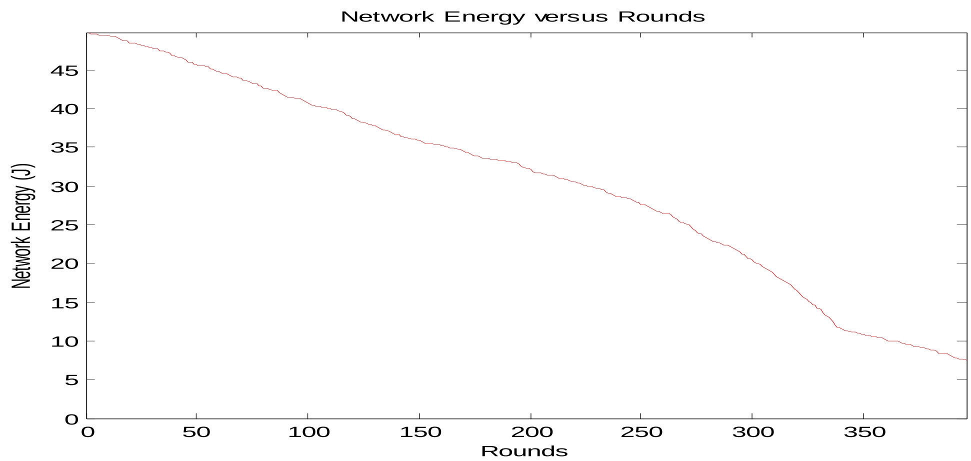

Figure3: Network energy v/s Number of rounds

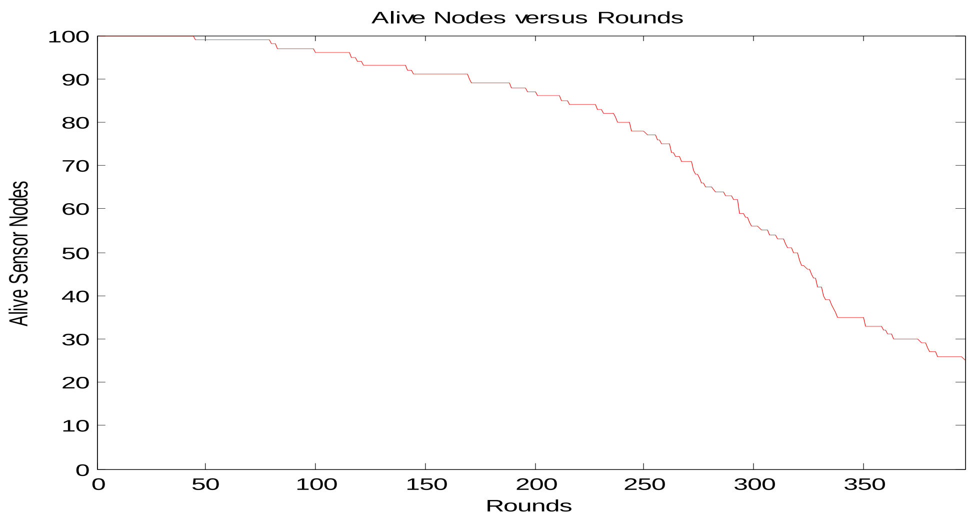

Figure4: Alive sensor nodes v/s Number of rounds

V. CONCLUSION

A new hierarchical routing protocol called Advanced PEGASIS using BFO in chain formation is proposed in WSN, which attempts to link all the sensor nodes in a network by as small distances as possible and thus optimizing the network energy and enhancing the network lifetime. The performance of this proposed technique is observed as better than that of the other chain formation techniques like Power Efficient gathering in Sensor Information System (PEGASIS), which uses greedy algorithm to build a chain. And the problem of long chain formation in PEGASIS is solved up to a greater extent. Also the chain based algorithms have advantages over cluster based algorithms because there is no overhead required which is associated in building clusters and also only one node takes turn to transmit aggregated information from all the nodes to the base station per round. As BFO uses a new chain construction algorithm, so it offers comparatively better performance.

REFERENCES

[1]. Bharathi M.A,B.P.Vijaya Kumar,Manjaiah D H," An Energy Efficient Data Redundancy Reduction Approach for Data Aggregation in WSN", Vol. 10, Issue 4,No. 1, July 2013,IJCSI.

[2]. B.V. Manikyala Rao, S. Pallan Setty, G. Lavanya Devi," Energy Efficient Routing Protocols in Wireless Sensor Network's." vol. 2, Issue 1, 2013, IJCC.

[3]. Cesare Alippi, Giuseppe Anastasi, Mario Di Francesco, Manuel Roveri,"Energy Management in Wireless Sensor Networks with Energy-hungry Sensors", IEEE instrumentation & measurement magazine, vol. 12, N.2, April 2009, pp.16-23.

[4]. Giuseppe Anastasi, Marco Conti, Mario Di Francessco, Andrea Passarella,"Energy Conservation in Wireless Sensor Network: A survey,"

[5]. Hanning Chen, Yunlong Zhu, and Kunyuan Hu,"Coperative BFO",Hinawi publishing Co-operation discrete dyanamics in nature & society,vol.2009,Article Id 815247,17 pages.

[6]. Hasan Al-Hasan, Mohammad Qatawneh, Azzam Sleit, Wesam Almobaideen,"EAPHRN:Energy – Aware PEGASIS-Based Hirarchal Routing Protocol for Wireless Sensor Networks. "Journal of American Science, 2011.

[7]. Kelvin M. Passino,"Biomimicry of Bacterial Foraging for Distributed Optimization and Control", IEEE control systems magazine, June2002, pp52-67.

[8]. Mourad Hadjila, Herve Guyennet, Mahammed Feham,"A Chain-based routing Protocol to Maximize the Lifetime of Wireless Sensor Network's.", Scientific Reserch, May 2013

[9]. Nikhil Kushwaha, Vimal Singh Bisht, Gautam Shah," Genetic Algorithm based Bacterial Foraging approach for optimization,"proceeding's of NCFAAIIA,2012, pp11-14

[10]. Stephanie Lindsey and Cauligi S. Raghavendra,"PEGASIS: Power Efficient Gathering in Sensor Information Systems", proccedings of IEEE Aerospace Conference.

[11]. T.Shankar, Dr.S.Shanmugavel,'Hybrid approach for energy optimization in cluster based WSN using energy balancing clustering protocol," vol.49 No.3, 31st March 2013, JATIT & LLS.

[12]. Vipul Sharma,S.S.Pattnaik, Tnauj Garg,"A review of Bacterial Foraging Optimization and its Applications", NCFAAIIA 2012.

[13]. Wendi Rabiner Heinzelman,Anantha Chandra Kasan, Hari Balakrishnan."Energy- Efficient Communication Protocol for Wireless Microsensor Networks", proceedings of Hawaii Conference on System Sciences, Jan 2000.