

A Systematic way of Soft-Computing Implementation for Wireless Sensor Network Optimization using Bacteria Foraging Optimization Algorithm: A Review

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ABSTRACT

The popularity of Wireless Sensor Networks (WSN) has increased tremendously in recent time due to growth in Micro-Electro-Mechanical Systems (MEMS) technology. WSN has the potentiality to connect the physical world with the virtual world by forming a network of sensor nodes. Here, sensor nodes are usually battery-operated devices, and hence energy saving of sensor nodes is a major design issue. To prolong the network's lifetime, minimization of energy consumption should be implemented at all layers of the network protocol stack starting from the physical to the application layer including cross-layer optimization. In Mobile ADHOC Networks (MANET) or Wireless Sensor Networks (WSN), the sensors or the mobile transceivers are randomly deployed in the sensor field which brings the problem of coverage for all or some of the nodes. As the coverage problem can increase overall effective distance of all nodes from the sensor which further affects overall throughput & power required by the system. It is a unique problem and in maximizing coverage, the sensors need to be placed in a position such that the sensing capability of the network is fully utilized to ensure high quality of service. The main objective of the paper is to find optimum route distance between nodes and sensors. And power should be less consummated between locations points and sensors an maximum utilization of bandwidth.

Keywords: Wireless Sensor Networks; Home Area Network; BFO; MATLAB

1. INTRODUCTION

Wireless Sensor Networks (WSN) have gained world-wide attention in recent years due to the advances made in wireless communication, information technologies and electronics field [6,9]. The concept of wireless sensor networks is based on a simple equation: Sensing + CPU + Radio = Thousands of potential applications [6]. It is an —In situ sensing technology where tiny, autonomous and compact devices called sensor nodes or motes deployed in a remote area to detect phenomena, collect and process data and transmit sensed information to users. The development of low-cost, low-power, a multifunctional sensor has received increasing attention from various industries. Sensor nodes or motes in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel.

WSN term can be broadly sensed as devices range from laptops, PDAs or mobile phones to very tiny and simple sensing devices. At present, most available wireless sensor devices are considerably constrained in terms of computational power, memory, efficiency and communication capabilities due to economic and technology reasons. That's why most of the research on WSNs has concentrated on the design of energy and computationally efficient algorithms and protocols, and the application domain has been confined to simple data-oriented monitoring and reporting applications. WSNs nodes are battery powered which are deployed to perform a specific task for a long period of time, even years. If WSNs nodes are more powerful or mains-powered devices in the vicinity, it is beneficial to utilize their computation and communication resources for complex algorithms and as gateways to other networks.

2. WIRELESS SENSOR NODE ARCHITECTURE

The basic block diagram of a wireless sensor node is presented in Figure 1.1. It is made up four basic components: a sensing unit, a processing unit, a transceiver unit and a power unit. There can be application dependent additional components such as a location finding system, a power generator and a 150obilize.

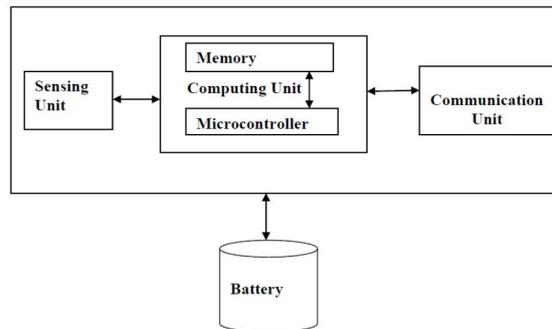


Figure 1.1: Architecture of a Wireless Sensor Node

3. APPLICATIONS OF WIRELESS SENSOR NETWORKS

According to a new report from research firm ON World —The home market for Wireless Sensor Networks (WSN) will reach US\$6 billion a year by 2012. The prediction includes both products and services centred on in-home energy management and health monitoring. Meanwhile, ON World predicts the market for "Home Area Network" (HAN) energy management solutions to reach 20 million homes worldwide by 2013.

Wireless Sensor Networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar. They are able to monitor a wide variety of ambient conditions that include temperature, humidity, vehicular movement, lightning condition, pressure, soil makeup, noise levels, the presence or absence of certain kinds of objects, mechanical stress levels on attached objects, and the current characteristics such as speed, direction and size of an object. WSN applications can be classified into two categories [3] as shown in Figure 1.2:

- Monitoring
- Tracking

In monitoring we have:

- Military security Detection.
- Habitat Animal Monitoring.
- Business Inventory Monitoring.
- Health Patient Monitoring.
- Environmental Monitoring.

In Tracking we have:

- Military Enemy Tracking.
- Habitat Animal Tracking.
- Business Human Tracking.

4. BACKGROUND WORK

Wireless sensor networks have their own unique characteristics which create new challenges for the design of routing protocols for these networks. First, sensors are very limited in transmission power, computational capacities, storage capacity and most of all, in energy. Thus, the operating and networking protocol must be kept much simpler as compared to other ad hoc networks. Second, due to the large number of application scenarios for WSN, it is unlikely that there will be a one-thing-fits-all solution for these potentially very different possibilities.

In 2002, Passino [1] proposed Bacterial Foraging Optimization Algorithm (BFOA) for distributed optimization and control. BFA is based on the foraging behavior of Escherichia Coli (E. Coli) bacteria present in the human intestine and already been in use to many engineering problems including multiple robot co-ordination. According to paper, BFA is better than Particle Swarm Optimization in terms of convergence, robustness and precision.

Bhakwad K.M. et al. (2011) in the paper entitled " Bacterial Foraging Optimization Technique Cascaded with Adaptive Filter to enhance Peak signal to Noise Ratio from Single Image [" proposed a new approach to enhance PSNR of highly corrupted image affected by impulse noise. The adaptive median filter is used to identify pixels affected by noise and replace them with median value to keep the information uncorrupted. The BFO technique minimizes error between adaptive median filter output image and noisy image to maintain an error percentage of 0.0001. The results of proposed method are superior to conventional methods in terms of perceptual quality as well as clarity and smoothness in edge regions of resultant image. This method can also remove salt and pepper noise.

Bio-inspired routing: In recent years insect sensory systems have been inspirational to new communications and computing paradigms, which have led to significant advances like bio inspired routing [4]. The most popular ACO (Ant Colony Optimization) is a colony of artificial ants is used to construct solutions guided by the pheromone trails and heuristic information they are not strong or very intelligent; but they successfully make the colony a highly organized society. Swarms are useful in many optimization problems. A swarm of agents is used in a stochastic algorithm to obtain near optimum solutions to complex, non-linear optimization problems [5].

5. OBJECTIVE OF THE WORK

- 1) Optimum route distance between nodes and sensors
- 2) Optimum or least power consumption between location points and sensors.
- 3) Maximum Bandwidth utilization.
- 4) Increase in Sensor Coverage.
- 5) Optimization of Mean location points of wireless sensors.

6. PROPOSED STEPS TO ACHIEVE THE OBJECTIVE

- With minimum number of sensor nodes having maximum coverage in the network and the nodes are within the communication range.
- By making optimized wireless clusters using the Euclidean distance from all the location nodes to the Sensor Nodes.
- By making the Clusters of the sensor nodes with a corresponding central transceiver point which will be further chosen from a group of sensors.
- By Optimizing the Sensors position within each individual cluster, using BFO.

7. BACTERIAL FORAGING OPTIMIZATION FOR CLUSTER HEAD SELECTION

Bacterial Foraging Optimization (BFO) [2] is a population-based numerical optimization algorithm. In recent years, bacterial foraging behaviour has provided rich source of solution in many engineering applications and computational model. It has been applied for solving practical engineering problems like optimal control [2], harmonic estimation channel equalization [10] etc. In this thesis, BFO has been used for cluster head selection to provide improved energy efficiency in routing.

7.1 Bacteria Foraging Optimization

The process of natural selection tends to eliminate animals with poor foraging strategies and favour the propagation of genes of those animals that have successful foraging strategies, since they are more likely to enjoy reproductive success. After many generations, poor foraging strategies are either eliminated or shaped into good ones. This activity of foraging led the researchers to use it as optimization process. The *Escherichia Coli* or *E. coli* bacteria that are present in our intestines also undergo a foraging strategy. The control system of these bacteria that dictates how foraging should proceed can be subdivided into four sections, namely, chemotaxis, swarming, reproduction, and elimination and dispersal.

7.2 Bacterial Foraging Optimization Algorithm:

The algorithm that models bacterial population chemotaxis, swarming, reproduction, elimination, and dispersal is given here (initially $j=k=l=0$). For the algorithm, updates to the θ_i automatically result in updates to P number of sensor nodes. The flowchart of the BFO is shown in Figure 4.2. The procedure of BFO is as follows.

- 1) First of all, get sample no of sensor nodes to be optimized
- 2) Initialize, the value of $p, S, N_c, N, s, N_{re}, N_{ed}, N_{pe}$ and the $c(i)$, $i=1, 2, \dots, S$. The initial values for the θ_i , $i = 1, 2, \dots, S$ must be chosen.
- 3) *Elimination-dispersal loop*: $l = l + 1$
- 4) *Reproduction loop*: $k = k + 1$
- 5) *Chemotaxis loop*: $j = j + 1$
 - a) For $i = 1, 2, \dots, S$, take a chemotactic step for bacterium i as follows.
 - b) Compute cost function $J(I, j, k, l)$. The cost function of the BFO is calculated in the following way: First sum the distance squares from each node to the CH for an one cluster. Then this value for all the clusters should be summed over.)
 - c) Let $J_{last} = J(I, j, k, l)$ to save this value since we may find a better value via a run.

7.3 Bacterial Foraging Optimization (Simulation)

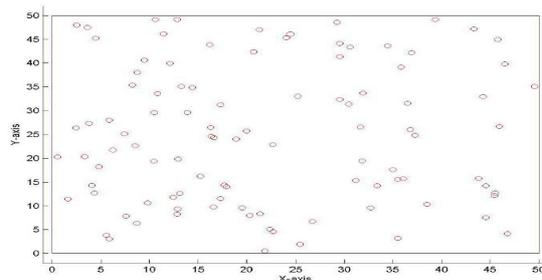


Figure 7.1 Initial positions of sensor nodes during simulation

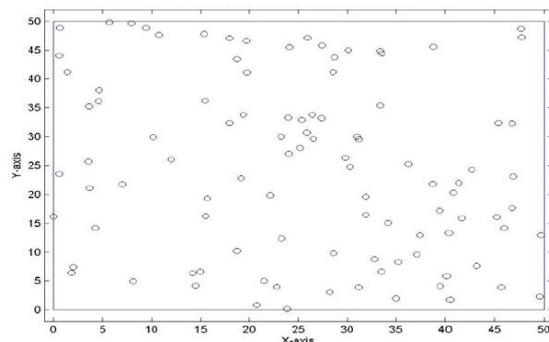


Figure 7.2 Random placement of sensor nodes in BFO

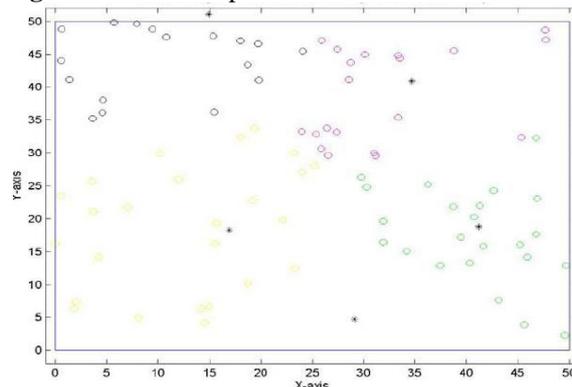


Figure 7.3 Clustering of sensor nodes in BFO

8. CONCLUSION

It is seen that BFO provides better performance than other popular techniques. However, the computational complexity of BFO for applicability to WSNs still remains a challenge. The use of Bacteria foraging algorithm firstly for WSNs for enhancing network lifetime of sensor nodes. To validate the algorithm, simulations had been carried out using MATLAB. Simulation results showed better performance of BFO as compared to other clustering protocols.

9. FUTURE DIRECTIONS

To conclude the paper, the following are some suggestions for the future work which can be done. In this paper, bio-inspired clustering algorithm Bacteria Foraging has been used. Other bio-inspired algorithms like Ant colony optimization, artificial Immune system, Genetic algorithm (significant time and power consuming) can also be compared to BFO; but the challenge of reducing computational complexity still remains. Comparable study of computational complexity of different algorithm need to be analyzed.

REFERENCES

- [1] K. M. Passino, "Biomimicry of bacterial foraging for distributed optimization and control," *Control System Magazine, IEEE*, vol. 22, pp. 52-67, June 2002.
- [2] Babita Majhi and G. Panda and A. Choubey, "On the Development of a New Adaptive Channel Equalizer using Bacteria Foraging Optimization Technique," in *Annual IEEE india conference*, 2006, pp. 1-6.
- [3] Wokoma, L.L. Shum, et al., "A biologically inspired clustering algorithm dependent on spatial data in sensor networks," in *Proceedings of the Second European Workshop on Wireless Sensor Networks*, 2005, pp. 386-390.

- [4] B. Atakan, O.B. Akan, and Tuna Tugcu, "Bio-inspired Communications in Wireless," in *Guide to Wireless Sensor Networks*.: Springer-Verlag London Limited, 2009, ch. 26, pp. 659-687.
- [5] J. Y. Yu and P. H. J. Chong, "A survey of clustering schemes for mobile ad hoc networks," *Communication Surveys and Tutorials, IEEE*, vol. 7, no. 1, pp. 32-48, 2005.
- [6] M. Chatterjee, S. K. Das and D. Turgut, "WCA: A Weighted Clustering Algorithm for Mobile Ad Hoc Networks," *Cluster computing, Springer Netherlands*, vol. 5, pp. 193-204, April 2002.
- [7] A.W. Krings Z. (Sam) Ma, "Bio-Inspired Computing and Communication in Wireless Ad Hoc and Sensor Networks," *Ad Hoc Networks, Elsevier*, vol. 7, no. 4, pp. 742-755 , June 2009.
- [8] S. Selvakennedy, S. Sinnappan, Yi Shang, "A biologically-inspired clustering protocol for wireless sensor networks," *Computer Communications, Elsevier*, vol. 30, pp. 2786-2801, 2007
- [9] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," *Communications Magazine, IEEE*, vol. 40, pp. 102-114, 2002.
- [10] KM Bakwad¹, SS Pattnaik¹, "Bacterial Foraging Optimization Technique Cascaded with Adaptive Filter to Enhance Peak Signal to Noise Ratio from Single Image" in the Department of ETV and ECE, National Institute of Technical Teachers' Training and Research, Chandigarh , 2011.