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# Soft Computing Implementation for Mobile Ad-hoc Network Optimization using Bacteria Foraging Optimization Algorithm

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***Abstract:*** **A mobile ad hoc network (MANET) is a network that has many free or autonomous nodes, often composed of mobile devices or other mobile pieces that can arrange themselves in various ways and operate without strict top-down network administration. It is often used to describe solution that are developed on the fly for a specific purpode.In computer networking an ad hoc networking refers to a network connection established for a single session. In Mobile ADHOC Networks (MANET) the mobile transceivers or sensors 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 goal of the paper is to implement a new soft computing technique, which is inspired from the earlier living beings the "Bacteria" and is known as Bacteria Foraging Optimization. As it works same as the bacteria find out their food in a specific set of area it is generally called BFO.**

***Keywords:*** **MANET, BFO, Sensor Coverage, BFOA, Closest Centroid**

## I. INTRODUCTION

An ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any established infrastructure or centralized administration. In such an environment, it may be necessary for one mobile host to enlist the aid of other hosts in forwarding a packet to its destination, due to the limited range of each mobile host's wireless transmissions. Much effort has gone into mobile ad-hoc network (MANET) research over the past decade. Yet, even today, mobile ad-hoc networking is seen as a relatively new area of research. The reason for this can be traced to the fact that the maturity in truly understanding these networks is still alarmingly low and actual deployment of these networks rare. An ad-hoc or short-live network is the network of two or more mobile devices connected to each other without the help of established infrastructure contrast to a fixed wireless network, an ad-hoc network can be deployed in remote geographical locations and requires minimum setup time and administration costs. Moreover, the integration of an ad-hoc network with a bigger network- such as the Internet-or a wireless infrastructure network increases the coverage area and application domain of the ad-hoc network. Mobile ad-hoc sensor networks are very beneficial in different scenarios. These networks advance operational MANETs are a kind of wireless ad hoc networks that usually has a routable networking environment on top of a Link Layer ad hoc network. The growth of laptops and 802.11/Wi-Fi wireless networking have made MANETs a popular research topic since the mid 1990s. Many academic papers evaluate protocols and their abilities, assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other. Different protocols are then evaluated based on measure such as the packet drop rate, the overhead introduced by the routing protocol, end-to-end packet delays, network throughput etc. Wireless Networks are being intensively utilized for monitoring and controlling the physical environment. They have been widely used in habitat monitoring, environmental monitoring, smart home building and military applications among many others. As sensor nodes are becoming cheaper and monitoring area size is becoming larger, more number of sensor nodes are required to be deployed in the area under surveillance. Manual deployment of sensor nodes is rigorous and inefficient for deploying large number of sensor nodes in a larger area. This problem becomes more complex for irregular terrain area. Sensor deployment has received considerable attention in recent times. Various soft computing techniques are used, now days to solve the problem of optimization in a given technical scenario. In wireless and ADHOC Network scenario we can also use the optimization techniques like Particle Swarm Optimization (PSO), Genetic Algorithm (G.A.), and Artificial Bee Colony Optimization (ABCO) etc can be used to optimize the route, sensor as well as node location, through-put & Bandwidth as well as the power consumption. Natural selection tends to eliminate animals with poor "foraging strategies" (methods for locating, handling, and ingesting food) and favour the propagation of genes of those animals that have successful foraging strategies since they are more likely to enjoy reproductive success (they obtain enough food to enable them to reproduce). After many generations, poor foraging strategies are either eliminated or shaped into good ones redesigned). Logically, such evolutionary principles have led scientists in the field of “foraging theory” to hypothesize that it is appropriate to model the activity of foraging as an optimization process: A foraging animal takes actions to maximize the energy obtained per unit time spent foraging, in the face of constraints presented by its own physiology (e.g., sensing and cognitive capabilities) and environment (e.g., density of prey, risks from predators, physical characteristics of the search area). Evolution has balanced these constraints and essentially “engineered” what is sometimes referred to as an “optimal foraging policy” (such terminology is especially justified in cases where the models and policies have been ecologically validated). Optimization models are also valid for “social foraging” where groups of animals cooperatively forage.

## II. PROBLEM FORMULATION

The deployment of the sensors is most critical as well as most essential task for the optimization of the Network. If the deployment will be optimized then only the challenges like

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

These challenges can be achieved:

- 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

## III. METHODOLOGY USED

An area to be covered by a set of location point Pi denoted by coordinate (xi, yi) where is a point in the terrain of size m X n, with a number of rows and columns. We represent each sensor node location as the centroid of location points it has to cover.

### *A. Sensor Coverage*

A sensor with a sensing range $r$ placed on a location point ($x1$, $y1$) can cover a location point ($x2$, $y2$) if the Euclidean distance between these two points is square root of $(x1 - x2)2 + (y1 - y2)2 \leq r$ (1) Thus, a location point is said to be covered if it lies within the sensing range of the sensor node deployed at the centroid.

### *B. Mean of the location points*

The mean value of the location points ($xi$, $yi$) for $i$ =1, 2, · · ·$M$, is represented by ($mx$, $my$), where $mx$ is mean of summation of all xi and $my$ is mean of summation of all yi.

### C. *Closest Centroid*

A location point $Pi$ is closest to centroid $Sc$ *if distance* ($Pi$, $Sc$) $\leq$ *distance* ($Pi$, $Sj$) $\forall j$, $j$ = 1, 2 . . . $R$ cluster centroids.

We represent each centroid by the mean value of location points within the sensing range. It attempts to divide the whole location area *’A’* into *’R’* regions by minimizing the Euclidean distances between location points and their closest centroid. Where *’R’* is the number of sensor nodes. The sensor deployment problem can be formulated as an optimization problem and defined as: Given a set of location points ($P$) and fixed no. of sensors ($R$), find the optimum location for deploying all $R$ sensors such that every location point is covered, and the required sensing range is minimum.

Objective Function

$$F = \forall R,\ \forall j(max(distance(SR, Pj)))$$

Where $SR$ is the sensor deployment point and $Pj$ is the location point, distance refers to the Euclidean distance calculated. The objective is to minimize $F$ such that the sensing range required covering all the location points is minimum using BFO.

## IV. BACTERIA FORAGING OPTIMIZATION AND CLUSTER FORMATION PHASE

### A. *Bacteria Foraging Optimization*

Bacterial Foraging Optimization (BFO) is a recently developed nature-inspired optimization algorithm, which is based on the foraging behaviour of E. coli bacteria. Up to now, BFO has been applied successfully to some engineering problems due to its simplicity and ease of implementation. However, BFO possesses poor convergence behaviour over complex optimization problems as compared to other nature-inspired optimization techniques. This paper first analyses how the run-length unit parameter of BFO controls the exploration of the whole search space and the exploitation of the promising areas. Then it presents a variation on the original BFO, called the adaptive bacterial foraging optimization (ABFO), employing the adaptive foraging strategies to improve the performance of the original BFO.

This improvement is achieved by enabling the bacterial foraging algorithm to adjust the run-length unit parameter dynamically during algorithm execution in order to balance the exploration/exploitation trade-off. The experiments compare the performance of two versions of ABFO with the original BFO, the standard particle swarm optimization (PSO) and a real-coded genetic algorithm (GA) on four widely-used benchmark functions. The proposed ABFO shows a marked improvement in performance over the original BFO and appears to be comparable with the PSO and GA.

### *B. BFO works in the following aspects:*

**a)** A new adaptive strategy, namely, the producer-scrounger foraging, to dynamically determine the chemotactic step sizes for the whole bacterial colony during a run, hence dividing the foraging procedure of artificial bacteria colony into multiple explore and exploit phases;

**b)** A new self-adaptive foraging strategy, namely, the area concentrate search, to respectively tune the chemotactic step size for each single bacterium during its run, hence casting the bacterial foraging process into heterogeneous fashion;

**c)** A comprehensive study comparing ABFO1 and ABFO2 with another two state-of-the-art global optimization algorithms, namely, GA and PSO, on high dimensional functions;

**d)** Single and colonial bacterial behaviors in both ABFO1 and ABFO2 that were simulated respectively in order to analyze in depth the adaptive and self-adaptive foraging schemes in the proposed models;

**e)** New results on benchmark functions up to 300 dimensions.

### *C. Cluster Formation*

Every node sends its position information to the base station. A certain number of nodes are elected to act as the auxiliary cluster-heads with a certain probability. According to the number of auxiliary cluster-heads, the network is divided into the same number of clusters evenly. If no node dies, the number of auxiliary cluster is fixed and also the number of members in every cluster is same means fixed to construct the cluster , the base station starts with the furthest node from it as the first auxiliary clus.ter heads, which chooses the nearest fixed number of nodes as its member nodes. then the base station chooses the furthest node from it as the second auxiliary cluster-head from the rest nodes , which chooses the nearest fixed number of nodes as its members. This process continues until all the auxiliary cluster head and members are chosen out. the base station sends notification to all the nodes in the network. According to this procedure, if no sensor node dies in the network, this cluster construction is stable. The network owns the same auxiliary cluster heads and every auxiliary cluster head owns the same members.

## V. BFO ALGORITHM AND CLUSTER FORMATION ADJUSTMENT

### *I. Bacteria Foraging Optimization Algorithm*

Bacteria foraging optimization algorithms is a well known computational methodology which is base on the study of the bacterial foraging behaviours .the complex but organized activities exhibited in bacterial foraging patterns could inspire a new solution for optimization problem. The under lying mechanism of the surviving of bacteria, especially E. Coli in a complex environment has been reported by researchers in the area of biological sciences. Inspired from these phenomena, BFOA was developed as an optimization algorithm by K.M. Passino in which the self – adaptability of individuals in the groups searching activities has attracted a great deal of interests. The classical bacterial foraging optimization systems consists of thee principle mechanisms namely chemotaxis, reproduction and elimination and dispersal. The algorithm of the proposed BFO techniques is as follows:

Step1: Initialization of the following parameters:
P: dimension of the search space
S: the number of bacteria in the population
$N_{c:}$ number of chemotatic
$N_S$: the length of the swim when it is on the gradient
$N_{re}$: the number of reproduction steps
$N_{ed}$: the number of elimination/dispersal events
$p_{ed}$ :the probability that each bacterium will be eliminated/dispersed
C (i): initial run length unit
X: the initial random location of each bacterium

Step2: Elimination/dispersal loop l=l+1

Step3: Reproduction loop k=k+1

Step4: Chemotaxis loop j=j+1
for i=1,2.........S,execute the chemotactic step for each bacteria as follows :

- Evaluate the cost function J(i,j,k,l) using following equation
  $J(i,j,k,l)+J_{cc}(X,P)$
- Let $J_{last}$ =J(i,j,k,l)so that the lowest cost could be found
- Tumble : generate a random vector $\Delta(i)R^p$ and $\Delta_m(i)$ , m=1,2............p is a random number in the range [-1,1]
- Computer $\psi(i)$
- Move using $X^i(j+l,k,k)=X^i(j,k,l)C(i)\psi(i)$
- Compute J(i, j+1 ,k, l) and use
- $J(i,j,k,l)+J_{cc}(X,P)$ to compute $J_{cc}$ (X,P(j,k,l)) then use to find the new J(i,j+1,k,l).
- Swim let m=0(count the swim length)
  While $m<N_s$ (no climbing down too long)
- Let m=m+1

- If $j(i,j+1,k,l) < j_{last} = J(i,j+1,k,l)$ then take another step in the same direction and compute the new $J(i,j+1,k,l)$
- Go to next bacterium $(i+1)$ if $i \neq S$

Step5: if $J<N_c$ goto step 4($j=j+1$)

Step6: Reproduction for the given k and l evaluate the health of each bacterium i as follows

$$J^i_{health} = \sum_{J=1}^{N_c+1} N \quad J(i,j,k,l)$$

The length of the bacterium i measures how many nutrient it got over its lifetime

- Sort bacteria according to their $J^i_{health}$ in asending order
- The bacteria with the highest $J^i_{healt}$ values compute by following equation

$$J^i_{health} = \sum_{J=1}^{N_c+1} N \quad J(i,j,k,l) \text{ die while other } S_r$$

With the lowest value split and take same location of their parents

Step7: if $k<N_{re}$ go to step 3($k=k+1$)

Step8: Elimination/dispersal with probability $p_{ed}$ randomly eliminate and dispersal each bacterium i , keeping the size of the population constant.

Step9: if $l<N_{ed}$ go to step 2($l=l+1$) otherwise end

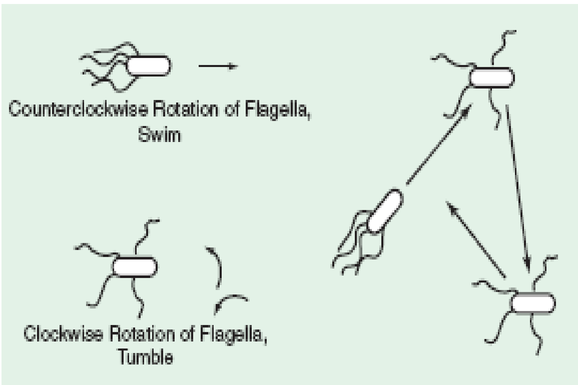


**Fig:1** Cluster Adjustment

The auxiliary cluster heads are not the final cluster heads and BFOA is used for the adjustment. The algorithm is employed by every node. Auxiliary cluster heads then decide the final cluster heads by BFOA after every member node sends its position and residual energy information to its auxiliary cluster head. Each auxiliary cluster head the position of the final cluster head and sends notification to the final cluster head and other members in the cluster. In this phase the BFOA is used by the auxiliary cluster head for the adjustment. We can use a fitness function which is based on the relative distance of each node from auxiliary cluster head and the residual energy of each node. On the basis of this fitness function and at the end of all chemo taxis steps we can find suitable position for each sensor node. At last the bacterium or all sensor nodes in the cluster send their relative position and residual energy to the auxiliary cluster heads. Then the auxiliary cluster head compute the final cluster head position. Now suppose before starting iteration all the bacteria are present at their real position and after iteration all the bacterias are present at their suitable position. Then the most suitable position is mapped into one of the real positions of the nodes in the cluster.

Auxiliary cluster head do this mapping according to:

$$D_{min} = \min \{ \|P_b - P_1\|, \|P_b - P_2\|, \|P_b - P_3\| ....... \|P_b - P_n\| \}$$

Hear $P_b$ = real position

$P_n$ = suitable position

Then the real position of certain node with $D_{min}$ will be chosen to the position of cluster head which means that the nearest node from the $P_b$ will act as the final cluster head.

## VI. RESULT

The figure shows the best performance done by the simulation in BFO.Simulation influence value works well it represents the best BFO optimal results.

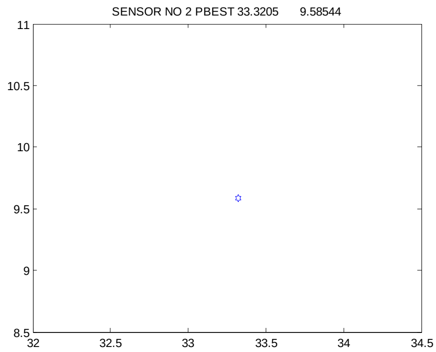


**Fig : 2** Best Point of sensor node in BFO

## VII. CONCLUSION AND FUTURE SCOPE

In this paper a new approach is proposed for finding global optimum solution for MANET. The dynamic nature of the problem is enables the algorithms to gain additional information by storing the information obtained during the optimization steps by using BFOA. It is seen that BFO provides better performance than other popular techniques. To validate the algorithm, simulations had been carried out using MATLAB. Simulation results showed better performance of BFO as compared to other clustering protocols. To conclude the paper some suggestion can be done for future work in this paper the algorithm is inspired by clustering algorithm known as Bacteria Foraging algorithm. Other bio inspired algorithms like Ant colony optimization, Generic algorithms and Particle Swarm Optimization can comparable study of computational complexity of different algorithm need to be analyzed.

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