Artificial Bee Colony Based Energy Efficient Routing Protocols in MANET: A Survey

[1.]Akhil Dubey, [2.]Deepak Meena
[1,2.] .M.Tech. Scholars, Dept. of Computer Science & Engg.
IEC-College of Engineering & Technology
Greater Noida, U.P., INDIA

[3.] Rajnesh Singh
[3.] Associate Professor, Dept. of Computer Science & Engg.
IEC-College of Engineering & Technology
Greater Noida, U.P., INDIA

***Abstract*--Now a day in computer science there are many exciting research being done all around of globe. In that routing protocols in MANET have vital place and more challenges for the scholars due to its limited bandwidth, power constraint and dynamic nature. Over the last ten or eleven years there are many efforts have been done by the researcher to make the energy efficient routing protocols either by doing modification in routing protocols or by developing new routing protocols like minimum energy routing protocol. But due to these modifications, network overhead occurs and it causes of the overall network degradation. So to heal this problem some researchers introduce swarm intelligence based algorithms for energy optimization in MANET. Basically swarm intelligence is a branch of entomology which deals with the study of the behavior and interaction of social insects like ants, bees, fire flies etc. The swarm intelligence based energy efficient routing protocols are based on the behavior of foraging insects. This collective behavior of insects helps to find the shortest path from hive to food sources. So in this paper we give the comprehensive study of energy efficient routing based on artificial bee colony optimization. We describe the behavior of the bees and artificial bee colony algorithm. Then we discuss bio inspired or predictive routing for MANETs.**

Keywords—MANET, Energy Efficient Routing, Swarm Intelligence, BCO, Bio Inspired Routing, PEEBR

I. INTRODUCTION

Mobile ad hoc networks [1] are a combination of different asymmetric wireless devices which are infrastructure less and create anywhere anytime. In this network devices are small and more powerful and make network as a fastest growing network. The devices of in this network are able to detect the other devices and create set up and provide the facility of communication, sharing data and perform other necessary actions. Due to ad hoc nature and mobility topology may rapidly change and in changing routing environment it more challenging to provide energy efficient routing. In MANET power resource and limited battery resources is the main constrain. Many scholars present many routing protocols that are classified as energy efficient protocols that are define in [2]. There are three main algorithms define in [3] for efficient routing which is given below-

A. Energy Efficient Routing

Each node which decides to forward packets that are wanted to send packet for a certain destination to a neighbor based on the minimum transmission power between this sending node and its neighbors.

B. Cost Efficient Routing

Every node chooses its neighbors to send the packet to the destination of the minimum cost. The cost function is defined as the sum of the cost of sending node to its neighbor plus the estimated cost of the route from its neighbor to the sender destination node.

C. Power-Cost Efficient Routing

It is the combinations of both above routing algorithms. According to this sender node use both routing techniques.

So in this paper we present the five sections. In second section we present the swarm intelligence approach, in third we give the bee colony optimization, in forth we present ABCO based different energy efficient routing and then conclude our paper in last section.

II. THE SWARM INTELLIGENCE APPROACH

In 1999 Bonabeau et. Al defines the Swarm intelligence is as a quality of artificial and natural systems involving multiple individuals interacting with each other and provides the environment to solve complex problems showing a collective intelligent behavior. In the swarm intelligence is the study of systems like colonies of ants and termites, schools of fish, flocks of birds, herds of land animals and Some human artifacts also fall into the domain of swarm intelligence. The properties of swarm intelligence are that it composed of many individuals behavior. In it the animals are either all identical or belong to a few other typologies. The acts on each other among the animals are based on simple behavioral rules that make use of local information exchanged directly or via the environment. The overall behavior of the system results from the interactions of individuals with each other and with their environment [4].

The main advantages of swarm intelligence are first flexibility that means the group can quickly suitable to a changing environment. Second is robustness that means even when one or more insects fails, the group can still perform its tasks. Third is self organization that means the group needs relatively little supervision or top down control. These properties make swarm intelligence a successful design paradigm. There are mainly two swarming intelligence techniques first is ant colony optimization and second is bee colony optimization. In this paper we present artificial bee colony based optimization [5].

III. ARTIFICIAL BEE COLONY OPTIMIZATION

Like the ant colony optimization Artificial Bee Colony Optimization (BCO) model is a new and basic general purpose Swarm Intelligence (SI) optimization technique which is based on efficient labor employment and efficient energy consumption and called as multi-agent distributed model. In the Ant Colony Optimization (ACO) model we adopted mainly one natural insect behavior which is the food searching. The main aims to discover the shortest path between the home and the food source place but from BCO model we adopted mainly two natural behaviors which is the social bee's life like the mating process behavior and the foraging process behavior [6].

In the bee colony model there are three types of bees Female Queen Bee, Male drone bees, Worker bees [7].

A. Queen Bee

The main work of queen bee is to laying egg which is used to develop a new colony because there is only one queen bee in the hive.

B. Male Drone Bees

In the hive there are two types of male drone bees first is ***Food Packers Bees*** the work of food packer bees is to serve the queen help it in laying the eggs. The second is ***Nurses Group Bees*** which is responsible for feeding the queen and the babies.

C. Worker Bees

. In the worker bees group there are three types of bees, first is Scouts Bees, main work is to discover the food. Second is Forager Bees, main work is to check the quality of food. Third is Primary Worker Bees, main work is to collect the food from the sources.

The bee colony algorithm is based on worker type's bees. In the bee colony algorithms scoot bees are responsible for the discovering the all possible food sources. After finding that they doing waggle dance to guide the forager bee and give them food direction in the sun defined angle. The forager bees are responsible for checking the quality of the food and also guide the worker bees to the food sources from the hive. The worker bees are responsible for the taking the nectar from source by following onlooker wangle dance.

Now we see the flow graph diagram of artificial bee colony optimization is given below-[9]

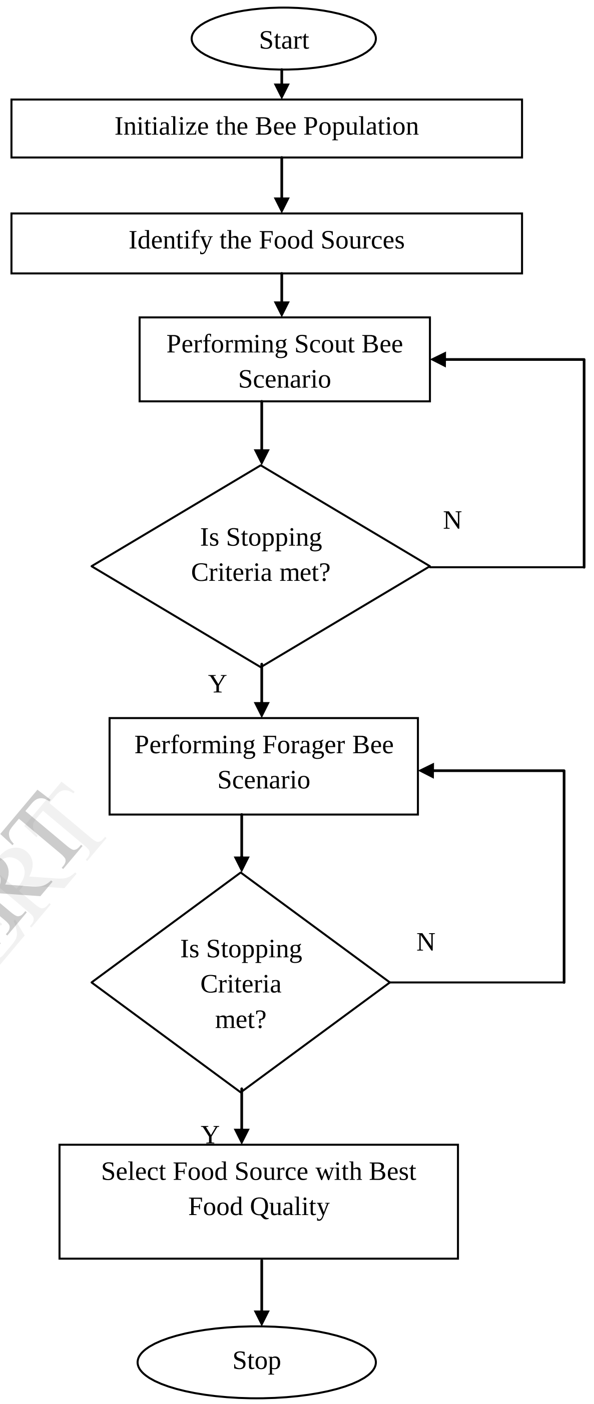

Fig 1. Flowchart for Basic BCO Steps

The algorithm for artificial bee colony optimization is given below-[8]

Step-1 start the algorithm

Step-2 first of all initializes the population of the worker bees

Step-3 then in artificial bee colony optimization performing path exploration like scout bees discover the path

Step-4 after finding the different paths by arranges the paths in decreasing order according to its distance.

Step-5 now checks the path quality like work of forager bees and rearranges the path according to the nectar quality

Step-6 after deciding the forager Path by performing path Exploration select the final path like forager bees

Step-7 finalizes and stops the algorithm

In the bee colony optimization there are some mathematical phenomenon define in [7]. Distance measurement is the first which is generally used for evaluating similarities between patterns.

$$J(w,z) = \sum_{i=1}^{N} \sum_{j=1}^{K} wij \|Xi - Zj\|^2 \quad (1)$$

Where Given N objects, each object is allocated to one of K clusters, J(w,z) is the Euclidean distance and Xi (i = 1, ... , N) is the location of the ith pattern and Zj G= 1, ... , K) is the center of the J^{th} cluster, can be calculated as

$$Zj = \frac{1}{Nj} \sum_{i=1}^{N} wij\ xi \quad (2)$$

Where N, is the number of patterns in the jth cluster, Wij the association weight of pattern Xi with cluster j, which will be either 1 or 0. When the bee find the good nectar food in other location then bees forget the old position and memorized the new position. The cost function for the pattern i (f.) can be calculated as

$$fi = \frac{1}{Dtrain} \sum_{j=1}^{Dtrain} d\left(xi, Pi^{CL\ known\ (xj)}\right) \quad (3)$$

Where Dtrain is the number of training patterns which is used to normalize the sum that will range any distance within [0.0, 1,0] and ($Pi^{CLknown(xj)}$) defines the class that instance belongs to according to database. The nectar quality or fitness fit_i can be define as

$$Fit_i=1/1+f_i \quad (4)$$

Where fi is the cost function of the clustering problem
And Pi is define as

$$Pi = \frac{fiti}{\sum_{n=1}^{SN} fitn} \quad (5)$$

To produce the candidate food position in memory from the old one the following formula is used in ABC.

$$Vij= Zij + \Phi ij(Zij- Zkj) \quad (6)$$

Where k E {I, 2... SN} and j E {I, 2... D} are randomly chosen indexes. Although k is determined randomly, it has to be different from i. Φi,j is a random number between [-1,1]. It controls the production of neighbor food sources around Zij and represents the comparison of two food positions visible to a bee.

The simulation of ABC is done by producing a position randomly and replacing it with the abandoned one. So the limit of the abandoned source is z_i and j ϵ {I, 2... D}, then the scout discovers a new food source to be replaced with z_i, this operation can be defined as

$$Z^i{}_i= Z^i{}_{min} + rand\ (O, l)(Z^i{}_{max} - Z^i{}_{min}) \quad (7)$$

After each candidate source position Vi,j is produced and then evaluated by the artificial bee, its performance is compared with that of its old one.

So in this section we present the bee colony optimization now we see the artificial bee colony based energy efficient routing techniques in next section.

IV. Energy Efficient Routing Based On Artificial Bee Colony Optimization

In the area of routing protocol in MANET there are many protocols are developed time to time by the authors. In swarm intelligence based routing scholars pay more attention on the ant colony optimization. But in this section we present some main protocols which are based on artificial bee colony optimization. These routing schemes are given as follows-

A. Bee Ad Hoc Routing Scheme

The routing schemes based on artificial bee colony, used in MANET are called as bio inspired routing. Now we presenting the first scheme based on ABCO. It is based on the searching method and foraging method of the honey bee. As I told earlier it is based on working bee model which has two bee scout bees and forager bees. The bee ad hoc architecture is depicted in detail in figure 2.

In this scheme [11] every node is consider as the hive with three floor entrance, dance floor and packet floor. Now we describe the working of these three floors separately.

In the ad hoc network the protocols for routing is defined as in the transport layer. So according to the diagram the node hive is lye in between network layer and application layer. So entrance floor is work as the interface for the media access control protocol of the network layer and deals with incoming and outgoing packets. If the hive node is the internal node then at the entrance scout received the packet if it has live time and broadcast it further. In a table the scout id and source node information is stored. If replica is already receive then killed it. If in dance floor forager has the same destination then scout has been appended to it. If current node is the destination node then forager sends it to packing floor otherwise forward it to MAC layer to the next node.

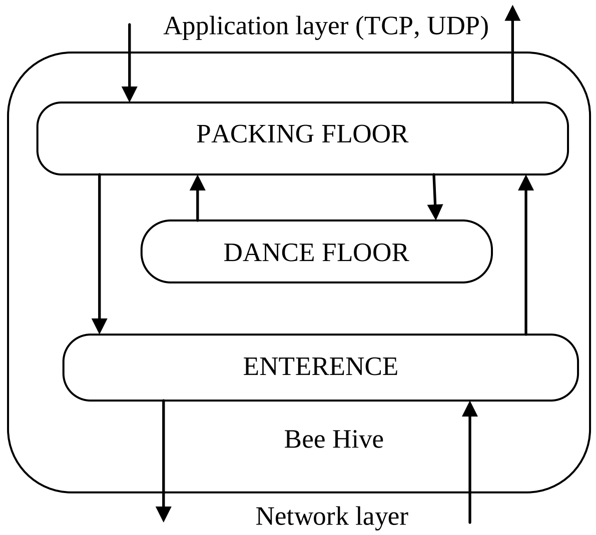

Fig 2. Overview of the bee ad hoc architecture [10]

Packing layer is providing the interface to the transport layer and received data from it. At once the data is come then it the packer to it. Packer stores the data packet. And it locket the new forager to it form the dance floor. If packer finds the perfect forager then it will hand over the data to it and dismiss.

Dance floor is the important floor for this routing scheme. All important decision has been taken in this floor. According to the quality of path forager appoint the new forager after returning its journey that it traversed. By the remaining power of the nodes lying on its route forager decide the quality of route. The cloning of forager may be allowed many times in two conditions. First, route is good if all nodes of the route have enough remaining power and second is if the nodes lying on the route have less power because packers are waiting for foragers then we called it this route is not good. One other condition is that route is good, no packers are waiting for foragers because other is doing nice job in data transporting. This scheme is firmly based on scout and forager concept of swarm intelligence, through this many forager are regulating for each route.

B. PEEBR

The PEEBR [12] means Predictive Energy Efficient Bee Routing algorithms. It is also the bio inspired routing algorithm. It deliberates selection energy conversion and evolution during routing. It is also based on scout and forager bee concept of bee colony optimization. In this during the traveling node to node along with the routing path scout bee collects energy consumption and delay parameters. And forager assigns the routing path according to check the goodness of the routing path. It has two main phases. The first phase named Node-level for battery power saving and in second phase choosing the path with energy consumption, named network level. According to the network level energy consumption there are two main information's find about the energy of the path. First is how many energy is residual in the battery of the all nodes. Second is how many energy is consumed in transporting the data in the given routing path. We show this example by the figure 3.

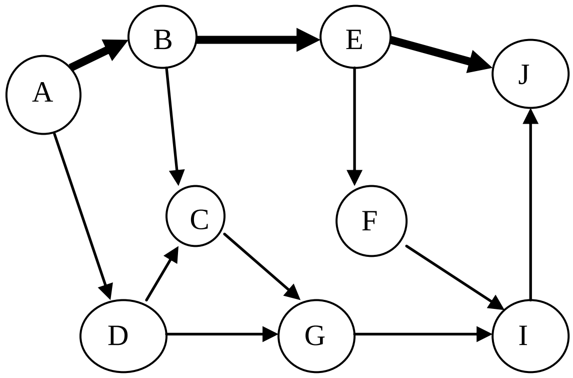

Fig 3. Example of path discovery process using bee agents[13]

According to this figure there are 3 routes from source A to J like A-B-E-J, A-D-G-I-J and A-B-E-F-I-J but according to the algorithm the energy efficient path is A-B-E-J show bold in the figure.

Now we show the algorithm proposed in [12]. According to this algorithm our motive is to select the energy efficient route. Now we have the information about source node and the destination node. We can start the procedure by searching the all possible optimal path with potential M. Every source node sends the scout for search the path according to it s time to live by the beacon massage and collect every information about the energy. If time to live is expired then it will reverse back. When scout agent reach to destination it reverse back by the same route that recorded to the source. Now the backward agent becomes forager. Packet has the information about the discovered path like battery power residual Pm. where i=1 to N nodes on each path j and the number of nodes $h(P_j)$ and end-to end delay $D(P_j)$. Now source node calculate the total energy consumption by each node over the path by the given formula $E(n_i)=Et(Pn_i)+Er(Pn_i)+Eo(Pn_i)$ where E(p) = i * v * t p and Et (p) = 280mA * v * t p where E(p) is the energy required for packet transmission *i* represents the current consumption, v is the voltage used. $E_t(p)$ is the energy consumed by the node in transmit mode. $E_r(P)$ is the energy consumed in reception mode. And $E_r(p) = E_o(p)$ = 280mA * v * tp and tp is

$tp = \frac{ph}{6*10^6} + \frac{pd}{54*10^6}$ Where Ph is the packet header size and Pa is the packet data size. Energy consumption will be calculated as

$$E(Rj) = h(Rj)*Er(p) \qquad (8)$$

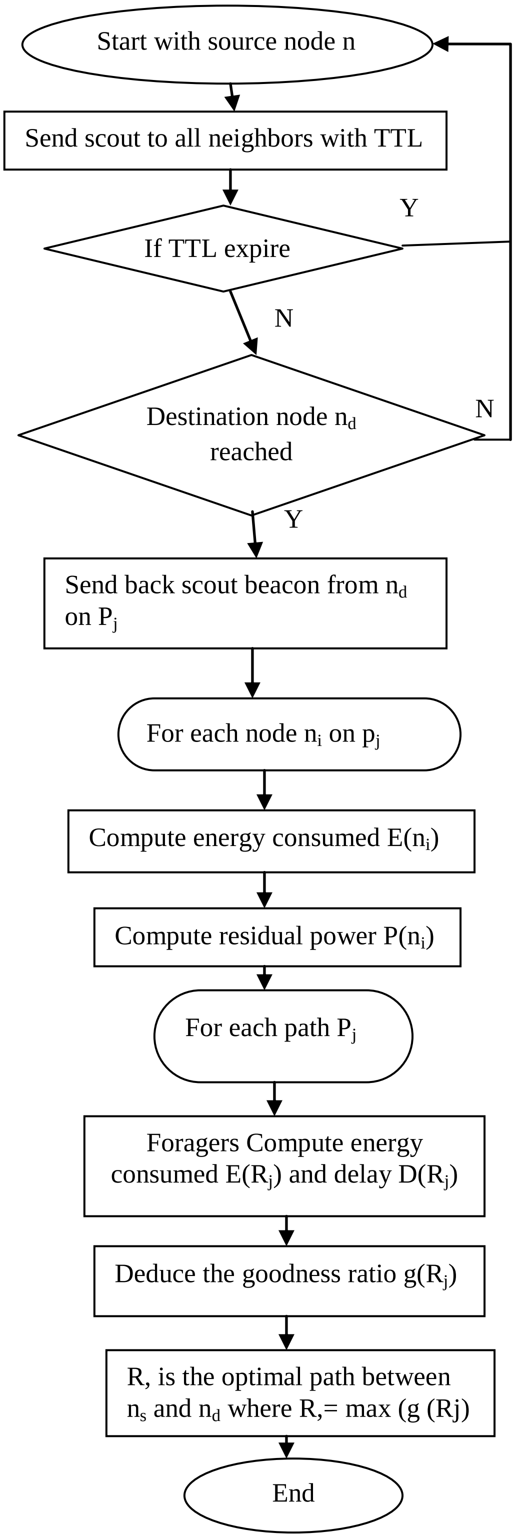

Fig 4. PEEBR algorithm flow chart [12]

Where h(Rj) is the number of hops over a path Rj and Er(P) is the amount of energy consumed during reception of a packet p. the end to-end propagation delay is calculated as

$$D(Rj) = \sum_{i=1}^{N} d(nji, nji + 1) \quad (9)$$

Where N is the number of nodes on path R, d(nji,nji+l) is the propagation delay between each node i on path j and the next node i+1 on the same path. Finally goodness of all path can be calculate by

$$g(Rj) = \frac{E(Rj)*D(Rj)}{\sum_{j=1}^{M} E(Rj)*D(Rj)} \quad (10)$$

Then the forager decide the optimal path with highest goodness path by this formula Ro= max (g(Rj)). After deciding the path other path will be discarded. The flow graph of this algorithm is shown in figure 4.

C. Dynamic Shortest Path Routing using ABC

In [14] authors present the scheme about the dynamic shortest path routing problem. This is also based on artificial bee colony optimization. In this scheme four phases first is initialization phase in which the population of food are initialized and define the paths. Second phase is employed bees phase in which discovery of new food occurs by Employed bees. Third phase is on looker bee phase in which the quality of food is checked and last phase is scout bee phase in which bee trying to improve the quality of food by searching.

So in this section we present the energy efficient routing schemes based on artificial bee colony optimization in swarm intelligence.

V. CONCLUSION

A mobile ad hoc network plays an important role in communication and natural calamities. It was vastly used in environmental monitoring like through it we can effectively act to prevent the consequences of floods or aware form it through signal communication. The ad hoc networks have been deployed in any where for monitor in real time. Ad hoc network also use at the time of earthquake. At the time of national disaster energy constraint is the main factor. So in this paper we have presented the different classes of routing protocols and different routing schemes which is based on artificial bee colony optimization, a field in swarm intelligence. Through this technology routing is makes easy and energy efficient at the time of natural disaster. In future we will try to present some different routing techniques and give the comparative simulated result with ant colony protocols.

ACKNOWLEDGEMENT

We all of us would like to thanks to lord Krishna and goddess Durga. We all of us would like to thanks our head of the department of our college computer science and engineering.

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