# Energy Efficient Bee routing Algorithm in Wireless Mobile Networks

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*Abstract :***Over the last decade, numerous research efforts have been made to develop energy-efficient routing protocols for the Mobile Ad-hoc wireless Networks MANET. However, these energy-efficient protocols have added an overhead on the network and its nodes which could result in overall network performance degradation. A new swarm intelligent routing algorithm inspired from Bees; the Bees Colony Optimization (BCO) model is introduced. The proposed work is to study and analyze the working of the Energy Efficient Bee Routing algorithm, for amount energy consumption along each of the potential routing paths between source and destination. The results were presented based on Simulations made with Implementation in NS2 (Network Simulation). A detailed comparative study is made with proposed algorithm under mobility and network size scenarios**

*IndexTerms* - **Energy Efficient routing; MANET; Bee Colony Optimization; bio inspired routing**

## I. INTRODUCTION

### I - Introduction

The increasing demand for wireless mobile communication, especially in situations where traditional infrastructure communication networks do not exist or were destroyed, has encouraged the appearance of the infrastructure less Mobile Ad hoc Networks commonly referred to as (MANETs).

A mobile ad hoc network (or MANET) [5] is a group of mobile, wireless nodes which cooperatively form a network independent of any fixed infrastructure or centralized administration. The mobile nodes are usually small, battery-powered elements. The base stations are at fixed locations and have an unlimited energy store. Mobile nodes communicate only with the base stations, which moderate communication and provide internode routing and fixed network connectivity. A MANET is characterized by energy-constrained mobile nodes, bandwidth-constrained, variable-capacity links and unpredictable, dynamic topology. In particular, a Manet has no base stations: a node communicates directly with nodes within wireless range and indirectly with all other nodes using a dynamically-computed, multi-hop route via the other nodes of the Manet.

Swarm Intelligence [1] involves a collective behavior of autonomous agents that locally interact with each other in a distributed environment to solve a given problem. Bee colony optimization model is a new paradigm of SI mainly needs two types of agents for routing: scouts who discover on-demand new routes to the destinations and foragers who transport data packets and simultaneously evaluate the quality of the discovered routes based on energy amount expected to be consumed along the path and the end-to-end delay. The foragers sense the state of the network, utilize measured metrics to rate different routes in MANET, and then choose appropriate path for routing of data packets with the aim of maximizing network lifetime.

Energy consumption [5] at the network interface is an issue for all mobile computing devices, whether they operate within a base station infrastructure or in a free-standing mobile adhoc network (MANET). Though universally recognized as an important issue in the design of Manet protocols, energy consumption has not been used as criteria in their evaluation. Evaluating the energy consumption of network protocols requires a compromise between two goals: a precise estimate of energy consumption and high-level insight into protocol behavior.

### II – Bee Colony Optimization[1]

Bee Colony Optimization (BCO) model is a new general purpose Swarm Intelligence (SI) optimization technique based on efficient labor employment and efficient energy consumption through a *multi-agent distributed* model. Unlike the Ant Colony Optimization (ACO) model, that has adopted mainly one natural insect behavior which is the "food search" that aims to discover the shortest path between the ant colony and the food source, BCO model has adopted mainly two natural behaviors from the social bees life.

Inside the bees hive, bees are divided into five groups plus the queen bee (or queen bees). The bee swarms staying in the hive are the "food packers" group and the "nurses" group responsible for feeding the queen and the babies. The three other groups are those involved in the *food search process:* The "scouts", the "foragers" and the "workers". By *distributing* the food search process among three troops of bees, the energy consumed by each bee to find a certain food source will be reduced and hence the search trip time will be proportionally minimized through three phases of search: First, discovering all potential sources by the scouts. Then, assigning each discovered source a certain probability according to its quality (nectar amount interpreted as the link cost) by the foragers to allocate an equivalent number of workers (interpreted by the number of hops between the source and the destination). Finally, collecting nectar by worker bees according to the qualification probability assigned by the foragers (choosing the optimal path according to its quality to begin sending the data stream on it).

The proposed routing protocol will utilize the bee foraging process. In this process, there are three main groups of bees

- The scouts: responsible of discovering all possible food sources (all paths). Then, they guide the foragers to their position from the hive by the *"waggle dance"* that shows the food direction. The angle from the hive between the sun and food source as illustrated by figure 1.
- The onlookers (or foragers): responsible of qualifying the discovered food sources (in terms of nectar amount and quality) to employ and guide the swarm of worker bees to their direction from the hive.
- The workers (or employed bees): the bee swarm that follows the onlooker's waggle dance in order to reach the qualified food source to collect the nectar. After abandoning the food source, a worker bee could transform to a scout to search the next potential food sources

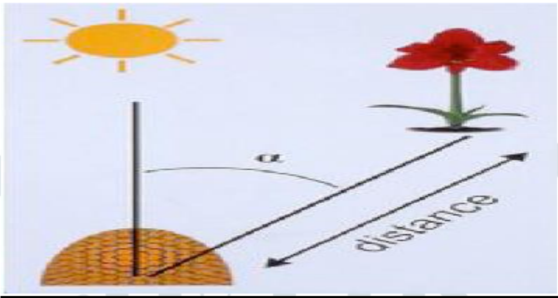


*Fig 1*

**ARCHITECTURE OF BEEADHOC[6]**

Each node in MANET has a hive, which consists of three parts: packing floor, entrance and dance floor. The structure of the hive is shown in Figure 2. The entrance is an interface to MAC (Medium Access Control) layer while packing floor is an interface to transport layer. All packets depart/ enter the hive through the entrance. The dance floor contains the foragers (routing information) for routing of data packets originated at the node.

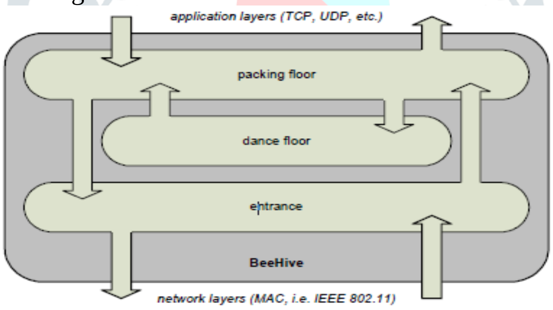


*Fig 2*

**III – PROPOSED EEBR: ENERGY EFFICIENT BEE ROUTING ALGORITHM**

The proposed MANET routing protocol PEEBR is a bee inspired algorithm. EEBR considers energy conservation during route discovery, evaluation and selection as discussed in the following sub-sections

**MANET Routing Challenge:** The main problem to be solved by the MANET routing algorithm is a *multi-constraint path problem.* Algorithms to solve this category of problems are heuristics to reduce the complexity of the path computation, but unfortunately, at the expense of unreachable optimal solution but rather finding a feasible solution. The path computation algorithm is the core of the routing algorithm. Instead of using a shortest path algorithm based on statically configured metrics, as in traditional routing protocols, the algorithm must select several alternative paths that are able to *satisfy a set of constraints* regarding, for instance, end to end delay bounds and energy requirements.

By applying the Bee Colony Optimization model on MANET routing algorithm mechanism, it will help finding the optimal path between a certain source node and a destination node among multiple possible paths through *multi-bee agent search.* Additionally, this optimal path (solution) associated with the highest "fitness" or quality, should also consume the least battery power while routing the data stream between the source and the destination. This could be realized by predicting the amount of energy to be consumed by all the nodes along the path. It helps providing a reliable, adaptive, flexible and energy-efficient routing technique for the infrastructure less wireless MANET networks.

**EEBR Algorithm Design:** The proposed Energy Efficient Bee Routing (EEBR) is a swarm-based energy optimization algorithm that uses two bee agents: The first is the *scout* bee that collects energy consumption and delay parameters while travelling from node to node along the routing paths. Then, each routing path will be assigned a goodness ratio by the *forager* bee EEBR algorithm has two main phases: The first is implemented on Node-level for battery power saving and the other is applied on Network-level for choosing the paths with the optimal energy consumption using Bees Colony Optimization (BCO) in routing.

**EEBR Node-level Energy Consumption Computation:** The node in MANET is generally a mobile wireless device that has a limited rechargeable battery. The decentralized nature of MANETs implies that each node should fulfill the routing (relaying) function beside its communicating function as a transmitting or receiving point. Therefore, in such distributed environment, in order to maintain a satisfactory performance of the overall ad-hoc mobile network, each node should efficiently consume its battery power while transmitting, receiving or routing.

**EEBR Network-level Energy Optimization Algorithm:** The energy information about a path should reveal:
• *Each node's battery power residual:* if it is below a certain predetermined threshold, then the whole path cannot be selected to transmit the data packets
• *The total energy to be consumed by the path nodes:* This parameter will indicate the efficiency of the path from energetic point of view, in order to route the packets over the path that consumes less energy. The path that consumes less energy is often with the least number of hops since it will pass by the least number of nodes.

**EEBR Energy Optimization Algorithm:**
The proposed energy efficient model inspired by the *BCD* swarm intelligent model is an optimization model for the MANET. It could be summarized as shown by figure 3. In the flow chart of the PEEBR algorithm, the optimal path discovery process from source n, to the destination node n, as follows:
1) Each source node n, in order to route efficiently its packets to a destination node nd, can start its routing path discovery procedure to define the optimal path among all potential M paths to the destination node nd'
2) For path discovery, each node ns sends bee agents (via beacon messages) over the M potential paths associated with a TTL (Time To Live predefined in order to prevent longer delays and increased routing overhead) to all neighboring nodes. The bee agent (scout) message will collect and save all required routing information including the battery power residual which is considered as a key metric beside other information as queuing delay.
3) If the TTL packet expires, the bee agent packet will indicate failure to the source and the path is rejected.
4) When a bee agent reaches the destination node nd,it is sent
5) back to its source n, through the same recorded path after collecting all required routing information. The backward bee agent (became a forager) packet will reveal its discovered path information depending on each potential path nodes: battery power residual Pm.) where i=1 to N nodes on each path j, the number of hops h(Pj ) and end-toend delay D(Pj ).
6) At the source node, the amount of energy to be consumed should be calculated as a function of the number of hops h(Pj) times the total amount of energy consumed by each node over the path given by expression.
7) The energy consumption *E(Rj)* will be calculated using expression (13) and the propagation delay *D(Rj )* using expression (13) and the propagation delay *D(Rj )* using
8) Finally, the goodness ratio of each path g(R j ) will be deduced from expression (15) by the forager to determine the optimal path R, that is the path with the highest goodness ratio as given by expression (16) in terms of energy expected to be consumed, number of hops and end-to-end delay in order to route the data packets on this path from the source node n, to the destination nd' The other potential routing paths could be used if any problem or failure occurred during transmission on the optimal path but with respect to their goodness ratio.

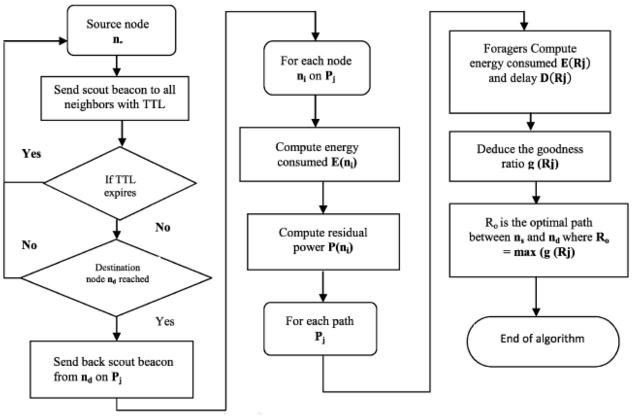


*Fig 3*

**IV-Simulation Model and Parameters:**
We use NS2 to simulate our proposed protocol in our simulation; the channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In our simulation, 16 mobile nodes are placed in a 1500 meter x 1500 meter rectangular region for 100 seconds simulation time. All nodes have the same transmission range of 250 meters. The simulated traffic is Constant Bit Rate (CBR).

| | |
|---|---|
| No of nodes | 16 |
| Area Size | 1500X1500 meters |
| Mac | 802.11b |
| Radio range | 250 meters |
| Simulation Time | 200 Seconds |
| Traffic Source | CBR |
| Packet Size | 128KB |
| Mobility Model | Random Waypoint Model |
| Initial Energy | 0.5 Joules |
| Pause Time | 0,20 |

Table 1 Simulation Settings and Parameters

**Performance Metrics**

**Routing Overhead**

Routing Overhead can be defined as the total number of messages transmitted during the simulation. Delivery Ratio Packet Delivery Ratio can be defined as the number of received packets divided by the number of generated data packets.

**Delay**

This represents the average delay based on packet rates.

**End-to-End Delay**

The End-to-End delay is averaged over all surviving data packets from the sources to the destination. This includes all possible delays caused by buffering route discovery latency, queuing at the interface queue, retransmission delays at the MAC and propagation and transfer times.

**Packets Dropped**

It is the number of packets dropped.

**Energy Consumption**

The total consumed energy divided by the number of delivered packet.

**Throughput**

It is the number of packets received successfully. It can also be defined as the total amount of data a receiver actually receives from sender divided by the tome taken by the receiver to obtain the last packet .

The proposed Bee routing is implemented using NS-2. The snapshot is given in figure 1 – 3. In which, the figure 1 shows that the initial network configurations, with some nodes are located. The figure 2 shows that routing information flooded against all mobile nodes

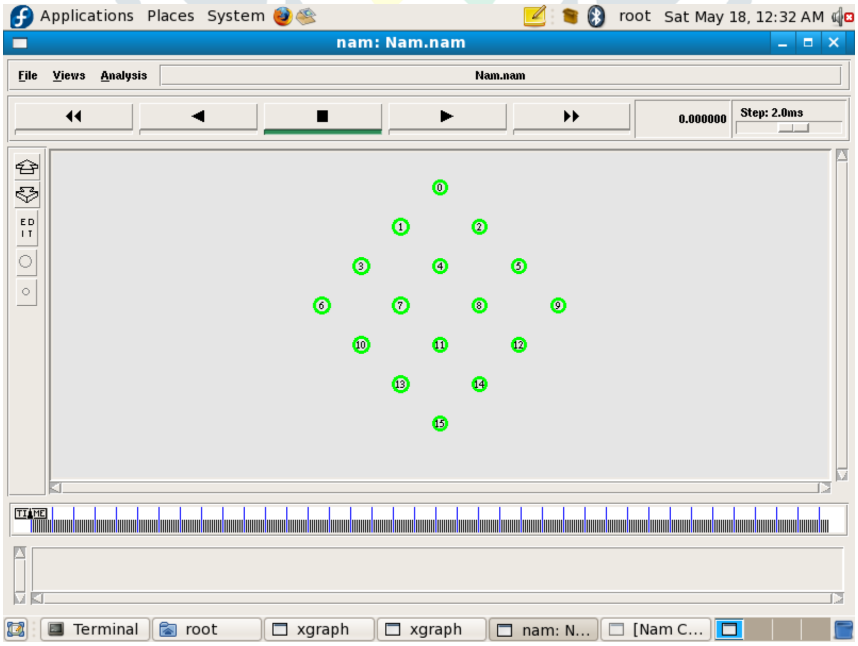


**Figure 1:** Initial Network Configuration which has 16 nodes

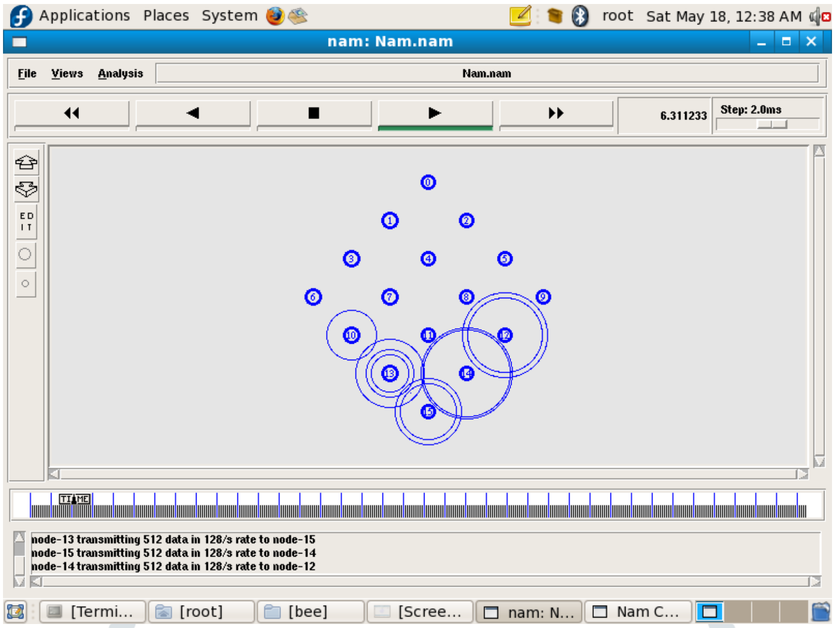


**Figure 2:** Routing Information in proposed using bee routing algorithm



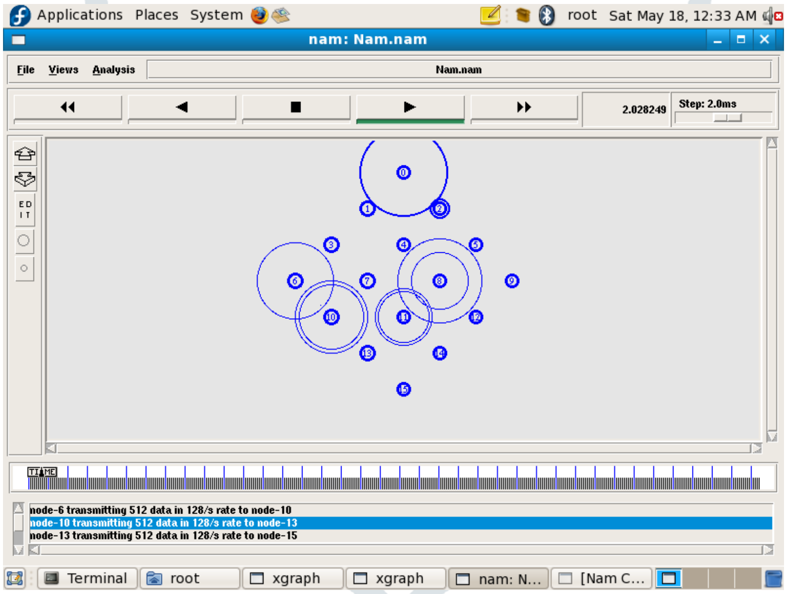


**Figure 3:** Data Transmission in proposed Bee Routing

Result graphs:

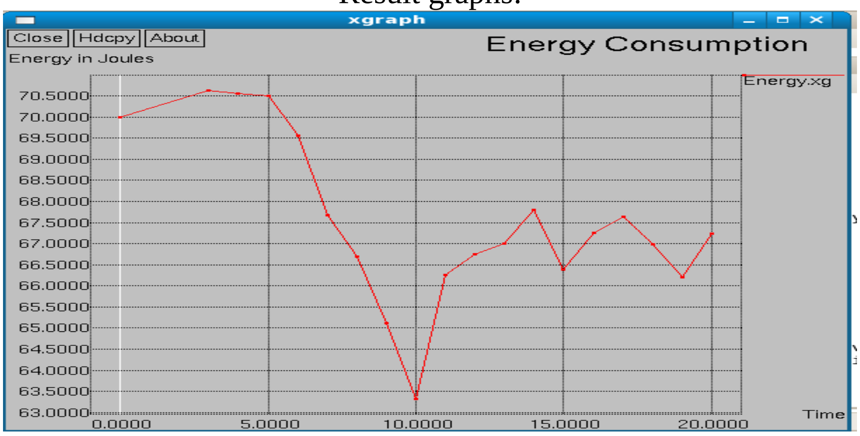


Figure 4

From the Graph it is clearly represented that the energy consumption with respect to Energy and Time

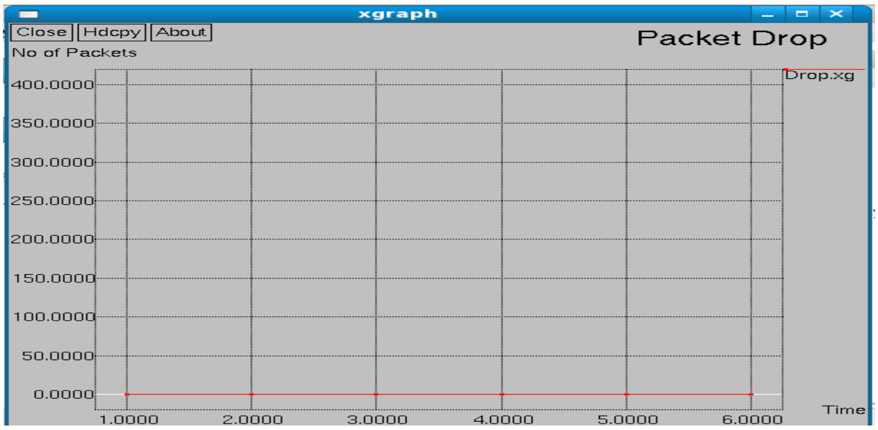


Figure 5

From the Graph it is clearly represented that the Packet Drop with respect to no of packets and Time

**Conclusion:** The design of the new Energy Efficient Bee Routing PEEBR routing discovery technique for adhoc mobile networks was introduced. PEEBR was inspired from the natural bee's food search behavior. This routing technique focuses on determining the optimal routing path based on its goodness ratio. The path goodness ratio is a combination of the amount of energy consumption expected and the propagation delay over that path. The simulation of Energy Efficient Bee Routing is done in ns-2 and a comparative analysis is done under mobility and network size scenarios. The future work of this research includes simulation in real world scenarios.

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