# Routing Metrics Improvisation in Wireless Mobile Networks Using Ant Colony Optimization

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## ABSTRACT
The design of routing algorithm is very important for the network performance. Collective intelligence of ants can be transformed in useful optimization techniques that can be successively implemented in computer networks especially ad-hoc mobile networks. This paper simulated on MATLAB 7.5, takes into consideration ant colony optimization approach and focuses on routing metrices like packet delivery ratio (%) measured against η (weights the no. of recent samples) and route efficiency metric (REM). The algorithm improves rules of pheromone update. Simulation results show that the proposed algorithm improves the packet delivery ratio and increases the successful transfer rate of WMN. The technique adopted gives outstanding results where packet delivery ratio (%) has maximum value of 95.9 % and minimum value of 4.37 %. The REM for forward and backward ANTS is calculated using a particular model and its variation against different node congestion metrics has been evaluated and plotted.

## General Terms
Algorithms, Matlab and Computer Networking.

## Keywords
Ant colony optimization (ACO), ACONET, Ant colony, Pheromones, Performance enhancement, Route efficiency metric (REM), Packet delivery ratio

## 1. INTRODUCTION
The term "routing" refers to the process of selecting paths in a computer network along which to send data. This process can be splitted in a routing protocol, used to exchange information about topology and link weights, and a routing algorithm, that actually computes paths between nodes [5]. Ant Colony optimization falls into a class of biologically inspired algorithms that have recently been developed. To name a few, the techniques of Particle Swarm optimization [8] and Bacterial Foraging [9] have been inspired by natural phenomenon. Ant colony optimization (ACO) is an optimization technique inspired by the exploratory behavior of ants while finding food [1]. The routing algorithm based on ants was developed by G. Di Carlo and M. Dorigo [4] and M. Gunes, U. Sorges and I. Bouazizi in [6] and further discussed in [7]. This form of communication is indirect, i.e., one ant releases the pheromone information into the environment, and another ant senses that pheromone information from the environment. As more ants travel over a particular path, the concentration of pheromone increases along that path. Pheromones along a path also gradually evaporate decreasing their concentration on that path. The pheromone acts significant stimuli since other ants are able to sense the pheromones deposited by each other and they generally take the path of maximum pheromone concentration [2]. This shows how on the optimum path ants progressively converge between their nest and the food. Ahmed studied some performance issues related to routing in MANETs [3]. The main purpose of this paper is to enhance the performance of routing parameters of mobile ad hoc networks using Ant colony optimization by evaluating the different routing parameters and metrics like packet delivery ratio (%) measured against η (weighs the no. of recent samples) and route efficiency metric (REM).

## 2. SIMULATION APPROACH

In this paper, the routing metrics and parameters are used to discuss performance enhancement of mobile ad hoc networks using Ant colony optimization are evaluated. The simulation tool used is MATLAB 7.5. It is a software package for high performance numerical computation and visualization. It provides an interactive environment with hundreds of built in functions for technical computation, graphics and animation. Matlab's built in functions provide excellent tools for linear algebra computations, data analysis, signal processing, optimization, numerical solution of ordinary differential equations, quadrature and many other types of scientific computations.

## 3. SIMULATION SCENARIOS

### 3.1 Measuring Packet Delivery Ratio (%)

The model suggested is adaptative and described by means and variances computed over the trip times experienced by the agents. A windowing mechanism is used to limit the number of samples used. It tells the number of packets that has reached the destination d. The moving observation window $W_d$, of size $W_{max}$ represents an array containing the trip times of the last $W_{max}$ forward ants that travelled from the node k to the destination d. The moving observation window $W_d$ is used to compute the number of packets that has reached from the node k to the destination d among the last $W_{max}$ forward ants that travel from the node k to the destination d. For each destination d in the network, the table contains a moving observation window $W_d$, an estimated mean $\mu_d$ and an estimated variance $\sigma^2_d$ [4].The mean $\mu_d$ and variance $\sigma^2_d$ represent the mean and variance of the trip times experienced by the forward ants to move from the node k to the destination node d. $t_{kd}$ represents the newly observed forward ant's trip time to travel from the node k to the destination node d and $\eta \in (0, 1)$ is a factor that weighs the number of recent samples that will affect the mean $\mu_d$ and the variance $\sigma^2_d$ [4]. The mean $\mu_d$ and variance $\sigma^2_d$ are calculated using the model:

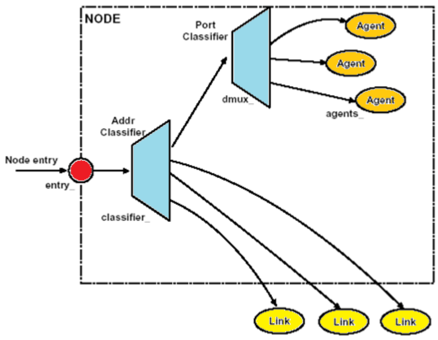


**Figure 1 Node structure for the simulator model [4]**

$$\mu_d \leftarrow \mu_d + \eta(t_{kd} - \mu_d) \qquad (1)$$

$$\sigma^2_d \leftarrow \sigma^2_d + \eta\,((t_{kd} - \mu_d)^2 - \sigma^2_d) \qquad (2)$$

The maximum size of the observation window is defined as:

$$W_{max} = 20c / \eta \text{ where } c < 1 \qquad (3)$$

In this model the constant c which is used to measure $W_{max}$ is generated by using a random function in the simulator Matlab 7.5 and the value $\eta$ (weighs the no. of recent samples) of is changing uniformly from 0.2 to 1.

**Table 1**

| Parameters | Values |
|---|---|
| $\eta$ (weighs the no. of recent samples) | 0.2, 0.4, 0.6, 0.8, 1.0 |
| c (constant value used to measure $W_{max}$) | 0.9543, 0.5472, 0.1386, 0.1486 and 0.2575 |

## 3.2 Route efficiency metric (REM)

Whenever a node sends a packet (Forward Request ANT, Backward ANT, normal data packet, etc), the packet has a metric value called Route Efficiency Metric (REM). Initially the source who originates the packet sets it to 1 (Minimum Congestion), although the Node Congestion value of source may be less than 1. When the packet is being forwarded or broadcasted, all the intermediate nodes multiply the REM with the individual Node Congestion Metrics. Then the REM can be defined as:

Route Efficiency Metric = $\Pi$ (Node Congestion values of intermediate nodes from source to destination)

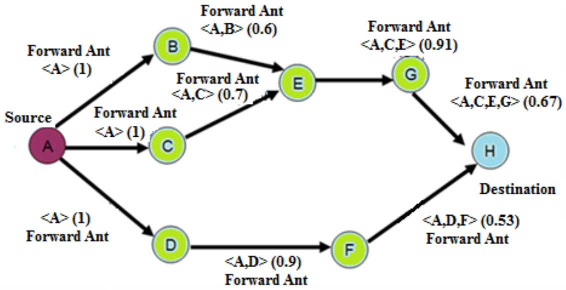


Figure 2 Route Discovery Phase, shows the propagation of Forward Ants from source to destination

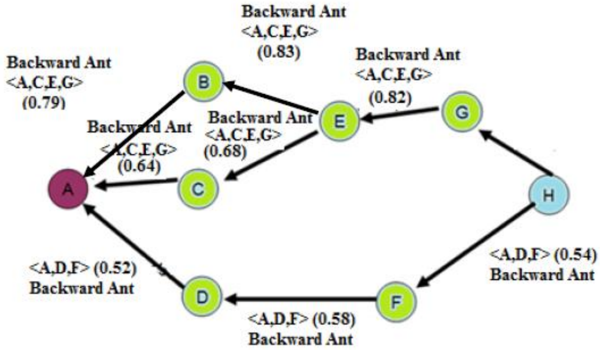


Figure 3 Route Discovery Phase, shows the propagation of Backward Ants from destination to source

**Table 2**

| Parameters | Values |
|---|---|
| Node congestion metric (for all nodes except reference node) | 0.37 |
| Node congestion metric (for reference node) | 0.1 to 1 |

**Table 3**

| Parameters | Values |
|---|---|
| Node congestion metric (for reference node 1) | 0.3, 0.5 ,0.6 ,0.7, 0.8, 1 |
| Node congestion metric (for reference node 2) | 0.2, 0.3, 0.6, 0.7, 0.9, 1 |
| Node congestion metric (for all nodes except two ref. nodes) | 0.83 |

## 4. RESULT EVALUATION

In this one by one all the parameters are studied and results are compared for different number of ants that have completed their tour. Also we vary the length of complete tour of the ants and calculated the pheromone updated values accordingly and then two different Ant systems are compared.

### 4.1 Packet delivery ratio (%)

When Packet delivery ratio (%) measured against η (weighs the number of recent samples), it is analyzed that for a lower values of η we get higher values of Packet delivery ratio (%), it reaches to the lowest value of packet delivery ratio (%) that is 4.37 % at $\eta = 0.8$ and highest value equals to 95.9 % at $\eta = 0.2$.

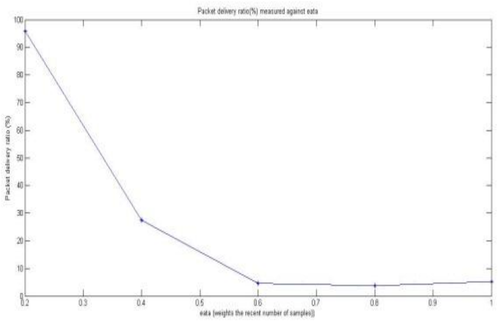

**Figure 4 Packet delivery ratio (%) measured against η (weighs the no. of recent samples)**

### 4.2 Route efficiency metric (REM)

The Route efficiency metric (REM) value totally depends upon the node congestion metric. More the value of node congestion metric (less congestion) more will be the REM value so REM value increases as we increase the node congestion metric. The value of Route efficiency metric (REM) for the propagation of Forward ANTS from source to destination in route discovery phase comes out to be 0.0957 (figure 5) and REM value for the propagation of Backward ANTS from destination to source comes out to be 0.0258 (figure 6). These values of REM for the propagation of Forward ANTS from destination to source and Backward ANTS from destination to source is calculated by using the formula given in the above simulation scenario of REM.

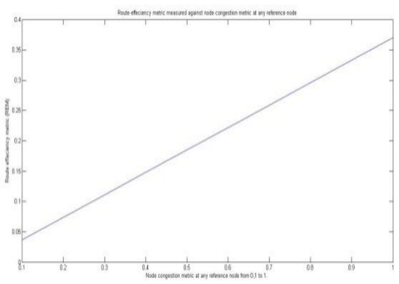

**Figure 5 Route Efficiency Metric (REM) measured against Node Congestion Metric at any reference node**

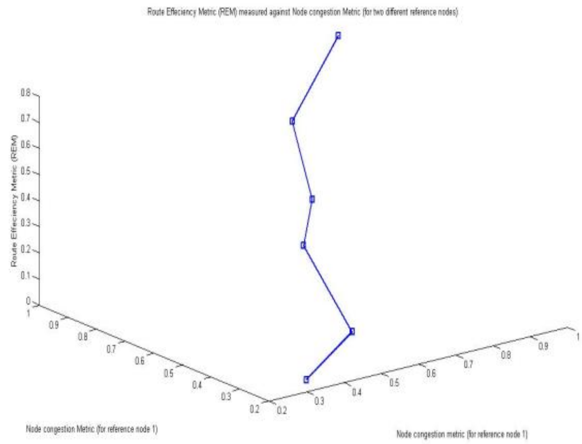

**Figure 6 Route Efficiency Metric (REM) measured against Node Congestion Metric (For two diff. reference nodes)**

## 5. CONCLUSION

In this paper the performance enhancement routing parameters and metrics for mobile ad hoc networks are evaluated using Ant colony optimization. It is observed that the packet delivery ratio (%) is inversely proportional to the η (weighs the no. of recent samples) and get minimum value of 10% at η equals to 1 while gets highest value of 100% at η equals to 0.1. The REM (Route Efficiency Metric) is directly proportional to the node congestion metric. The value of Route efficiency metric (REM) for the propagation of Forward ANTS from source to destination in route discovery phase comes out to be 0.0957 (figure 5) and REM value for the propagation of Backward ANTS from destination to source comes out to be 0.0258 (figure 6).

## 6.REFERENCES

[1] T. Stutzle & M. Dorigo,2002, An Experimental Study of the Simple Ant Colony.

[2] C.E. Perkins and P. Bhagwat, 1994, Highly dynamic destination-sequenced distance vector (DSDV) for mobile computers proc. of the sigcomm 1994 conference on communications architectures, protocols and applications, pages: 234–244, Aug 1994.

[3] T. H. Ahmed, 2005, Simulation of Mobility and Routing in Ad Hoc Networks using Ant Colony Algorithms. In International Conference on Information Technology: Coding and Computing, volume II, pages 698–703, Las Vegas, Nevada, USA, IEEE Computer Society, April 2005.

[4] Gianni Di Caro and Marco Dorigo, AntNet: Distributed stigmergetic control for communications Networks. Journal of Artificial Intelligence Research, vol 9, pages: 317–365, 1998.

[5] P. Van Mieghem, Data Communications Networking. Techne , 2006, in press.

[6] M. Gunes, U. Sorges, I. Bouazizi, 2002, ARA - The Ant-Colony-Based Routing Algorithm for MANETs, April 2002.

[7] D. Subramanian, P. Druschel and J. Chen, 2003, Ants and Reinforcement Learning: A Case Study in Routing in Dynamic Networks , May 2003 .

[8] J. Kennedy and R. Eberhart, 1995, Particle swarm optimization. In Proceedings of IEEE International Conference on Neural Networks, pages 1942–1948, 1995.

[9] K. Passino, J.2002, Biomimicry of bacterial foraging for distributed imization and control. Control Systems Magazine, IEEE, vol. 22(3), pages: 52 –67, Jun 2002.

［10］ Deepak Bansal & Ravinder Singh Sawhney, 2011, Performance Evaluation of Ant Colony Optimization in Mobile Ad-hoc Networks and comparison of Different Ant Systems, CiiT International Journal of Wireless comm. Vol.3, No 14, October 2011.