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# Review and Comparisons between Multiple Ant Based Routing Algorithms in Mobile Ad Hoc Networks (MANET)

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***Abstract:*** *Along with an increase in the use and development of various types of mobile ad hoc and wireless sensor networks the necessity for presenting optimum routing in these networks is a topic yet to be discussed and new algorithms are presented. Using ant colony optimization algorithm or ACO as a routing method because of its structural similarities to these networks' model, has had acceptable results regarding different parameters especially quality of service (QoS). Considering the fact that many articles have suggested and presented various models for ant based routing, the need for studying and comparing them can be felt. There are about 17 applied ant based routings, this article studies and compares the most important ant based algorithms so as to indicate the quality and importance of each of them under different conditions.*
***Keywords:*** *Quality of Service(QoS), Mobile Ad Hoc Network (MANET), Ant-Based Routing.*

## I. INTRODUCTION

The importance of mobile ad hoc networks (MANET) and wireless sensors is quite obvious under critical conditions due to lack of its infrastructure and its self-organizing feature. Therefore the ever-growing use of it is quite expected. Along with this growth, the related and relevant topics develop and experience innovation as well. One of these topics is routing which in actuality has a decisive role in the quality of the whole network. The effects of various parameters such as traffic, bandwidth, interference, node mobility, energy and a lot of other parameters have made this mode complex.

Numerous topics have been presented so far in order to promote the routing quality of MANETs networks [1] and each one has improved one or more parameters. Ant colony optimization is one of the relatively new optimization algorithms [2] which its use in ad hoc networks has led to different types of ARA (Ant Routing Algorithm) routing [3] through various methods.

In 2010, Vasundhara Uchhula and Brijesh Bhatt [4] compared a number of ant routing algorithms which in addition to being short it did not point out the specific disadvantages and advantages in order to select the algorithm under suitable conditions. This article compares the most common ant-based routing algorithms which have been mentioned so far in ad hoc networks, in addition the problems and advantages of each and the ease of algorithm selection will be studied. Following that in section 2 a general view of different types of routing will be presented. Section 3 states the most important ant-based routing algorithms. Section 4 presents the results of the study and section 5 presents a summary.

## II. TYPES OF ROUTING ALGORITHMS

The entire network routings can be divided into three common areas: proactive, reactive or on demand, and hybrid.

### 2-1. Proactive Protocols

The nodes' tables and networks are constantly updated in these protocols and this is done through sending control packet information, therefore they are called "Table Driven" as well. DSDV [7], GSR [5] and FSR [6] protocols are samples of this group. The problem with this type of routing is that it requires a lot of control packets and it occupies the network bandwidth in the peak of activity.

### 2-2. Reactive Protocols

Only when routing is demanded the source node starts sending control packet s and routing in this model. AODV [7], SSA [7] and ARA [3] protocols are among these protocols. Delay in routing is the problem with this kind of protocol.

**2-3. Hybrid Protocols**

An interaction between the two mentioned methods leads to the creation of these types of protocols. Depending on topology conditions of the network the network information is updated periodically and also after the request a limited number of control packets are sent. Some instances of it are ZHLS [6] and HOPNET [8] protocols.

## III. ANT- BASED ROUTING ALGORITHM

As indicated in figure 1 the natural process of ants routing is based on the spread of a substance named pheromone. Ants which reach the food sooner spatter more pheromone in their path and the following ants select this path due to higher amounts of pheromone. Network routing models the mentioned method in three stages through using forward ants (FANT), backward ants (BANT) and also a target function in selecting the path. In the searching stage, the ants are first sent for routing they find the rout and send the suitable controlling messages. The source begins sending data in the sending stage. In the rout maintenance and investigation in case the connection is interrupted between the two nodes, the information and if necessary routing will be updated.

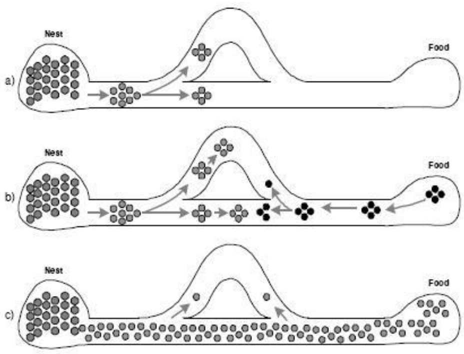


Figure1: Ants Routing Method

**3-1. Ant-Based Routing in MANETs (first version)**

Mesut Gunes and his colleagues [9] presented one of the first versions of ant-based routing in 2002. Based on their algorithm which was an “on demand” type or reactive, a G graph is first modeled with n nodes and its related connective links. Then the ants start moving forward in the network while routing and selecting the next node after the current node i is done based on the amount of pheromone which was first randomly initialized on the basis of formula (1). The backward ants are formed and sent to the source after finding the destination or a node which has access to it. Updating Pheromone (ϕ) is done in the returning path in the transit nodes based on formula (2) as well.

$$p_{i,j} = \begin{cases} 1 & ,if\ \varphi_{i,j} = \max_{k \in Ni}\{\varphi_{i,k}\} \\ 0, & else \end{cases} \quad (1)$$

$$\varphi_{i.j} = \varphi_{i.j} + \Delta\varphi \quad (2)$$

Ni presents the sum of neighboring nodes (j) in formula (1) and Δϕ is the constant amount of pheromone increase in case of the ant passing through or the control packet.

One of the benefits of using this method is its dynamic topology, multi-path routing and etc. But the large number of sent control packets, lack of continuous pheromone increase and other issues are its shortcomings. We will name the above-mentioned method “ant routing” in order to prevent confusion due to the similarity between the name of this algorithm and the following algorithms.

**3-2. Ant-Based Routing in Mobile Ad Hoc Networks (MANETs) (revised version)**

This algorithm which is the revised form of the previous model is specifically known as ARAA [10]. The probability function in formula (3) is used in this model instead of using pheromone dynamics (ϕ in the previous model). And of course pheromone continuously decreases and also increases while sending data (formula 4). A memory buffer is also considered for each group so that the routing packages can be controlled regarding volume and number.

$$p_{i,j} = \begin{cases} \dfrac{\varphi_{i,j}}{\sum_{k \in Ni} \varphi_{i,k}} & ,if \ \ j \in N_i \\ 0, & if \ \ j \notin N_i \end{cases} \quad (3)$$

$$\varphi_{i.j} = (1-q)\varphi_{i.j} + \Delta\varphi \quad (4)$$

q is a number smaller than 1 and indicates the vaporized pheromone in the route. The above reforms in the new version have led to advantages such as homogeneous load distribution among nodes, preventing sending extra useless packages but it is not suitable for huge routing demands and large number of nodes.

**3-3. Probable Routing for Managing the Resources in MANETs**

In addition to forward and backward ants there are also destination trail ants in this type of routing which is named ARAMA [11] which are used around the destination node in order to increase pheromone and convergence. Each node has a pheromone table and one probable routing which formula (5) shows its probable function.

$$p(D,i,j) \begin{cases} \dfrac{Fun(\tau_{D,i,j}, \eta_{i,j})}{\sum\limits_{j \in N_i} Fun(\tau_{D,i,j}, \eta_{i,j})} & ,\text{if} \quad \text{i} \in N_i \\ 0 & ,if \quad \text{i} \notin \text{N}_\text{i} \end{cases} \quad (5)$$

$\tau_{D,i,j}$ is the proper amount of pheromone with regard to the j^th neighbor of the i node, $\eta_{i,j}$ is heuristic amount of the link or the data of the next node such as traffic and energy. The used function can be any sort of combination of parameters and its simplest type is $Fun(\tau_{D,i,j}, \eta_{i,j}) = \tau_{D,i,j} \times \eta_{i,j}$. After the forward ants reach the destination in routing they are assigned a score or $0 < \rho \le 1$ value conforming to the parameters which influence the rout updating according to formula (6).

$$\tau_{D,i,j}(n) = f(\rho_{D,j})\tau_{D,i,j}(n-1) + g(\rho_{D,j}) \quad (6)$$

f is the vaporization function and it is as $f(\rho)=1-\rho$. $g(\rho)$ is known as Enforcement Function which increases the speed of responding to new data and $g(\rho)=\rho^k$ is one of them. n is also the number of backward ants received. Among the advantages of this proactive and reactive method is the existence and proportional distribution of energy but it is not very efficient in high volumes of packets due to a lot of switching. For more information on this algorithm refer to [11].

**3-4. Ant-Based Fuzzy Routing in MANETs (FACO)**

FACO [12] applies three parameters of the remaining energy of the node (little, medium, and a lot), buffer amount (full, half full, and empty) and the intensity of the received signal (strong, mediocre, and weak) in order to make better decisions to a fuzzy system. The fuzzy system output called Fuzzy Cost is also considered in five fuzzy levels from very little to a lot and is eventually defuzzified through center-of-gravity method and plays its role in routing. Like other algorithms, in this algorithm also after requesting rout the forward ants spread from the source to the adjacent nodes. Meaning the possibility to select neighboring j for destination d in node i is as formula (7).

$$p^i_{j,d} = \frac{\Phi^i_{j,d}(t)}{\sum\limits_{L} \Phi^i_{j,d}(t)} \quad (7)$$

L is the neighboring nodes and $\phi$ is the pheromone amount. Of course each ant saves the essential data and fuzzy cost up to the time it reaches the destination. Backward ants are formed in the destination and sent to the source and update the rout. The rout value (formula 8) and the updated pheromone (formula 9) determine the rout selected by the source for sending purposes.

$$Rout\_Cost(t)^{i}_{j,d} = \sum_{L=1}^{t} Fuzzy\_\cos t_{L}^{L+1} \quad (8)$$

t is the number of links travelled and $Fuzzy\_\cos t_{L}^{L+1}$ is the fuzzy value link of the neighboring nodes.

$$\Phi^{i}_{j,d}(t) = (1-\rho)\Phi^{i}_{j,d}(t-1) + \rho\Phi^{i}_{j,d} \quad (9)$$

ρ is the learning rate. Note that the updated pheromone updates probability function. The backward ants are destroyed after they reach the destination and carry out the above-mentioned stages.

In case of error message, maintaining the rout and updating the tables are also carried out like other algorithms.

**3-5. Energy Aware Ant Routing Algorithm in MANETs**

It specifically focus on the total energy of the network through using CMMBCR algorithm [14] in addition to using ant-based routing process in this model which is called EAAR [13].

The process of the algorithm includes: the forward ants are sent to all neighboring nodes in case there is no route to the destination in the routing table of source node. The intermediate nodes which check the energy parameters and the number of steps also avoid accepting repetitive ants. Also ant parameters for instance the number of steps must not be λ (1<λ< 2) times worse than the best state saved in the memory of node. If M will be the number of steps of the best received ant by the intermediate node when an ant enters with N steps formula (10) must be true for the ant to be accepted and after storing the important data, the ant is sent to the next nodes.

$$N \leq \lambda M \quad (10)$$

After reaching the destination node the end-to-end delay of the ant is calculated and in a fraction of this time the received forward ants turn into backward ants and sent towards the source. Also along the path the data of the modes' routing tables are updated proportionate to the minimum battery charge left from the nodes along the path to (MBR) node and the number of steps (H) (formula 11).

$$T^{i}_{n,d} = \frac{MBR}{H} \quad (11)$$

$T^{i}_{n,d}$ is the amount which the data packet checks when sending to the destination. When the source node receives the ants it starts sending data packets based on the possibility formed after the data was updated (formula 12).

$$P_{n,d} = \frac{(T^{i}_{n,d})^{\beta}}{\sum (T^{i}_{j,d})^{\beta}} \quad (12)$$

β is a number used in order to prevent extreme shrinking of the possibility and it somehow normalizes it. Maintaining the route is also done while sending data through an increase in the amount of pheromone caused by the ever-growing passing of information packets through a path and a decrease in pheromone levels in lesser used paths just as it is in other algorithms mentioned in the previous sections.

In general because of optimum and appropriate use of ARA, multi-path routing, maintaining and carefully controlling the routs regarding energy management is a good algorithm. But not evaluating delay and investigating when the number of nodes is large, is amongst its relative shortcomings.

## IV. EVALUATION AND COMPARISON

As you can see the evaluation results along with the specifications and conditions of each algorithm in table 1, In Ant Routing formation of tables merely on the basis of pheromone does not require a large number of control packets in ant routing so it is natural for the overhead to be little but the packets are not well controlled.

The control over the networks has increased with the interference of more parameters in ARA and ARAMA but despite the improvement in load distribution, it has lost its efficiency in large networks and large number of data.

Evaluating on the basis of fuzzy calculations leads to high overhead in calculations in FACO and has no consequences except for limiting the efficiency development of the network and of course energy consumption also increases which has not been attended to.

EAAR algorithm focuses more on energy therefore the life span of the network and the energy consumed in each node and also the entire network has improved but are end-to-end delay and network efficiency in large sizes suitable? which has not been studied and compared in the above mentioned algorithm.

Table 1: comparing different types of ant- based routing in Mobile Ad Hoc Networks (MANETs)

| Advantages | Shortcomings | Improved parameter | Energy algorithm | Tables' structure | Factor types | Routing and Data transfer structure | Routing type | Presented year | Algorithm |
|---|---|---|---|---|---|---|---|---|---|
| Dynamic topology, being multi-routed | Lack of control on sent packets | Overhead | - | Pheromone density, next step, IP destinations | Forward and backward ants | Based on pheromone density | On demand | 2002 | Ant Routing [9] |
| Load distribution, controlling the number of packets and | Low efficiency in large sizes and a large number of | Delivery rate and accuracy of optimal route | Nodes entering sleeping state under special conditions | Pheromone density, next step, IP destinations and buffer | Forward and backward ants | Based on probable function from pheromone | On demand | 2003 | ARA [10] |
| Suitable for controlling energy distribution and simultaneous control of parameters | Delivery decrease due to a lot of switching | Homogeneous energy distribution, minimum step in small-number nodes | Lucent wave LAN PC and 2.4 GH | Pheromone density, next step, IP destinations and buffer | Forward and backward ants and destination trail ants | Based on probable function from pheromone and network parameters (Heuristic) | Hybrid | 2005 | ARAMA [11] |
| The possibility to select a better route through the source node after routing | A lot of calculations in low-numbered nodes and overlooking the total energy of the network | Delivery rate, delay and number of routing discovery | Applying the remaining battery in fuzzy data | Pheromone density, destination possibility, fuzzy data, IP destinations and intermediate node | Forward and backward ants | Based on pheromone amount and Fuzzy Cost | Hybrid | 2009 | FACO [12] |
| Multi- routed, higher efficiency with large-sized packets | Not evaluating delay and investigating when there is a large number of nodes | Total energy consumption reduction of each node and destroyed packets | Conditional Max- min battery capacity routing (CMMBCR) | Pheromone probability, number of steps and the amount of remaining energy from the nodes | Forward and backward and control ants | Sending control packets to neighboring nodes and transferring data based on probability | Hybrid | 2010 | EAAR [13] |

## V. CONCLUSION AND FUTURE WORKS

What is quite obvious here is that using ant-based routing in MANET networks can bring about good results and widely using it in combination with various other algorithms and methods is still attended to and shows better outcomes. Also for numerical evaluation a number of parameters such as the number of delivered packages, the energy consumed by the entire network and the ratio of control packets to all packets or overheads are compared in table 2 under similar condition (30 nodes, the size being 1000× 1000 square meters and IEEE802.11 protocol MAC layer). The comparison is made among the mentioned algorithms except for Ant Routing which ARA is the revised version of it and an algorithm known outside this area (DSDV).

Table 2: numerical comparison between some parameters in the algorithms

| Parameter | ARA | ARAMA | FACO | EAAR | DSDV |
|---|---|---|---|---|---|
| Delivered packages | 220 | 192 | 228 | 236 | 210 |
| Energy consumption by (Kj) network | 55 | 58 | 60 | 52 | 71 |
| overhead | 0.32 | 0.37 | 0.4 | 0.39 | 0.52 |

As seen in table 2 the ant-based routing algorithms come to better results in comparison with algorithms outside this set (DSDV as a sample) which proves the conclusion of this article based on the necessity to recognize different types of this routing model and the ability to compare them in presenting new methods and using each one in accordance to the situation, we have studied a number of the most important ones in this article.

What we are intending for the future and working on currently is designing and simulating an intelligent algorithm which can change the type of its ant-based routing algorithm according to its usage under different situation in accordance with the network topology.

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