
Secure Route Selection in Manet Using Ant Colony Optimization

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Abstract: A Mobile Adhoc network is a collection of nodes that are dynamically and arbitrarily located in such a manner that the inter connections between nodes are capable of changing on a continual basis. Ad hoc wireless networks are increasing in popularity, because of the spread of laptops, sensor devices, personal digital assistants, and other mobile electronic devices, these devices will eventually need to communicate with each other. For the implementation of MANET, the important factor which is concern is the routing of data from source to destination via various nodes as a mediator due to mobility of mobile nodes. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network topology is unstructured and nodes may enter or leave at their will. For mobile ad hoc networks, the complexity of routing increases because of its characteristics such as dynamic topology, absence of centralized authority, time varying quality of service (QoS) requirements, etc. Ant Colony Optimization (ACO) algorithm uses mobile agents as ants to discover feasible and best path in a network. ACO helps in finding the paths between two nodes in a network and selection of path can be changed dynamically according to condition of the wireless network in case of network congestion.

Keywords: pheromones, trail, bandwidth, routing and load distribution, MANET, Ant Colony Optimization

1. Introduction

A mobile ad hoc network (MANET) is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. They may contain one or multiple and different transceivers between nodes.

Routing in communication networks is necessary because, generally, nodes are not directly connected. The main problem solved by any routing protocol is to direct traffic from sources to destinations, but nowadays, because of increasing complexity in modern networks, routing algorithms face important challenges.

The routing function is particularly challenging in these networks because the network structure is constantly

changing and the network resources are limited. This is particularly true in wireless ad hoc networks where node mobility and link failures produce constant changes in the network topology. Routing algorithms lack of adaptability to frequent topological changes, limited resources, and energy availability reduces network performance.

The demand for real time and quality of services (QoS) in the network has been increased as the internet expands. The role of a QoS routing strategy is to compute paths that are suitable for different type of traffic generated by various applications while maximizing the utilizations of network resources. But the problem of finding multiconstrained paths has high computational complexity, and thus there is a need to use algorithms that address this difficulty. The major objectives of QoS routing are:

- i) To find a path from source to destination satisfying user's requirements.
- ii) To optimize network resource usage and
- iii) To degrade the network performance when unwanted things like congestion, path breaks appear in the network.

Most of the unknown on-demand protocols use the shortest path as their route selection metric. This leads to congestion and link breakage of some of the stations in the network. The protocols which do not consider the load conditions at the station during the route setup phase are unable to take advantage of the less loaded stations in the network. Thus multipath routing using ACO done in this work can overcome the above problems, providing load balancing and route failure protection, successful packet transfer, overall throughputs and average end-to-end delay by distributing traffic among a set of diverse paths.

2. Ant Colony Optimization

Ant colony optimization algorithm (ACO) is a probability based concept for solving computational problems and situations which we can reduce for finding good or best paths through graphical representation.

The ACO metaheuristic is based on generic problem representation and the definition of the ant's behavior. ACO adopts the foraging behavior of real ants. When multiple paths are available from nest to food, ants do random walk initially. During their trip to food as well as their return trip to nest, they lay a chemical substance called pheromone, which serves as a route mark that the ants have taken [4]. Subsequently, the newer ants will take a path which has higher pheromone concentration and also will reinforce the path they have taken. As a result of this autocatalytic effect, the solution emerges rapidly.

To illustrate this behavior, let us consider the experiment shown in Figure 1. A set of ants moves along a straight line from their nest A to a food source B (Figure 1a). At a given moment, an obstacle is put across this way so that side (C) is longer than side (D) (Figure 1b). The ants will thus have to decide which direction they will take: either C or D. The first ones will choose a random direction and will deposit pheromone along their way.

Those taking the way ADB (or BDA), will arrive at the end of the obstacle (depositing more pheromone on their way) before those that take the way ACB (or BCA). The following ants' choice is then influenced by the pheromone intensity which stimulates them to choose the path ADB rather than the way ACB (Figure 1c). The ants will then find the shortest way between their nest and the food source.

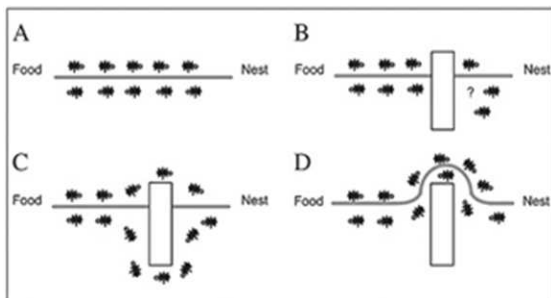


Figure 1. A. Ants in a pheromone trail between nest and food: B. an obstacle interrupts the trail: C. ants find two paths to go around the obstacles: D. a new pheromone trail is formed along shorter path.

2.1. How ACO Works in MANET

Mobile Ad Hoc Network (MANET) typically receives multiple paths to the same destination. This work is using Ant Colony Optimization to decide which is the best path to install the routing table and to use for traffic forwarding.

ACO assigns the first valid path as the current best path. It then compares the best path with the next path in the list, until ACO reaches the end of the list of valid paths. This list provides the rules that are used to determine the best path:

1. Prefer the path with the highest WEIGHT. Ants follow the path having higher pheromones deposit.

Note: WEIGHT is a Route Selection parameter. It is local to the router on which it is configured.

2. Prefer the path with the highest bandwidth and lower cost.

3. Prefer the path that was locally originated via a network.

4. Prefer the path with the lowest origin type.

Continue, even if best path is already selected.

5. Continue, if best path is not yet selected.

3. Route Selection Parameters (RSP)

Our proposed parameter for route selection is Route selection parameter which is calculated by each node and uses it as a measure of route selection that it combines with the number of hops. For using RSP as a measure of route selection, there should be maintenance of its value in routing tables or cache by each single node in the network. The estimation of RSP at each node is given by:

$$RSP = \text{PACKET FORWARDING RATIO} * \text{MOBILITY BANDWIDTH} * \text{COST};$$

- 1) PFR (PACKET FORWARDING RATIO):

It is calculated as a ratio of number of packets received at destination and the number of packets sourced through the application layer (i.e. CBR) and basically it specifies rate of packet loss, which actually limits the maximum throughput of networks.

- 2) MBW (MAXIMUM BANDWIDTH):

It totally relies on availability of bandwidth between intermediate nodes included in the route/path. And it goes towards the route having the greatest availability of bandwidth.

4. Proposed Algorithm

Target is to find the shortest route trip, to link a series of cities, some rules are to be followed up by the ants means by set of ants and each one of them will be making one of the possible round trip along the cities. At each stage, there is a movement of ant which selects the movement from one city to another depending upon these rules:

Rule1: It must visit each city exactly once;

Rule2: For a city at a much distance, there will be less probability of being chosen means in terms of visibility;

Rule3: The more the concentration of the pheromones trail found out an edge between two cities, the greater the chances that the edge will be chosen;

Rule4: After finishing its trip, the ant deposits enough pheromones on the edges being traversed by them, when the journey is short;

Rule5: After each iteration, trails of pheromones evaporate.

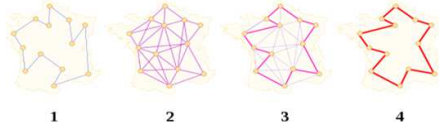


Figure 2. Zig zag motion of ant

5. Mathematical Models

In ant colony optimization, ant is a simple computational agent which iteratively constructs a solution for a problem, for every possible route; here route efficiency function (REF) is calculated by ants. All the intermediate solutions are called as solution states. In each iteration of the algorithm, each single move from a state a to state b, corresponding to a more complete intermediate solution. Hence every ant n computes a set $A_n(a)$ of feasible expansions of its present state in every iteration and further moving to one of these in probability.

The probability p^n of moving from state a to state b depends on the combination of two parameters for an ant n. Firstly, the attractiveness η of the move, which is calculated by some heuristic method implying priori desirability of that move and secondly the trail level λ of the move implying how proficient it is where λ is the amount of pheromone deposited for transition from state a to state b, $0 \leq \alpha$ is a parameter for controlling the influence of λ , η is the desirability of transition state a to b(a priori knowledge, typically $1/d$, and d is the distance and $\beta \geq 1$ is a parameter for controlling the influence of η).

Pheromone Updates

In general, the nth ant moves from state a to state b with probability

$$p^n = (\lambda^\alpha \eta^\beta) / \sum_{b \in allowed} \lambda^\alpha \eta^\beta$$

When all the ants completed their solutions, the trails are updated by

$$\lambda \rightarrow (1 - \rho) \lambda + \sum_n \Delta \lambda^n$$

ρ is the coefficient of pheromone evaporation and $\Delta \lambda^n$ is the amount of pheromone deposited by nth ant, mainly given for a distribution problem, with moves that corresponds to arcs in the graph) by

$$\Delta \lambda^n = \begin{cases} Q/L_n & \text{if ant n uses curve ab in its tour} \\ 0 & \text{otherwise} \end{cases}$$

L_n = cost of length of tour for nth ant and Q =constant.

6. Conclusion

In this manuscript, we proposed an Ant Colony Optimization algorithm to find the best route from source node to destination node. This algorithm can be implemented to solve the Traveling Salesman Problem in the Ad hoc Network. This algorithm give the best solution for the shortest path problem in Ad hoc networks.

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