Routing in Ad Hoc Networks Using Ant Colony Optimization

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Abstract—A Mobile Ad Hoc Network (MANET) is a self-configuring infrastructureless network of mobile nodes connected by wireless links. Hence, routing in this kind of networks is a great challenge. Ant Colony Optimization is an algorithm to solve problems like routing in MANETs based on food searching behavior of ants. AntHocNet [1] is based on ideas from Ant Colony Optimization. AntHocNet is a hybrid algorithm consisting of both reactive route set-up and proactive route maintenance. It does not maintain routes to all possible destinations at all times but it sets up paths when they are needed at the start of a data session. In this paper, performance evaluation of AntHocNet, AODV and DSR routing protocols is done using the simulator ns2.34. Simulation results demonstrate scalability of AntHocNet when compared to AODV and DSR i.e., AntHocNet performs better at high data rates and at large number of nodes. Its performance is low when compared to AODV and DSR at low data rates and at less number of nodes.

Keywords—ant, MANET, foraging, AODV, DSR

I. INTRODUCTION

A mobile ad hoc network (MANET) [4] is a collection of mobile nodes which communicates with each other without any supporting infrastructure. Routing in MANETs is quite challenging because of MANET’s dynamic features, its limited bandwidth and power energy. Bio-inspired algorithms like ant colony optimization (ACO) algorithms are used to develop the routing algorithms for MANETs.

A mobile ad hoc network (MANET) is a decentralized group of mobile nodes which exchange information temporarily by means of wireless transmission. The network topology is unstructured and nodes may enter the network or leave the network at any time. A node can communicate to other nodes which are within its transmission range. Since there is no background network for the central control of the network operations, the control and management of the network is distributed. When delivering data packets from a source to its destination, the packets should be forwarded via one or more intermediate nodes.

Most of the nodes in a MANET may rely on batteries or other exhaustible means for their energy. So for these kind of nodes, the most important system design criteria for optimization should be energy conservation. MANETs are generally more prone to physical security threats than fixed-cable nets.

Applications of MANETs are Military battlefield, Emergency rescue operations (where non-existing or damaged communication infrastructure occur), In Personal Area Network intercommunication (between various mobile devices such as a PDA, a laptop, and a cellular phone by MANETs). Similarly in other civilian environments like taxicab, sports stadium, boat and small aircraft, mobile ad hoc communications will have many applications.

A. Bio-inspired Networking

Bio inspired networks are the networks that takes inspiration from Biology and hence it can be used to solve the problems of computer networks. Even though, Internet is the world’s large-scale complex system, it is not the only one. Biological systems have evolved over billions of years, adapting to an ever-changing environment.

These biological systems share several fundamental properties with the Internet, like the absence of centralized coordination, increasing complexity as the system grows in size, and the interaction of a large number of individual, self-governing components, etc. It is easy to draw analogies between Biological Systems and Internet even though they have different origins.

Swarm intelligence [3] is a computational and behavioral metaphor solving distributed problems inspired from biological examples provided by social insects such as ants, termites, bees, etc. Swarm intelligence provides a basic way to explore collective problem solving without centralized control. Ants show their collectiveness in finding the food source. A group of ants indirectly communicate with each other by just modifying the environment. There is no direct communication between them. All the ants work towards global objective of collecting food. Common goal is more important than any individual goals. They optimize their behavior to achieve the common goal. In the last few years, Swarm Intelligence principles have been successfully applied to a series of applications including optimization algorithms, communication networks and robotics.
B. ACO

Ant Colony Optimization algorithms are subset of Swarm Intelligence. Ant Colony Optimization has been successfully applied to a large number of different, discrete optimization problems including traveling salesperson, the quadratic assignment, scheduling, vehicle routing, routing in telecommunication networks. Colonies of insects are capable of solving a number of optimization problems.

In ACO algorithm [5], the basic concept is inspired by the foraging behavior of real ants. When ants search for food, they start from their nest and move at random towards the food. Ants use a highly sophisticated chemicals called 'pheromones' to provide a sophisticated signaling system. While walking, ants deposit quantities of pheromone, marking the selected routes that they follow with a trial of the substance. When an ant encounters an intersection, it has to decide which path to follow next. The concentration of pheromone on a certain path is an indication of its usage. An ant chooses a path with a high probability to follow and then thereby reinforces it with a further quantity of pheromone. Overtime, the concentration of pheromone decreases due to diffusion. This foraging process is an autocatalytic process characterized by a positive feedback loop, where the probability that an ant chooses any given path increases according to the number of ants choosing the path on previous occasions. Ants that take the shortest path will reach the destination first i.e. food source. On their way back to the source i.e. nest; the ants again have to select a path. After a sufficiently long period of time, the pheromone concentration on the shorter path will be higher than on other longer ones. Thus, all the ants will finally choose the shortest path. This ant foraging process can be used to find the shortest path in networks. Also, ants are capable of adapting to changes in the environment, and find a new shortest path once the old one is no longer feasible due to some obstacle. Thus, this process is appropriate to mobile ad hoc networks where the link changes occur frequently.

In bioinformatics includes the applications of ACO [6] to protein folding. It consists of finding the functional shape or conformation of a protein in two or three dimensional space. Multiple sequence alignment concerns the alignment of several protein or DNA sequences in order to find similarities among them. This is done, in order to determine the differences in the same protein coming from different species. This information might support the inference of phylogenetic trees.

ACO algorithms are currently among the state-of-the-art methods for solving, the sequential ordering problem, the resource constraint project scheduling problem, the open shop scheduling problem, and the 2D and 3D hydrophobic polar protein folding problem.

The traveling salesman problem is one of the applications of ACO. Consider a set N of nodes representing cities, and a set E of arcs fully connecting the nodes N. Let \( d_{ij} \) be the length of the arc \((i, j) \in E\), that is the distance between cities i and j, with \( i, j \in N \). The TSP is the problem of finding a minimal length Hamiltonian circuit on the graph \( G = (N, E) \), where a Hamiltonian circuit of graph G is a closed tour visiting once and only once all the \( n = |N| \) nodes of G, and its length is given by the sum of the lengths of all the arcs. In Ant System, artificial ants build solutions of the TSP by moving on the problem graph from one city to another.

The quadratic assignment problem is the problem of assigning n facilities to n locations so that the cost of the assignment, which is a function of the way facilities have been assigned to locations, is minimized. QAP is a generalization of the TSP. This is also solved by ACO. Graph coloring problem is the problem of finding a coloring of the graph G so that the number q of colors used is minimum.

II. LITERATURE REVIEW

The robustness and efficiency of the collective behavior of insects' societies with respect to variations of environment conditions is a key-aspect of their biological success. Because of these same properties, they have recently become a source of inspiration for the design of routing algorithms for dynamic networks. Several Ant algorithms varies with each other based on how pheromone is updated, how routing table probabilities are calculated, how often and how many ants sent for request.

A. ABC

Every node in the communication network has a pheromone table entry for every other possible destination node in the network, and each table has an entry for every neighbor nodes. Ants move from one node to another node, selecting the next node to move according to the probabilities in the pheromone tables for their destination node. When an ant arrives at a node, the entry in the pheromone table corresponding to the node from which the ant has just come is increased. When ants have reached their destination, they die. The ants get delayed on parts of the system that are heavily used. Some noise can be added to avoid freezing of pheromone trails.

B. ARA

It works in an on demand way. It sets up multiple paths between source and destination. At the start the data session FANTS are broadcast by sender to all its neighbors. Each FANT has a unique sequence number to avoid duplicates. A node receiving a FANT for the first time creates a record consists of destination address, next hop, pheromone value in its routing table.

The node interprets the source address of the FANT as destination address, the address of the previous node as next hop, and computes the pheromone value depending on the number of hops the FANT needed to reach the node. When
the FANT reaches destination, the destination node extracts
the information and then destroys the FANT. A BANT is
created and sent towards the source node, the path is
established and data packets are sent. Data packets are used
to maintain the path so over head is introduced.

C. AntHocNet

AntHocNet is a hybrid algorithm, containing both
reactive and proactive elements. The algorithm is reactive in
the sense that it only gathers routing information about
destinations that are involved in communication sessions. It
is proactive in the sense that it tries to maintain and improve
information about existing paths while the communication
session is going on (unlike purely reactive algorithms,
which do not search for routing information until the
currently known routes are no longer valid). Routing
information is stored in pheromone tables that are similar to
the ones used in other ACO routing algorithms. Forwarding
of control and data packets is done in a stochastic way,
using these tables. Link failures are dealt with using specific
reactive mechanisms, such as local route repair and the use
of warning message.

III. SIMULATIONS

To test and compare the performance of AntHocNet
protocol, the network simulator NS-2[2], version 2.34 is
used. The network model used in simulation is composed by
mobile nodes and links that are considered unidirectional
and wireless. Each node considered as communication end-
point is host and a forwarding unit is router.

In addition to NS-2, a set of tools, mainly Bash
scripts and AWK filters, to post-process the output trace
files generated by the simulator are developed. In order to
evaluate the performance, multiple experiments have been
sets up.

IV. METRICS

A. Routing Overhead

It is the total number of control packets transmitted by
the nodes of the network versus data packets delivered at
their destination.

B. Packet Delivery Ratio

This is the ratio of total number of packets successfully
received by the destination nodes to number of packets sent
by the source nodes throughout the simulation.

V. RESULTS

The following figures shows the Routing Overhead and
Packet Delivery Ratio of AntHocNet, AODV, DSR at
different data rates 1Mb,10Mb,100Mb and 100Mb in UDP
environment.
VI. CONCLUSION

Simulation results demonstrate scalability of AntHocNet when compared to AODV and DSR i.e., AntHocNet performs better at high data rates and at large number of nodes. Its performance is inferior to that of AODV and DSR at low data rates and at less number of nodes. From this it can be concluded that AntHocNet is suggested for large-scale, high data rate. As the number of nodes increases the performance of AODV and DSR deteriorates whereas AntHocNet’s performance increases even with the increase in number of nodes. At high data rates also AODV and DSR has very low performance and it deteriorates rapidly. For AntHocNet its performance is either constant or increasing at high data rates.
REFERENCES


