Resolving Dynamic Shortest Path Routing Problems in Mobile Adhoc Networks using ABC and ACO

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***Abstract*:** Mobile Ad Hoc Network (MANET) is a dynamic multihop wireless network which is self organized and self managed network. MANET is decentralized by a collection of mobile nodes. The major problem in MANET is fast changing nature due to the random movement of the nodes. Routing is the process of moving information across the network from a source to a destination. Routing is challenging in this type of networks due to the mobility of nodes, energy and limited resources etc. This type of networks has difficult to find a path between the communicating nodes. Nature-inspired algorithms (swarm intelligence) such as ant colony optimization (ACO) algorithms and Artificial Bee Colony (ABC) algorithm have shown to be a good technique for identifying multiple stable paths between source and destination nodes. The Ant Colony Optimization (ACO) algorithm is proposed for finding dynamic shortest path and also avoiding the convergence to a locally optimal solution. The Artificial Bee Colony (ABC) algorithm is proposed for finding the dynamic shortest path with best parameter vector which minimizes an objective function.

Keywords: Ant colony Optimization (ACO), Artificial Bee Colony (ABC), *D*ynamic optimization problem (DOP), dynamic shortest path routing problem (DSPRP)

I. INTRODUCTION

A mobile adhoc network is a decentralized group of mobile nodes which exchange information temporarily by means of wireless transmission [1]. Routing in MANET is a dynamic optimization problem as the search space changes over time due to the time varying nature of the topology of the networks. Traditional routing techniques such as distance-vector and link-state algorithms that are used in fixed networks cannot be directly applied to mobile ad-hoc networks. Centralized algorithms have scalability problems, static algorithms have trouble keeping up-to date with network changes, and other distributed and dynamic algorithms have oscillations and stability problems [4]. MANET supports robust and efficient operations by incorporating the routing functionality into MHs. In MANETs, the unicast routing establishes a multihop forwarding path for two nodes beyond the direct wireless communication range. Routing protocols also maintain connectivity when links on these paths break due to effects such as node movement, battery drainage, radio propagation, and wireless interference [1]. In multihop networks, routing is one of the most important issues that have a significant impact on the performance of networks. In this paper, we investigate the shortest path routing problem, which belongs to the topological routing. The DSPRP in MANETs is a real world dynamic optimization problem (DOP).

In this paper, we adapt two algorithms Ant Colony Optimization (ACO), Artificial Bee Colony algorithm (ABC) to deal with DOPs to solve the DSPRP in MANETs. Immigrants and Memory schemes and their combination into the ACO, ABC are used to enhance its searching capacity for the SPs in dynamic environments. Once the network topology is changed, the optimal solutions in the new environment can be searched using the new immigrants or the useful information stored in the memory. The rest of this paper is organized as follows. We discuss related work in Section II. The MANET network model and the DSPRP model are described in Section III. Section IV presents the design of a Ant Colony optimization algorithm (ACO) SP routing problem. Section V presents the design of Artificial Bee Colony optimization algorithm (ABC) for SP routing problem. Section VI presents the experimental results with network deployment. Finally, Section VII describes the conclusion and some discussions on the future work.

II.RELATED WORK

In [2], a genetic algorithmic approach was presented to the SP routing problem. The GA based SP algorithm exhibits a much better quality of solution (i.e., the route optimality) and a much higher rate of convergence than other algorithms. A population-sizing equation that facilitates a solution with the desired quality was also developed.

In [17], a PSO-based search algorithm was proposed. A priority-based indirect path-encoding scheme is used to widen the scope of the search space, and a heuristic operator is used to reduce the probability of invalid loop creations during the path-construction procedure. It was claimed that the PSO-based SP algorithm is superior to those using GAs, including the one in [2].However, all these algorithms address only the static SP problem. When the node mobility occurs the network topology changes, they will consider it as a new network and restart the algorithms over the new topology.

P.Deepalakshmi et al. [5] have proposed an ant based QoS routing protocol for MANET to support multi-media communications. From the given source to destination multiple paths have been found with varying path preference probability. The multimedia data is sent over the path with higher path preference probability which can provide higher bandwidth, shorter path and lesser delay in terms of number of hops.It is well known that the topology changes rapidly in MANETs due to the characteristics of wireless networks, e.g., battery exhaustion and node mobility. Therefore, for the dynamic SP algorithms are not good choices since, in this regard, immigrants and memory schemes have their inherent advantages.

These algorithms use the immigrants or the useful information stored in the memory to help the population quickly adapt to the new environment after node mobility occurs. Hence, these algorithms can keep running over the continuously changing topologies, and avoid the expensive and inefficient restart.

III. DYNAMIC SP ROUTING PROBLEM

In this section, we describe our network model and then formulate the DSPRP [10]. We consider a MANET operating within a fixed geographical region. We model it by an undirected and connected topology graph G (V, E), where V represents the set of wireless nodes (i.e., routers) and E represents the set of communication links connecting two neighboring routers falling into the radio transmission range. A communication link (x,y) cannot be used for packet transmission unless both node a and node b have a radio interface each with a common channel.We summarize some notations that we use throughout this paper:

G(V0,E0) Initial Manet topology graph;

G(Vx, Ey) MANET topology after xth change;

s Source node;

d Destination node;

Px(s,r) Path from s to d in graph Gx;

Cl Cost on communication link l;

The Dynamic Shortest Path Routing Problem can be described as follows.

Initially, we wish to find a least cost loop-free path on the topology graph by given a delay upper bound, a source node, and a destination node and a network of wireless routers. Then, due to energy conservation or some other issues, some nodes are scheduled to sleep or some sleeping nodes are scheduled to wake up periodically or stochastically. Therefore, the network topology changes from time to time. To find the new optimal delay-constrained least cost acyclic path after each topology change is the main objective of the DSPRP.

IV. ANT COLONY OPTIMIZATION

Combinatorial optimization problems such as routing can be solved using Ant Colony Optimization (ACO) in computer networks. Initially the ants spread out in all directions in search of food. When an ant finds a food source, it collects the food and on returning back, marks the trail with Pheromones. These pheromones are falled at regular intervals to act as a trail. Also the pheromones slowly vanish over time. So the Pheromones act as a guiding trail to other ants which begin to follow this path. The same way, number of ants which trace a specific path strengthen the scents of pheromones on the path. In this way, a number of paths might exist from the nest to the food source. Also the shortest path will be the one with the highest pheromone scent (due to shorter round-trip time) (see Fig 1) and also naturally the path with the highest concentration of ants.

At the same time, it must be noted that usually multiple trails exist from the nest to the food source. When a previously short route get blocked/lengthened due to an difficult en route, the other short route get strengthened with higher pheromone content due to shorter end-to-end travel time and more ants move to this path. Hence the route can also adapt to fast changes in the environment.

A. Route Discovery

When a source needs to send a packet to a particular node, it first checks the cache for existing routes. When no routes are known, it broadcasts Forward Request ANTS which are propagated through the network till it reaches the destination.This process can be compared to ants initially spreading out in each direction in search of food source.

When a packet reaches the destination, the destination node sends a Backward ANT for every Forward Request ANTs that it receives. The destination node sends a Backward ANT for each of them when different Forward Ants reach the destination through different routes . This is to ensure that multiple paths exist between the source and the destination. Slowly the best path (which for ants is the shortest path) gets strengthened through increased pheromone count.

The Backward ANTs from the destination reach the source and the source stores the route in the cache memory. Hence this way, multiple paths to the destination will be stored in the source. Next the source needs to decide the best route to follow. In most conventional techniques like DSR/AODV, the source chooses the shortest path to the destination with the assumption that the same helps in reducing energy and time.

Also similarly in the case of harvester ants, the shortest path (which has the highest pheromone scent) serves as the best path for the ants. However research has shown that in MANETs, the best path for routing (considering the overall network benefit as well as node benefit) is not necessarily the shortest path but instead the path which optimizes number of hops (length of path), congestion along path and load balancing. Hence building on the existing Node, this algorithm calculates Route Efficiency Metric (REM) based on the Individual Node Congestion values.

B. Calculation of Route-Efficiency Metric

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

Then the REM can be defined as

Route Efficiency Metric = Π (Node Congestion values of intermediate nodes from source to destination).

C. Route maintenance phase

Route Maintenance in a mobile adhoc network plays a very important role as the network keeps dynamically changing and routes found good during discovery may turn to be bad due to congestion, signal strength, etc.

Hence when a node starts sending packets to the destination using the Probabilistic Route Finding algorithm , it is important to find the goodness of a route regularly and update the pheromone counts for the different routes at the source nodes. To implement this, when a destination node receives a packet, it probably sends a congestion update message to the source which informs the source of the REM value for that route. This Congestion Update message also serves an ACK to the source. These Congestion Update messages are sent probabilistically 0.1, so that they have minimum overhead and do not increase much the congestion if the route is already overloaded. On receiving the Congestion Update message from the destination, the source updates the cache with the REM values as shown below

*New REM value = α * (Old REM Value) + (1- α) *(Received REM value)*

The above is done so that a particular fluctuation in a Node which may result in abnormal Node Congestion and hence REM value does not affect the overall REM value for that route. Also this makes sure that the pheromone counts for the active routes are constantly being refreshed and restrengthened so that better choices are made. Hence the probability of a route being selected constantly changes as the REM value for the route changes. In the future to incorporate the Energy Consumption values for the individual routes so that the choice also optimizes the same.

V.ARIFICIAL BEE COLONY ALGORITHM

In ABC, the colony of artificial bees contains three groups of bees: employed bees, onlooker bees and scout bees. Onlooker bees and scout bees are called unemployed bees. Initially, the scout bees discovered all food source positions. In ABC system, artificial bees fly around in a multidimensional search space and some (employed and onlooker bees) choose food sources depending on the experience of themselves and their nest mates, and adjust their positions. Some (scouts) fly and choose the food sources randomly without using pre trials. If the nectar amount of a new source is higher than that of the previous one in their memory, they memorize the new location and forget the previous one. Thereafter, the nectar of food sources are exploited by employed bees and onlooker bees. Then, the employed bee which was exploiting the exhausted food source becomes a scout bee in search of further food sources once again. In ABC, the position of a food source represents a possible solution to the problem and the nectar amount of a food source corresponds to the fitness function. The total number of employed bees is equal to the number of food sources (solutions) since each employed bee is associated with one and only one food source. ABC algorithm has following phases such as initialization phase, employed bees phase, scout bees phase, onlooker bees' phase.

A. Initialization phase

All the vectors of the population of food sources, are initialized (m=1...SN, SN: population size) by scout bees and control parameters are set. Since each food source, is a solution vector to the optimization problem, each vector holds n1 variables, (xmi,i=1...n1), which are to be optimized so as to minimize the objective function.

B. Employed Bees phase

Employed bees search for new food sources having more nectar within the neighborhood of the food source in their memory. They evaluate its profitability (fitness) by finding a neighbour food source.

C. On looker bees phase

Unemployed bees consist of two groups of bees: onlooker bees and scouts. Onlooker bees probabilistically choose their food sources depending on the information given by the Employed bees. In Artificial Bee Colony, an onlooker bee chooses a food source depending on the probability values calculated using the fitness values provided by employed bees.

D. Scout Bees phase

Scout bees can be defined as the unemployed bees that choose their food sources randomly. Employed bees whose solutions cannot be improved through a predetermined number of trials, described by the user of the ABC algorithm and called "limit".

VI. EXPERIMENTAL RESULTS

A. Network Deployment

In this paper, the initial network topology is created using random waypoint (RWP) model [7]. The random waypoint model is a commonly used model for simulations of wireless communication networks. This mobility model is a simple and straightforward stochastic model that describes the movement behavior of a mobile network node in a given system area. A node randomly chooses a destination point (waypoint) in the area and moves with constant speed on a straight line to this point. After waiting some time, it chooses a new destination and moves with constant speed towards the destination. Fig. 1 shows the initial network topology created using RWP model.

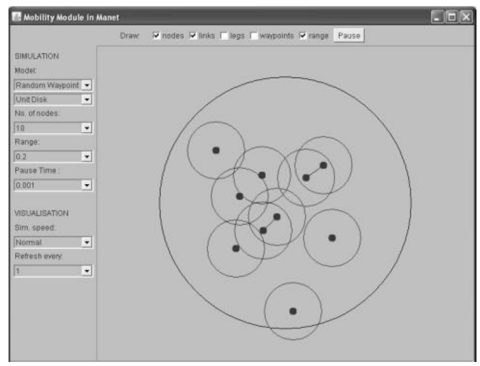

Fig. 1 Network Topology

B. Results

In the simulation experiments, we implement the two traditional algorithms such as Artificial Bee Colony (ABC), Ant Colony Optimization (ACO) for DSPRP. By simulation experiments, we evaluate their performance in a continuously changing wireless network. First, we investigate the memory size that ensures a specified quality of solution for the memory-related schemes.

We pick up MEGA and MRIGA as examples and run them on the cyclic topology series. Since there are 20 different topologies in this cyclic series, we set the minimum memory size to 20. Then we increase it to 30 and 40, respectively. We repeat 20 different topologies five times, and the memory schemes will show more power when the same environments are visited more times. Therefore, we sample the data from the latter part of the evolutionary process in ABC, ACO. We observe that this scheme had the best fitness value compared to other schemes.

VII. CONCLUSION

Mobile Ad-hoc Networks provide a wide number of challenges in routing and network management due to their dynamic and distributed nature. This paper investigates the application of ABC and ACO algorithms for solving the DSPRP in MANETs. A DSPRP model is built up in this paper. A specialized ACO, ABC is designed for the SP problem in MANETs. Several immigrants and/or memory schemes that have been developed for ABC, ACO algorithms and general DOPs are adapted and integrated into the specialized algorithms to solve the DSPRP in MANETs. Then, extensive simulation experiments are conducted based on a large-scale MANET constructed in this paper to evaluate various aspects of these algorithm variants for the DSPRP. The experimental results indicate that both immigrants and memory schemes enhance the performance of algorithms for the DSPRP in MANETs.

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