Genetic Algorithm-Based Routing Protocol for Energy Efficient Routing in MANETs

Pawan, Rajendra K. Sharma, A.K. Sharma and Vinod Jain

Abstract Genetic algorithm is a very popular optimization technique in artificial intelligence. In mobile ad hoc networks (MANETs), all the devices are battery operated. The power consumption at nodes in transferring the data is a big issue in MANETs. In this paper, a new protocol for routing in MANETs using genetic algorithms is proposed. This protocol uses the power of genetic algorithms to find a path that consumes minimum power in transferring the data from source to destination node. Simulation results prove that the proposed algorithm performs better than the previous algorithms.

Keywords Wireless ad hoc networks · MANET · Power consumption · Power-aware routing protocols · Genetic algorithms · Crossover · Mutation

1 Introduction

Mobile ad hoc networks (MANETs) are infrastructure less dynamic networks. Nodes can be added or removed dynamically from these networks. Further nodes may move from one location to another location in MANETs. Because of mobility of nodes routing is very difficult in MANETs. In most of the MANETs, devices connected are battery operated. So power consumption of these devices is a very critical factor while calculating the performance of routing algorithms for MANETs. The energy level of the devices falls rapidly and a node may die very

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soon if routing algorithm do not perform well or do not perform efficiently in MANETs. Genetic algorithm is a very popular optimization technique in artificial intelligence. The power of genetic algorithm can be used to efficiently route the traffic in MANETs so that the power consumed in transferring data from one node to another can be optimized (minimized).

1.1 Energy Efficient Routing Protocols

In literature, many power-aware routing protocols have been proposed by many authors [1–11]. Abolhasan et al. [1] discuss a review on various routing protocols for mobile ad hoc networks. Cui and others [4] provide an approach to increase the lifetime of the ad hoc network by using a utility-based algorithm. Ramanathan and others [8] provide challenges and directions to improve the performance of mobile ad hoc networks. Wedde and others [11] proposed Bee Ad Hoc that works on bee behavior to improve the performance of mobile ad hoc networks. D.E. Goldberg published a paper in 1989 [5] that focused on how genetic algorithm can be used in optimization problems. Authors provide a detail description about working of genetic algorithm and its various operators such as selection, crossover, and mutation. After having a look on this literature, it has been concluded that genetic algorithm can also be used to improve the performance of routing algorithms in mobile ad hoc networks.

2 Genetic Algorithm

Genetic Algorithm (GA) is an optimization technique which uses special operators such as selection, reproduction, and mutation to solve problems which are difficult to solve by using traditional techniques. GA works on some optimization function which may be a minimization function or a maximization function. The basic idea of genetic algorithm has been taken from medical science where characteristics of one population forwarded into next population. Before applying the genetic algorithm, a problem must be able to be represented in genetic form so that genetic operators can be applied on it.

The genetic algorithm is a special generate and test algorithm. It starts from a set of sample solutions to the problem called the initial population. This initial population can be generated randomly. Then different genetic operators such as selection, recombination, and mutation can be applied on the population repeatedly till some terminating criteria do not meet. Genetic algorithm is an optimization technique and does not guarantee to provide the best solution in given time. Generally, GA works on approximation and provides optimal or near optimal solution in the specified time. The amount of time GA takes to provide the solution depends on the convergence of the genetic algorithm. In literature, there are methods that provide techniques to improve the convergence of genetic algorithms.

Some features of genetic algorithm are as follows:

1. GA uses populations which is a set of candidate solutions.
2. GA uses genetic operations to generate new population.
3. GA is stochastic in nature.

The major components of genetic algorithm are as follows:

1. Representation of problem in genetic form (initial population creation).
2. Calculating the fitness of different candidate solutions of the population.
3. Selecting parents to participate in recombination.
4. Applying crossover and mutation operators.
5. Survivor selection to create the next population.

3 Simulation Design and Implementation

3.1 Experimental Setup and Proposed Algorithm

In MANETs, the transmission power PR of a route depends mainly upon the distance between the two nodes and on some other factors of the network and the environment. PR is mainly function distance mathematically transmission power PR = k(distance)2

The value of k is assumed to be one.
Transmission power PR = k(distance)2

In this paper, genetic algorithms have been applied in finding a path to transfer the data from source to destination. We assume that every node have all the information about their neighbors.

Algorithm for cross_over()
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1. Take two parents that will participate in crossover process.
2. Find an intermediate node that is common in both the parents. This node will be used as a meeting point in these two parents to perform one point crossover.
3. Generation of child1—Copy all the nodes from parent 1 into child1 up to the meeting point and then copy remaining nodes from parent2 into child-1.
4. Generation of child2—Copy all the nodes from parent2 to child2 up to the meeting point and then copy remaining nodes from parent1 into child-2.
5. Repeat the process of crossover in the same way in all the iterations.

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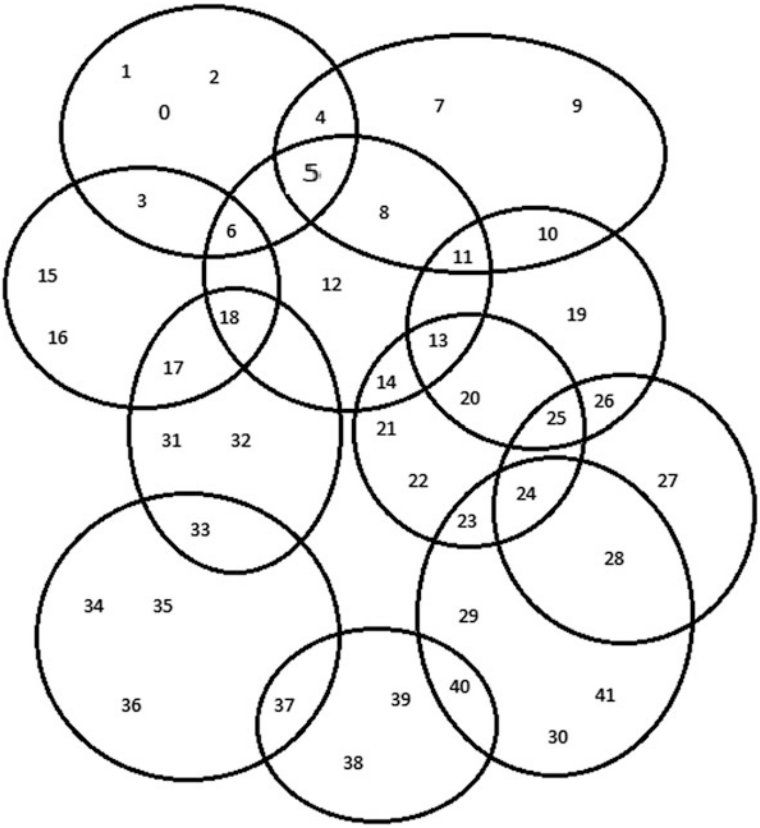

Fig. 1 Sample mobile ad hoc network

Consider the sample network shown in Fig. 1.

Let us consider that node-1 wants to send a data packet to node-41.

Sender node: 1
Receiver node: 41

Encoding: A permutation encoding has been done to represent the problem in a form suitable for application genetic operators like crossover and mutation.

A path from source to destination will become a chromosome. Following is an example of a valid chromosome:

Path: [1, 5, 4, 11, 9, 10, 26, 24, 41]

It is assumed that the network will store the cost of sending data from a node to all its neighbors. So every node creates a cost matrix to send data from this node to all of its neighbors.

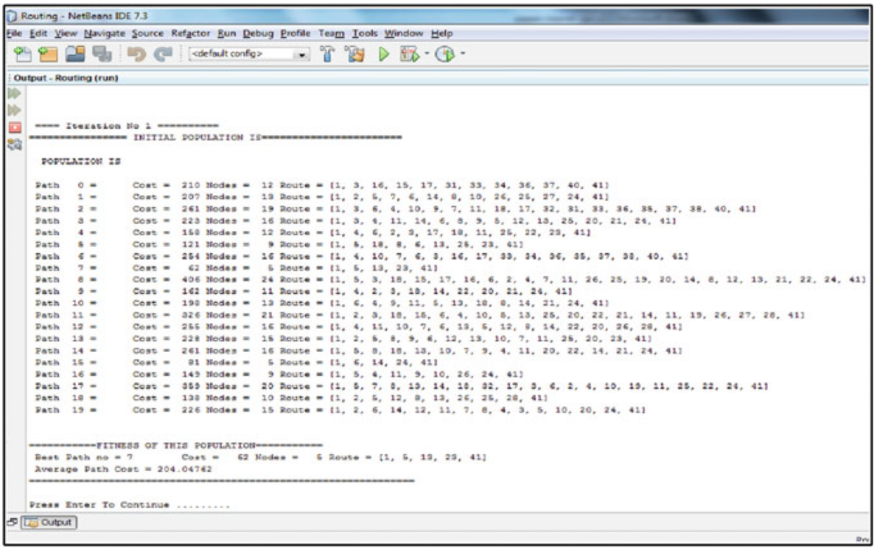

Fig. 2 Initial population

A random cost matrix has been created for the implementation and testing of the protocol.

The initial population of 20 paths has been created randomly. Every path is starting from node-1 (the sender node) and ends at node-41 (the receiver node).

The random population is given in Fig. 2.

3.2 Experimental Result

The average path cost in initial population is 204.04 and the cost of best path is 62.

Path no. 7 in the population is the best path which is as follows:

Cost = = 62 Nodes = 5 Route = [1, 5, 13, 23, 41]

3.3 Cross Over Operator

This operation selects two parents from the population and generates new children. While performing the crossover operation a common node in both of the parents has been sleeted. The route traversed after that node in two parents is swapped to generate two children. The example is as follows:

parent1 = 3 Cost = 139 Nodes = 11 Route = [1, 3, 2, 5, 11, 12, 8, 13, 20, 23, 41]
parent2 = 10 Cost = 131 Nodes = 10 Route = [1, 6, 12, 14, 13, 19, 20, 22, 24, 41]

Node Selected For Cross Over = 12

Child1 = Cost = 147 Nodes = 13 Route = [1, 3, 2, 5, 11, 12, 14, 13, 19, 20, 22, 24, 41]
Child2 = Cost = 123 Nodes = 8 Route = [1, 6, 12, 8, 13, 20, 23, 41]

For example let us explain how child-2 has been generated:

First of all route traversed in parent 2 till node-12 has been copied in child-2, i.e., = [1, 6, 12]. After that route traversed in parent 1 after node-12 has been copied in the remaining part of the child, i.e., [8, 13, 20, 23, 41]

So finally child 2 = = [1, 6, 12, 8, 13, 20, 23, 41]

In the same way child-1 has been generated.

It can be observe that the crossover operation generates a new path (child 2) which is having less path length as compared to both of the parents. Thus, this process will improve the fitness of the population in every iteration.

Population after five iterations is shown in Fig. 3. The average path cost in this population is reduced to 108.04 and the cost of best path is 62. Path no. 19 in the population is the best path (same as the first initial population) which is as follows:

Cost = 62 Nodes = 5 Route = [1, 5, 13, 23, 41]

After this population, some more paths have been added in the population that can be used as alternate paths if there is any problem in sending the data through the best path.

4 Results and Discussion

Power-aware routing algorithm for mobile ad hoc networks can be optimized using GA genetic algorithm. GA can be used in finding a path that cost minimum in transferring data in MANETs. The work has been implemented in java on a sample network of 42 nodes. It has been observed that GA finds best paths very quickly in little iteration. It also finds some alternate paths that can also be used if one path failure occurs by any reason. In future, the proposed algorithm can be tested on a mobile ad hoc network having thousands of nodes.

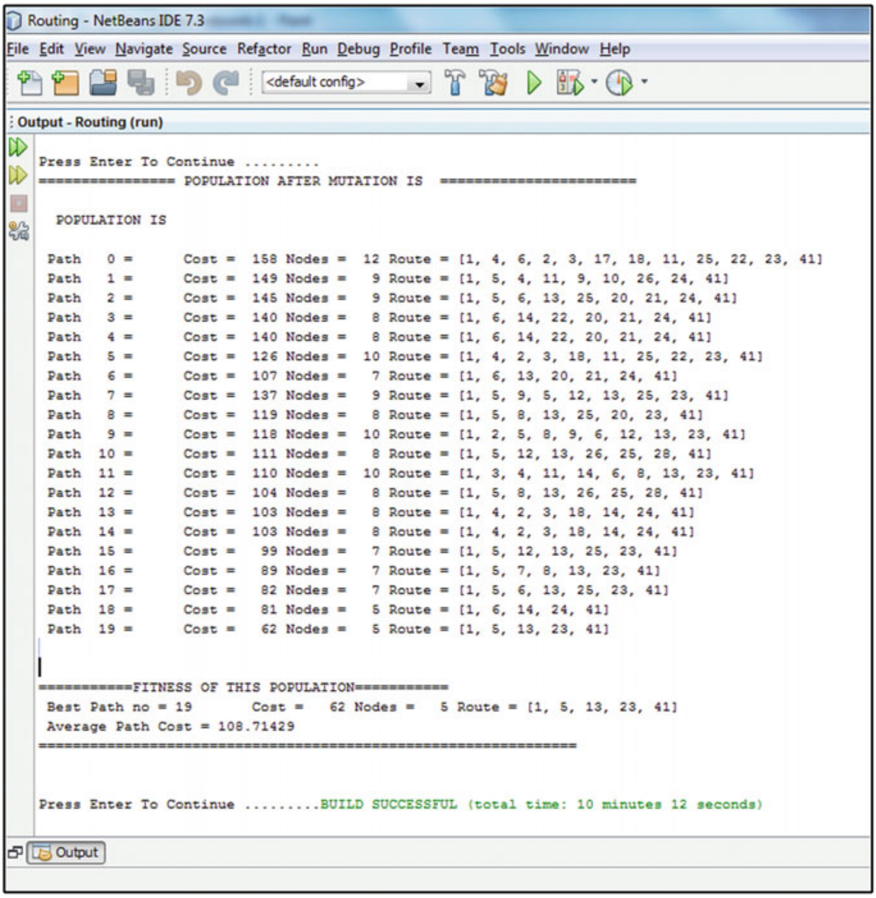

Fig. 3 Population after 5 iterations

5 Conclusion and Future Work

Genetic algorithm is a useful technique in finding path between two nodes in a mobile ad hoc network (MANET). An optimal solution to the problem can be find using GA that will find a path to transfer a packet from node-1 to node-41. GA process find a solution with cost = 63 in only five iterations. So it is concluded from this paper that genetic algorithms can be used to solve routing protocols in MANETs. However, the performance of GA with other existing techniques has to be justified in future.

6 Figures

See Figs. 1, 2, and 3.

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