Improving the Performance of the Networks Using Genetic Algorithm

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***Abstract*— The field of Networks has gained an important part of the interest of researchers and has become very popular in the last few years. The network must operate without fixed infrastructure and can survive rapid changes in the topology. It can be studied formally as a graph in which the set of edges varies in time. I propose a new adaptive and dynamic routing algorithm for networks inspired by the genetic algorithm (GAR) in combination with network delay analysis. Using GAR we can find, if not the shortest, at least a very good path between the source and the destination.**

There are several algorithms for the shortest path (SP) problem: one of them is the Dijkstra algorithm. Since these algorithms can solve SP problems in polynomial time, they are efficient in fixed infrastructure wireless or wired networks. However, they exhibit unacceptably high computational complexity for real-time communications involving rapidly changing network topologies.

It is anticipated that genetic algorithm GA can efficiently and dynamically give consistent better solutions regardless of: The network topology, The change in the network, removing any node, or link from the network, The volume of the network (if there are many paths).

Keywords- genetic algorithm, routing Algorithms, Topological database, GAR, fitness function.

I. INTRODUCTION

In any network, such as the Internet, routing is one of the most important issues that has a significant impact on the network's performance. Any good routing algorithm should strive to find an optimal path for data transmission within a specific time in order to satisfy the need for fast and reliable network.[1]

GA is a non-traditional based optimizing technique which can be used to optimize the network. GA operations [4], [5] can be briefly described as Coding, Initialization, Evaluation, Reproduction, Crossover, Mutation and Terminating condition. GA has been used in previous studies to optimize the network and also in the design of network [5].The limiting factor of GA based solution is the time constraint. The time required to generate a solution is quite high in GA. I propose a GA approach to the dynamic routing problem with a new technique to populate the generation which will provide an optimal solution in reduced time along with a comparison of the various selection mechanisms [3].

In previous studies, routing strategies did not undertake the efficient study and analysis, but I want to propose a new technique using genetic algorithm to make the performance of the new algorithm better and give the optimal routing path in all cases in the network. Genetic algorithms are used for a number of different application areas. An example of this would be routing problems in which the character (number) string of the chromosome can be used to encode the values for the different paths being optimized.

There are many studies in the domain of genetic algorithm and the application of the GA, but in the routing application using genetic algorithm few studies were done, and this has encouraged me to work and research in this field.

II. Literature Review

Munemoto's [3] algorithm employs variable-length chromosomes for encoding the problem. Crossing sites (points) are the loc_i (positions of nodes in a route), where identical genes (nodes) in both the chosen chromosomes (routes) are found at the same location.
Thus, it leads to a situation in which only a few crossover sites are usable for exploring feasible solutions. In other words, crossover is totally dependent on positions. Indeed, identical genes should occupy the same locus for crossover.

Inagaki proposed an algorithm that employs fixed (deterministic) length chromosomes. The chromosomes in the algorithm are sequences of integers and each gene represents a node ID that is selected randomly from the set of nodes connected with the node corresponding to its locus

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number. All the chromosomes have the same (fixed) length. In the crossover phase, one of the genes (from two parent chromosomes) is selected at the locus of the starting node ID and put in the same locus of an offspring. One of the genes is then selected randomly at the locus of the previously chosen gene's number. This process is continued until the destination node is reached. The details of mutation are not explained in the algorithm. The algorithm requires a large population to attain an optimal or a high quality solution due to its inconsistent crossover mechanism. Some offspring may generate new chromosomes that resemble the initial chromosomes in fitness, thereby retarding the process of evolution.

R. S. Ramakrishna [2] worked in this field in the Ph.D. degree and developed a new algorithm that worked in both fixed and variable length chromosomes, but this algorithm does not get the optimal path in all cases, but compared with others algorithms this algorithm can perform efficiently.

The proposed project (GAR) in this work is based on the basics of the three algorithms to make a good analysis and reach for the optimal path in all cases if this is possible, hopefully.

III. METHODOLOGY

Representation Mechanism: Network configuration has been represented based on the multi-parameter encoding mechanism [7]. Routing table is created for all pairs of node combination. The entries in the routing table correspond to the paths included between a pair of nodes. In the proposed algorithm each route is represented by a string which is in accordance with the links in the routing table and these constitute the configuration strings.

The first step in GA is initialization. The routes are selected randomly from the routing table. Between each pair of nodes a route is selected from the routing table and that forms the configuration string (CS). The RT of all CS that satisfies the given constraint is maintained. The size of the RT is fixed which is greater than the population size and as new strings are generated the older strings are removed by the newer ones [6].

Also we need fitness function to interpret the chromosome in terms of physical representation and evaluate its fitness based on desired traits in the solution. However, the fitness function must accurately measure the quality of the chromosomes in the population. The definition of the fitness function, therefore, is very critical. The fitness function in the SP routing problem is obvious because the SP computation amounts to finding the minimal cost path [8]. So Topological database (database that contains the initial paths for all nodes in the network) must be used in the algorithm to select the initial generation randomly regardless of the source and destination, is very important to make a good selection of the next generations. Also I propose new ways to generate the population and to make selection and crossover operations.

A. Genetic representation

A chromosome of the proposed GA consists of sequences of positive integers or characters that represent the IDs of nodes through which a routing path passes. Each locus of the chromosome represents an order of a node (indicated by the gene of the locus) in a routing path. The gene of first locus is always reserved for the source node, ***see figure (1).*** The length of the chromosome is variable, but it should not exceed the maximum length, where the total number of nodes in the network is.

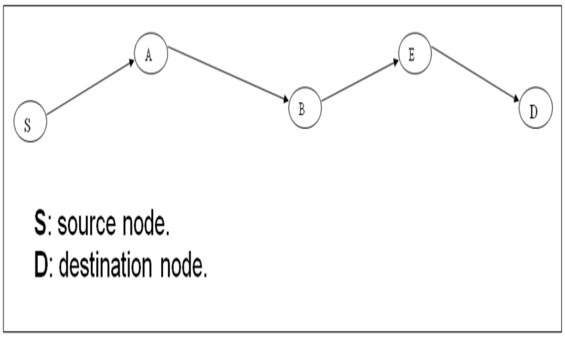


Figure 1. Gene Representation

B. Generate the initial generation (select G0)

Heuristic generation

In previous studies, this step did not take the efficient study and analysis, but in this project, I tried to make the first generation cover all aspects of the solution.

Topological database: database that contains the initial paths for all nodes in the network, used in the algorithms to select the initial generation randomly regardless the source and destination.

But in this project I used different technique to select the initial paths; this technique takes in the consideration the source and the destination. When we generate the initial paths, the first generation must contain all links in network. Notes:

- The matrix contains all links: (AB, AE, AC,BD , BF, CD…)
- Take the links in the array and compose the initial paths but the first node is the source and the last node is the destination.
- Any link must be taken once in every path (infinite loop problem).
- Must take all the links in the network.

C. Crossover between chromosomes

Crossover examines the current solutions in order to find better ones. Physically, crossover in the SP routing problem plays the role of exchanging each partial route of two chosen chromosomes in such a manner that the offspring produced by the crossover represents only one route. This dictates selection of one-point crossover as a good candidate scheme for the proposed GA. One partial route connects the source node to an intermediate node, and the other partial Route connects the intermediate node to the destination node.

Kinds of crossover that we can use in routing:

1- One-point crossover: this means we take randomly one position in the first chromosome as a location to make the crossover, and then the location for the other chromosome is the same. However, this can produce wrong results after the crossover operation, which may produce paths that do not exist in the topological information of the network.

For example: If we take the following paths from the network above figure (2), and make the crossover between them at location 2: AEB, ABF. After crossover, the following paths are produced: (ABB, AEF) and if we look for the network above, the two paths do not exist. This type of crossover needs a lot of overheads to yield consistent results.

2- Two-point crossover: This means we take randomly one position in the first chromosome as a location to make the crossover, then the location for the other chromosome is taking the same for the gene not for the location (another gene as we selected in the first chromosome, but not necessarily the same location).

For example: If we take the following paths from the network above, figure (2), and make the crossover between them at location 3 then the location in the second path is 2: AEBD, ABF After crossover, the following paths are produced: (AEBF, ABD). If we look for the network above, the two paths exist; the only problem in this type is looping path (two identical genes in the same chromosome).

D. Mutation:

In order to perform a mutation, a gene is randomly selected first from the chosen chromosome (“mutation point”). One of the nodes, connected directly to the mutation point, is chosen randomly as the first node of the alternative partial-route.

For example: If we have the paths (S →A →B→E→D) and make the mutation at location 2 the result is (S →A →F→D), that may be more effective than the first path.

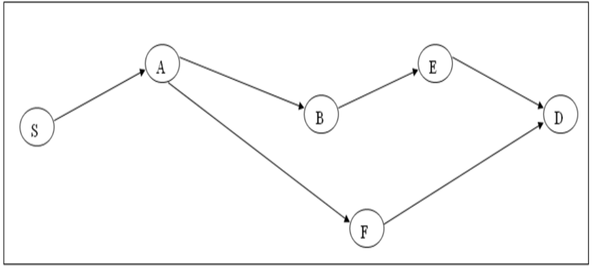


Figure 2. Mutation

E. Fitness function

$$F_i = \frac{1}{\sum_{j=1}^{l_i - 1} C g_i(j), g_i(j+1)}$$

Where Fi represents the fitness value of the i-th chromosome, li is the length of the i-th chromosome; gi (j) represents the gene (node) of the j-th locus in the i-th chromosome, and (C) is the link cost between nodes.

Example to demonstrate the methodology:

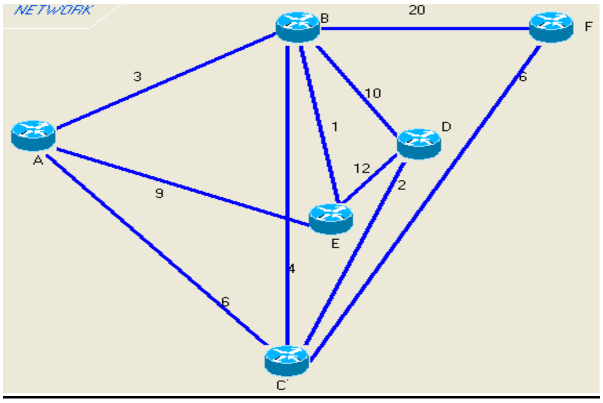


Figure 3. Six Routers Network

Using the above network (figure 3), suppose the source is A and the destination is D

Initial paths: ACBD = 20, ABD =13, AED = 21, ABED = 16, ABFCD = 31…All links are taken.

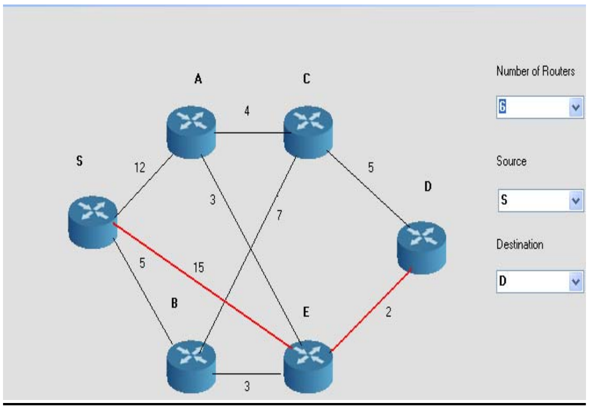
Crossover: ABD, ACBD → ACBD = 20 and ABD = 13…The same paths

ACBD, ABED → ACBED = 23 and ABD = 13...Not taken because the cost of the first path is greater than the initial and the second path already exists

ABFCD, ACBD →ABFCBD (loop in B), ACD = 8

The first path is discarded, but the second is taken because its cost is less than the others. If we continue in this operation we will see that no paths could be produced less than ACD. This means this is the optimal path. If we look at the network above we find that this is definitely the optimal path.

Experimental example from the project that I have developed to demonstrate the new algorithm:



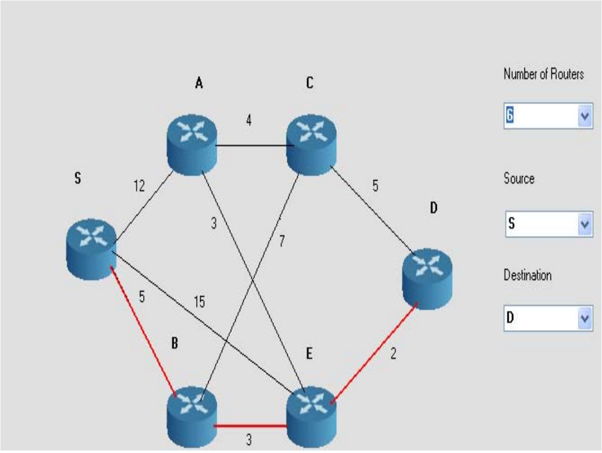
Number of Routers 6

Source S

Destination D

Figure 4. Finding Path using RIP

The cost of the path is 17 (not the optimal path).



Number of Routers 6

Source S

Destination D

Figure 5. Finding Path using GAR

The cost of the path is 10 (the optimal path).

IV. RESEARCH QUESTIONS

Many questions might arise in this research. At the moment the questions are as follows:

1. What is the most suitable form to represent the route?

2. How can we make new changes in the operations of the genetic algorithm to produce good generations?

3. How can we create good fitness function to judge the quality of the generations (paths)?

V. CLAIMED CONTRIBUTIONS

The benefits of this research in my opinion are:

1. Creating new algorithm of routing using genetic algorithm, always finding the optimal path in any network.
2. Making visualization of the network to perform the suggested algorithm.
3. Comparing the suggested algorithm with other routing protocols such as RIP.

However, I envision the outcomes of this research go beyond local aspects and also become relevant from a distributed point of view because of the efficiency of the genetic algorithm to solve many problems in any field.

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