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Dynamic Routing Using Geneticalgorithm A Systematic Review

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Abstract:Routing related issues are the prime concern in networking. To solve such networking related issues, various approaches are used. A network is an interconnected system of objects. A network object may represent anything depending on the application, e.g., computers in a computer network, telephones in a telecommunication network, cities in a road network, oil wells and refineries in an oil pipeline network. Designing or building a network involves interconnecting objects of interest under certain conditions. A network design is a blueprint for building a network. This paper will help to select genetic algorithm as an option to find optimal solutions for routing by understanding basic knowledge of process involved in following genetic algorithm as a tool to proceed with solution.

Keywords: Network interconnections, Genetic algorithms, Capacitive minimum spanning tree, graphs, mutation, crossover,

I. INTRODUCTION

As routing is basic process to solve the network issues. many a problem we face to find optimal path when multiple nodes are interconnected. Most of network designing need to sort problems that obey certain constraints. So, our goal is to design a network with minimal costing. Many network design problems are modelled as optimization problems. In an optimization problem, the objective is to minimize or maximize a given objective function under certain constraints. It is these constraints that control the objective value that is being optimized. Unconstrained problems are easier to solve. For example, a loosely defined problem of connecting a given set of computers could potentially have numerous solutions if one were to ignore the cost of connecting them.

This paper gives a brief knowledge of solving routing problems using graph theory and capacitive minimum spanning tree,as genetic algorithm is also one of the popular approaches to solve the optimal networking problems in routing, weincluded different features of Genetic Algorithm, how and why it is implemented and the various operators that can be used such as selection, crossover, and mutation. it also describes the various types of each operator with their variations.

In this paper, strength and limitations of using genetic algorithms are also listed. This is to help to define constraints for taking approach of genetic algorithms into consideration for further work.

A. Graph theory

A graph G can be defined with a set of verticesand a set of edges. The vertices are often termed to as nodes , and the edges is termed to as links. A graph is denoted as a pair (V, E). Edges in a graph may be *directed or undirected*. A graph having only no directed edges is called an *un-directed graph*, and a graph with all directed edges is known as directed-graph. A graph that contains both directed as well as undirected edges is called *mixed graphs*. This thesis will be dealing only with undirected graphs.

An edge $e \in E$ in a graph is usually associated with two vertices or end-points. An edge could be associated with just one vertex as both of its end-points are the same, which are called *loops*. Generally, it is assumed that there is at most one edge between two given vertices, which are known as*edges with parallelism*. A graph which do not have parallel edges and loops is termed a *simple*

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graph. If there is an edge connecting v_1 and v_2 in a graph then the two nodes v_1 and v_2 are adjacent. A graph $G' = (V_x, E_x)$ is a *sub-graph* of graph $G = (V, E)$, if $V_x \subseteq V$ and $E_x \subseteq E$. Only edges with both end-points in $V_x$are included in E_x. A*connected graph* is a graph in which there exists at least one path between any two vertices.

A *simple path P* between two vertices v_1 and v_2 is a set of edges $\{e_1, e_2, e_3 \ldots e_n\}$ such that e_i and e_{i+1} have a common end-point, and e_1 and e_n have end-points v_1 and v_2, respectively. If a real number is associated with each of its edges then it is called *edge-weighted*. Depending on the application, these real numbers may represent the length or cost of an edge. If a real number is associated with each node in the graph then it is called vertex-weighted, which is also called a *capacitated Graph.*

Spanning Trees Process:G= (V, E) is given, T= (V, E_x) is a called spanning tree with connection, and it is treated as sub-graph with no cycles. If there are n nodes in a spanning tree then this spanning tree has n-1 edges. I f there is n nodes then the no. of spanning tree will be n^{n-2}. An MST with total edge weight is minimal for given graph is treated as spanning tree. For the minimum spanning tree there are some good algorithm which can give us good idea for understanding MST.

B. Minimum Spanning Tree with capacitive value (CMST)

For designing an efficient telecommunication network the major issue is to calculate a minimum cost layout with a specified traffic allowed to transmit. One more thing regarding this problem is that as the time changes the network required to update. From a long time, this problem is taken care. A number of algorithms has invented regarding this problem.

The basic problem in network design is the centralized computer network design. In this case a central processor and a set of remote terminals with specific demands are given. Between a terminal pair or to the processor of centre and a terminal there is a nodewhich can be added for a known cost. The connection or link between a terminal and central processor must have the following properties:

- the network should be a tree;
- the traffic on said node of the network should be at most capacity constraint;
- the cost of total design should be minimized.

When there is unit demand we consider all terminals equal to one and the links have the same capacity, it is easy to solve the problem of capacitive minimum spanning tree. The terminals having non-unit demand that is not an easy task. When the demands from all terminals are not unique,so the problem becomes the totally *generalized CMST* problem.Every node in CMPT has its well-defined demand and can detect the flow of traffic on a particular link.

a) Homogeneous demand case: every client node has its own demand and all client's nodes demand treated as one. This case describes that every sub tree which is rooted reduces the problem in finding spanning tree have k at most nodes.

b) Heterogeneous demand case: In this case demand for non-unit case is shown as below in the figure. The meaning of non-unit is that all node has not demand just one, every node demand could be one or more than one.

Applications of CMST:CMST problem is a problem in the designing of communication network. In this type of problem in which there must be a central node and all other node are attached with central node directly or it may be indirectly with their cost and node which is linked with the central node have capacity which is maximum that always maintain the network communication designing criteria. There are a lot of applications of CMST like--

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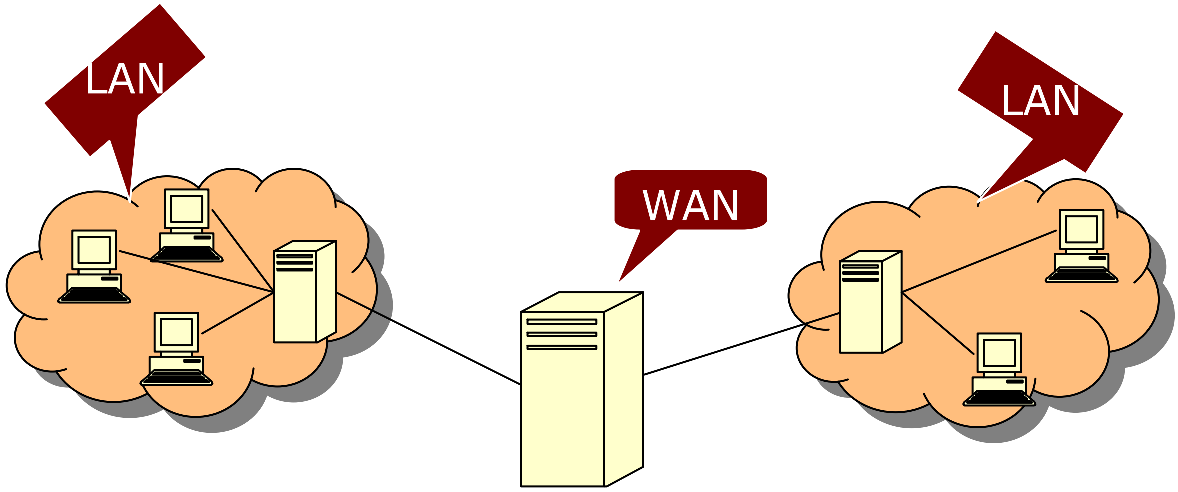

Fig 3: Network DesignCentralized

As above fig shows there is a wide area network a central node exist and two clusters of LANs which is giving idea that client node is attached with the server.

Other applications:

- Telecommunications network design
- Centralized communication network design

In a telecommunication network, a network is designed having the minimum cost by installing expensive (fibre-optic) cable with its edges, with some capacity constraint k on the cable being used. The cable costs at the rate of per unit length. Traffic flow to every client node can be controlled by central node in the design of network access network topology optimization is the problem that can be arises. This type of problem has some characteristics—

1. Need hierarchical n/w structure
2. Assume pattern of simple traffic demand

Motivation for different approaches for routing: There are many network topologies designs related problem which include CMST, which tells us about the finding the minimum cost that in a given spanning tree there are a central node and there is some node which are connected with central node and they have their capacity constraints. Each link is having their cost which is totally based on the distance, quality of lines, capacity etc. and one main thing that every node has some demand with it. Basically, many networks are static in CMST, but there are some times need to change in the adding or deleting nodes of this type of network is called network with dynamic features and such type of cases is called DCMST dynamic CMST.EW algorithm providesbasic solution for the DCMST problems, but it's not necessary to always provide optimal solution. In this paper we are describing ways to use genetic algorithm to find the best result than EW algorithm to dynamic CMST.
Evolutionary computing is done in the genetic algorithm which is thinking as the improvement of AI area. Basically, genetic algorithm are the computer programs. Genetic algorithm is treated as the search procedure which are used in solving the problem and modelling of the evolutionary systems.

EW (Esau & Williams) Algorithm: As it's known that for a Minimum Spanning Tree problem *Kruskal's* algorithm [14] start with n subtrees, each containing a single node and then merging them until only one tree is left. In *Kruskal's* Algorithm the merging is based on the proximity of the subtrees. And for the CMST problem the *Kruskal's* Algorithm is slightly modified to find the feasible CMST for a given problem. One of the modifications is to connect the subtree directly to the root or central node if the sum of vertex or node weight is up to capacity constraint k.
As in a CMST problem a communication line is capable of transmitting only a limited amount of traffic and still satisfy the application requirements, the desired configuration will be determined, in part, by the amount of traffic at each remote location. This method to be described assumes that the *line-loading* capabilities are given. The cost is proportional to distance will suffice as the basic variable in the construction of a most-economical configuration. In explaining the algorithm here, the

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cost is proportional to distance; the algorithm assumes that a maximum distance configuration is one in which each remote location is connected to the center by a single link.
The EW (Esau & Williams) algorithm [5], [9] and [18] is based on the savings. Instead of merging two subtrees based on the proximity, EW introduces a new concept savings to merge any two subtrees. For connecting two subtrees EW compute savings for all subtrees and join those two subtrees, which produce the greatest savings.
The distance between two nodes, dist (i, j) represents distance between i and j. The distance between all nodes are stored in an n ×n matrix, on the bases of this distance matrix the n ×n saving matrix will be computed using the formula as:

$$\text{Savings}\ (i, j) = \text{dist}\ (i, j) - \text{dist}\ (i, r)$$

r is the central node/vertex. The subtree i and j, which shows the best savings will be connected if it also fulfills the capacity constraint.

Problems with Esau-William's Algorithm: The problem with this algorithm [4] is that, it does not provide the optimal result for the CMST problem in all the cases. Consider the case when during the algorithm, the weight must be k/2 which is coming when all sub-tree has been formed, as we know that k is the capacity constraints, as there is a difficulty when the we are merging the 2-sub tree, EW will connect root with the sub tree directly.

C. Basics of Genetic Algorithms

Genetic Algorithm (GA) was developed by *John Holland* his students and other batchmates.

It is a method to find out the solution on the basis of analyzing strings in a proper way.It tries to evaluate the optimal solution of agiven problem. This algorithm makes new pattern by given pattern. It chooses a specific way to find out the optimum solution of a given problem. It creates various groups of data sets bit by bit and perform some operations by including some external data. The results obtained by genetic algorithm used to specify the large number of data sets.
The requirement of this approach is plays very vital role because this approach does not need any deep knowledge of problem type. Its success depends various factors like complexity, parallelism, independence and combination of nature of the given problem.

Biological Background

Chromosomes: All live body on earth are made up of small cells. a cell is a collection of chromosomes which are made up of DNA pattern strings. A DNA serves as a base foundation for a living body. It's mostly unique in every one. Actually, its relevance only matches with parent cells.Each DNA cell is made up of specific combination of protein particles. A DNA is responsible for various features of a human body. For example, eye color can be decided by it.

Reproduction: A DNA play very important role in reproduction of a new pattern by various cross over schemes. Parent chromosomes combine to make a uniquely new type of pattern to form a new DNA. This process is called mutation. Mutation is a process in which original DNA performs some specific operations to generate a new unique DNA.

Fitness: The word fitness in terms of chromosomes defines the essential physical representations of the information's to specify new pattern for reproduction. It's really tough to define the fitness function as its accuracy depends of desireless of process. Most of the time it is efficient to compute its value to reach the solution as optimum value can be decided on the basis of it.

Evolution: Evolution specify the subsequentially enhancement in pattern then previous one. It actually defines the adoptability of the chromosomes which need to change frequently due to environment changes.

Search Space: The feasible solution of genetic algorithm is called state space as by taking this approach one need to find the best solution. Each single point of this space is evaluated on the basis of fitness function. This is the main reason to find an optimal solution we need to go up to extreme in

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maximum or minimum values in search space. Each point generates a possible solution to the given problem.

Roulette Wheel Selection: In this approach parents were chosen by evaluating their status of fitness function. As much fine their values as much chances to select them. The higher the value of their fitness in Roulette wheel arrangement the more chances to get selected. A small glass ball is diced in wheel and as wherever it stops is taken as to give the chance
This can be written as algorithm as follows.

- Compute the sum of all fitness factor in pattern – call it **p**.
- Evaluate a random number starting from the interval **(0, p)** –call it r.
- Check the pattern and add the fitness factor starting by **0** – add to **p**.
- If the addition s is higher than r, end and return to the pattern

Rank Selection: The selection on the basis of earlier methods have some problems as if there is a major difference in fitness factor then result will be biased to higher one all the time. For example, if variation is of 90 percent to 10 percent then it is higher chance to select the 90 percent always.
In this approach we define a rank to each chromosome on the basis of their fitness factor value.by this we make a fair chance to each rank to qualify in election process.After selection of a chromosome it is further processed for the crossover process and said by Darwin, best will be survive, a best will be chosen by various other methods.

Steady-State Selection: This approach is basically use to collect the chromosomes which have enough capability to survive for new pattern generation. By using this approach, one cannot try to find any single optimum solution.

In this selection method genetic algorithm, we define some very basic fitness factors to determine between a bad and a good type of chromosomes. Good one is forwarded for next generation and bad one is discarded.

Elitism: This method uses crossover and mutation and give a chance to lose best chromosomes actually used to reduce the loss of a best-found solution by preserving it for next generation. A new pattern may be formed but as its parents are of best chromosomes it can be a best so using this method is just to reduce the complexity of a genetic algorithm in performing a complex task.
Crossover: This genetic operator is used to modify the value or programming of chromosomes. It is rejoining process completes in following steps:

(i) Random selection of two individual strings,

(ii) Random selectionfor cross-site along the string length,

(iii) swapping of positional values between the two string

Here are some crossover types:

1. Two Point Crossover: This crossover is a variation of single-point or one-point crossover. In this crossover two random crossover points are selected instead of one. And then the Childs are created from them through these points such as:

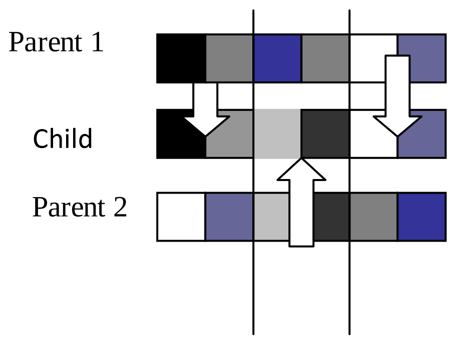

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Fig 6: Two-point crossover

2. **Multi-point Crossover:**This crossover is also known as n-point crossover. In this crossover first choose n random crossover points. Then split the parents along those points, create offspring from them as:

Parents

Childs

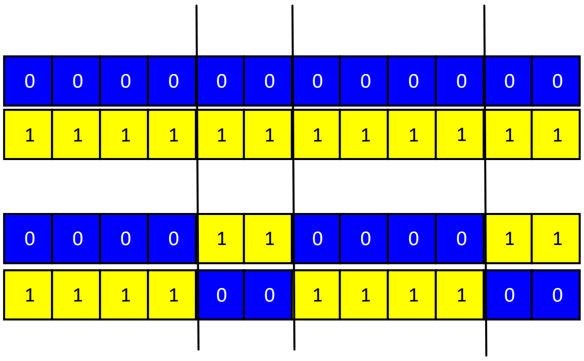

Fig 7: N-point crossover

Mutation: It is motivated to stop the falling into a local optimum of thespace of state. Make random changes in the genome of an individual. The most common choice: with a small probability, flip each bit in the genome. The different types of mutation are:

1. **Bit inversion:**This mutation is preferred for binary encoding where the selected bits are inverted as: 10**0**000000**1**=1010000000,

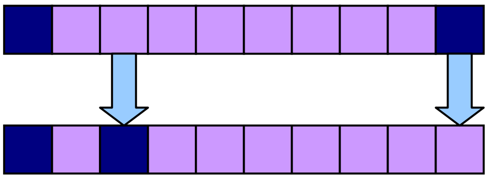

Fig 8: Bit inversion Mutation

2. **Order changing:**In this mutation n numbers are selected and exchanged. This is mainly used for permutation encoding. The numbers are selected randomly and scrambled. For example:

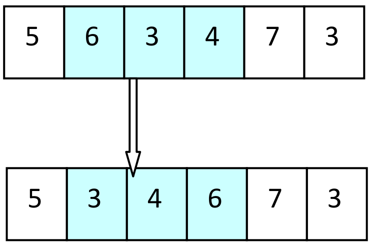

Fig 9: Order changing mutation

where the second, third and fourth values have been randomly scrambled.

3. **Value changing:**This mutation is used to change the value of the chromosome. This is preferable for Value encoding. In this mutation a random chromosome position is selected and them the value is changed such as:

3.4	4.2	4.6	6.4	3.2

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3.4	4.2	4.5	6.4	3.2

Fig 10: Value changing mutation

Strengths of Genetic Algorithm:

1. The nature of the finding solution by genetic algorithm is mostly parallel processing. Many algorithms are operational serially and so they are limited to explore a solution space up to some extent. A serial approach is processed in one direction of solution while a parallel approach tries to perform its operation in either direction. If a serial approach found a sub optimal solution then it stops by delivering result but in parallel if one path leads to finish even then we can hope for solution.
2. A parallel approach permits to evaluate many schemas at once, A non-linear problem mostly suited for genetic algorithm approach. In a non-linear approach most of the problems having various fitness factors and they need to be treated independently.
3. Genetic algorithms do not need previous knowledge about the problem to process them.

Limitations of Genetic Algorithm: As we know that genetic algorithms are the very powerful in the solving the problems they are not treated as panacea genetic algorithms are very efficient also. as it has many advantages as well as there are some limitations also. However, all of these can be overcome and biological evolution validity not bear by it.

1. For the showing candidate solution, the specified solution must be durable means that if there are some random changes then it must tolerate so that if there are fatal errors comes than it should not give consistently result.

2. When the fitness function is taking into account one must think that the higher fitness is considerable and calculate the better solution for the given problem. If we choose the fitness function in very lazy way or poorly then the GA will result very poorly and the result will not come as we are desired, it may be the chosen of fitness function is wrong then solution will be wrong.

CONCLUSION

The Genetic Algorithm approach can be analysed and compared by taking other encoding schemes. Future work on proposed algorithm may involve exploring different crossover and mutation operator in order to improve the performance of GA with respect to optimization as well as time taken to compute the solution.

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EW: Esau and Williams Algorithm
CMST: Capacitated minimum spanning tree
DCMST: Dynamic CMST
BSA: Best saving algorithm
COD: Closet or Direct Heuristic
CFOD: Closet Feasible or Direct Heuristic
TSP: Traveling salesman problem
GA: Genetic Algorithm
DNA: Deoxy-riboNuclic Acid

