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Optimization of ACO-GA for Routing Optimization

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Abstract- For network routing optimization many protocols and methods are evolved over time and this continuous race for more accurate and speedy data delivery is going on, our research is also one attempt on that race. Nature is best knowledge available on this planet, so ignoring this available science on any field would be foolish. Ants are social insects that searches food collectively and passed their knowledge of food path to others by leaving a hormone called pheromone on the way; researches used this earlier solely and with Genetics for routing optimization. Combination of both is used in routing optimization where output of GA is passed on ACO algorithm but we proposed to use firstly ACO and then passed the output of ACO in GA to get possible path. By our approach we not only reduced the domain of routes for GA but also optimized the time, every time GA uses for evolving best set of chromosomes. We just not only optimized the routing but also optimized earlier research of combination of ACO and GA.

Keywords- Ant Colony Optimization, Genetic Algorithm, Routing Optimization, Meta-Heuristic

I. INTRODUCTION

ACO and GA are the two meta-heuristics approaches that are already used and researched in the network optimization. Network routing is the process of getting best possible paths in a network through which to send network traffic. We can classify communication networks can as in two type, circuit-switched or packet-switched. The example of circuit switched network is the telephone network in which the physical circuit is set up when the communication starts and lasts till the communication ends. Unlike Circuit Switching, in packet-switched network or data network, where each data packet can follows a different path and no dedicated connection is established [1].The example of data networks are LAN and the Internet. However, one of the main feature of the network routing problem is that it is ever changing or dynamic in nature. Meaning that, one of the routing attribute is that the traffic over the network changes all the time. Additionally, the links and nodes of the network can suddenly go out of the service, and new links and nodes can be added at any moment. All these characteristics have to be considered in order to create the best possible or optimized solution to this problem. ACO is a meta-heuristic technique that uses ants mimicking routing algorithm to find solutions of the optimization problems [2]. ACO is based on that time behavior of ants when they are searching their foods for the nest. Ants search the food in different directions and pass on their knowledge of food path to other nest ants by releasing a special type of hormone on the way. An individual ant is unable to communicate directly with other ants like us and individually ants are not good enough in searching food effectively, but as a group, ants possess the ability to solve complex problems and successfully find and collect food for their nest. After getting out from the ant colony each ant individually searches for the food in different areas and when an ant gets the food it return towards nest during this time of searching of food each and every ant leaves a hormone called Pheromone trail in the way between food and nest. The longer the route less would be pheromone amount on the path but when the food is found in the shorter route then number of rounds to the foods increased so also the amount of pheromone is also more than in comparison to other longer routes. Other ants of the colony also select the path that has more pheromone, so the more hormone on the three are more chances of selecting that path.

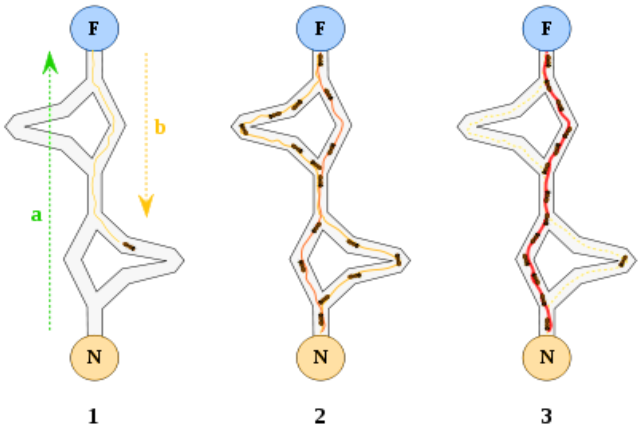

Fig.1: Ants following shorter path by pheromone concentration

In ACO, there are a number of artificial ants (which mimic the data packets) that build solutions to the considered shortest path routing problem and exchange this shortest and most suitable path information with each ant of the ant nest [4].

There are three general algorithms for ACO. First algorithm of the ACO does not allow the ants (packets) to visit a node that is already visited in the process routing that is no ants(packets)are allowed to make a loop in its path. In the second ACO algorithm, the packets are allowed to visit already visited nodes with the exemption of the current lastly visited node so in a sense loop making is allowed in a limited fashion. In the third and last developed method(algorithm) of ACO when the network model is large, then revisit of last 'n' number of visited nodes is not allowed, exempted nodes are allowed for revisiting [5,6].This restriction on limited number of nodes is done to curb the chances of forming loops in the path of destination node. We used last method of ACO in our research project with slight modification, which gives better result in large networks and not earlier used in the hybrid model of the routing optimization [6,7].

II. GENETIC ALGORITHM

The Genetic Algorithms (GAs) are tools based on the principle of evolution and used to find an optimal solution of the problem by using genetic tools[13]. A set of initial population of candidate solutions, called chromosomes, is maintained at each iteration of the evolution. Each chromosome made of certain linearly arranged genes which are represented by binary strings [8].There are mainly three major operations in the GA namely, reproduction, crossover, and mutation, which are used are used to evolve new offspring solutions. Based on the Darwinian principle of survival of the fittest, reproduction stage produces the fittest solutions from the domain of chromosomes. Path chromosome samples which are represented by bit patterns are processed by the GA and chromosomes with larger fitness function are selected to produce new offspring bit strings by means of crossover operations, and now the newly generated offspring are converted into new parameter solutions. A chromosome (a bit string) which has higher fitness function value will get more chances of participation in the offspring generation. To generate new bit string chromosome from the parent chromosome GA tool Crossover is used, that divides two parent bit strings into two or more segments and then joins the segments undergoing crossover to get two offspring bit strings [9]. Crossover involves a tool named mutation that produces chromosome offspring that are radically different from their parents. For example if the crossover operation is performed on the two bit string chromosomes, “111110010” and “000101011”, and they are split at the third bit; then, two new bit strings, “111101011” and “000110010” are generated.

Chromosomes generation, chromosomes evaluation, duplicate chromosome discarding and chromosomes reproduction are parts of the GA algorithm. For the implementation of the GA chromosomes are encoded in the binary digits and crossover is performed on these binary digit chromosomes. Most important last step of GA is mutation where radically new set of chromosomes are created from the parent chromosomes. The mutation and crossover are the two most important steps of the GA. Effective coding and implementation of the mutation and crossover decides the efficacy of the algorithm and efficacy of the routing result [10,11].

Outline of the Basic GA

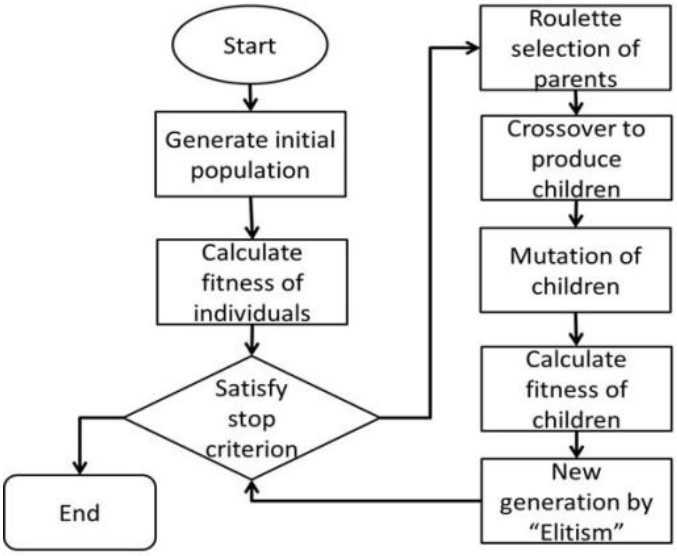

Fig.2: Basic of GA

1. Random set of chromosomes are generated or input of chromosomes is provided from the problem (suitable solutions for the problem)
2. Fitness f(x) of each chromosome 'x' is evaluated in the population
3. New population is created by execution and repetition of following steps until the new population is complete.

   a) Two parent chromosomes are selected from the population pool on the basis of their fitness value e.g. better the fitness value more chances of getting selected.
   b) A new chromosome offspring is produced with a crossover probability. Without crossover function performed, offspring would be exact copy of parents.
   c) Mutated new offspring is created with a mutation probability at each position in chromosome.
   d) New population is placed in the population offspring.

4. For a further execution of the algorithm e new generated population is used.

5. If the end condition is satisfied, stop, and return the best solution in current population
6. Move to step 2.

On the basis of Survival of the fittest theory of the Darwin only the best ones survive and generate a new offspring. As a lot of work is done on GA so many selection methods for selecting best possible chromosomes are developed during this time, most useful and common selection algorithms in them are Rank selection, Steady state selection, Roulette Wheel selection, Boltzman selection and some others[12].

III. PROPOSED WORK

First we are providing routing table input to the ACO algorithm as an input as ACO searching of the shortest routes from the search space is faster in comparison to other traditional algorithms like GA. In this way we shortlisted some paths by the use of ACO in a very short time and pass the output of the result to GA for optimization and path evolution. There are various algorithms of ACO, as we have discussed those algorithms and their performances earlier. As we are using ACO for getting better throughput. I used ACO algorithm first without any loop backs in my hybrid mode for best throughput and for getting small domain of short paths for the routing purpose. GA is basically a search algorithm which is uses the principle of survival of the fittest for sexual reproduction and enable biological species to adapt to their environment and compete effectively for its resources. While it is a relatively to the point straightforward algorithm, the algorithm is an effective stochastic search method, proven as a robust problem solving technique that generates better than random results.

If the distance of the path is different, then it is very easy to find the shortest distance using ACO algorithm. If the nodes have same distance then the ACO can't to find the optimal solution, to overcome this we use the GA for finding the fitness value for each and every node based on the cost value of the node. As it is known from the earlier researches that the ACO can find the shortest distance in shor duration of time, but it not be the optimal solution, for this reason we use both ACO and GA for produce the best possible solution.

Other major advantage of using GA we already discussed as it provides better success rates and ACO's third method with optimized results. We did some other changes in the GA also, in its selection method. In place of Roulette Wheel selection method we used combination of Roulette Wheel and Elitism in our project. Thus we took some top paths provided by the ACO as an input in GA. This way we reduced the time and optimized the performance of the GA as with less search space, GA can provide results in comparatively less time[14].

IV. IMPLEMENTATION AND RESULTS

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. Developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, Fortran and Python[6].

MATLAB is designed mainly for the mathematical numeric computng but MuPAD Symbolic engine allows access to symbolic computing capabilities. Simulink is another tool of MATLAB that adds graphical multi-domain simulation. MATLAB scripting language is used to MATLAB applications. MATLAB script is weekly typed programming language types are implicitly converted. As variable can be assigned without declaring their types, it is an inferred type language.
Only that time type declaration is needed when symbolic objects are used.

Table: Comparison Table

	No of Packets		Success (%)	Throughput (Mbps)
10	30000	ACO 1	97.04	164.837
		GA	99.96	137.359
		Combined	99.97	172.363
20	40000	ACO 1	95.93	106.698
		GA	99.99	90.994
		Combined	99.93	112.409
30	80000	ACO 1	96.61	76.194
		GA	99.88	69.826
		Combined	99.93	82.175

V. CONCLUSION

As it is clear from the simulation results that ACO algorithm gives better throughput and generates short routes but it is not capable enough to make success rate better for the chosen paths.

In this research we have found that results of our combined algorithm are better than other sole algorithm. Genetic Algorithm has better success rates but with large size of searching domain it is not fast enough as Ant Colony algorithm is.

VI. FUTURE WORK

By writing better code and algorithm for both algorithms and as we have used different kind of ACO algorithm in our research and made changes in selection algorithm of GA one can also optimize this algorithm for better results.

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