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Performance Analysis of Fault Tolerant Heuristic Algorithms for Determining Optimal

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Abstract- In this paper, the performance of different bio inspired algorithms are compared to obtain optimal path. Performance of different individual algorithms are analyzed for different topological weights. In networking, it is easy to find the route for static systems where once the optimal path is found, the same is used to communicate between two devices for a long time. Research has shown that it is difficult to find optimal paths for networks with dynamically changing network parameters. In this paper the focus is on performance of three fault tolerant heuristic routing algorithms for such networks. The simulation result shows that 60% of the time Ant Colony Optimization method outperformed Genetic and Beehive algorithms.

Index Terms- Ant Colony Optimization, Beehive algorithm, Fault Tolerant, Genetic algorithm, Network topology.

I.INTRODUCTION

Time delay, insufficient bandwidth and congestion play an important role in a network. The different approaches for routing protocols can be categorized as, Table driven routing protocol, On-demand routing protocol and Hybrid routing protocol. In this technique [1], every node in a network maintains its own routing table for communicating with other nodes. Each node is collaborated with other nodes to get information about any updates within the network. This technique has less delay [2] because the routes are already available in a routing table. In this technique, there is no routing table for any node in the network. Every time when there is need of transmission, the source sends its hello packets to find the route to the destination. Once the transmission is completed the route is terminated and the route discovered may not be used again for communication. This technique is combination of both table driven and on-demand routing protocol for communication. In this technique the routes already exist in the routing table and they are used whenever they are required and serves their demand from additionally activated nodes in a network.

Bio inspired algorithms have shown promising directions in the recent research [3] trends for large fault tolerant networks. An algorithm which is designed based on the living organism behavior or by using the natural phenomenon to solve some mathematical problems are known as Bio-inspired algorithms. These bio-inspired algorithms are highly scalable, flexible and environment aware. Whenever some nodes inside the network have any changes to their parameters like delay and bandwidth, these algorithms have the capacity to handle those situations without effecting the ongoing operations inside the network.

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Bio-inspired routing represents a class of algorithms focusing on efficiency [4]. The three bio inspired algorithms used for analysis are,

- Ant colony optimization (ACO)
- Beehive optimization
- Genetic algorithm (GA)

In the ACO algorithm, the natural behavior of African ants is used to find the shortest and heuristic path in a given network [5]. The network maybe wireless or wired. ACO was initially proposed by Dario in 1992. It has advantage of getting the best optimal path for the given source and destination and disadvantage is that it takes more time to find the best optimal path. Beehive algorithm is inspired by the communicative, quality evaluation methods and procedures of honey bees. Bees travel through these network regions called foraging areas. The bees discover food sites for which they also assess their quality and perform the waggle dance on the dance floor, only if the quality is above a certain limit. This results in an extensive exploitation of flower sites of high quality. Consequently, summarize the dance floor into a routing table where the bee agents launched from the same source but arrived from different neighbors at a given node could exchange routing information to develop the network state at this node. Genetic algorithm (GA) is inspired by the genes and chromosomes. It is based on the concept of evolution and has many opportunities to give a better solution for more number of iterations and convergence. GA is used to find the optimal route in a large space network. The algorithm is highly dependent on fitness where the chromosomes contend with each other. In this paper, all three bio inspired algorithms are applied on the network to obtain optimal paths. Comparison of the performance of these optimal paths is done by considering the fitness, in order to get a better solution for a given network.

II.LITERATURE REVIEW

The Genetic Algorithm [6] is used for the route discovery and route maintained within the entire chromosomes. Even genetic algorithm is used in the ad hoc networks for large search space. In the simulation the reliability of unearth and the multipath are evaluated by using the throughput, average end to end delay and the packet delivery. Genetic algorithm has ability to search a route when the link fails in the network for transmission. In [7] an attempt is done to make the network congestion free. Many algorithms [8] have excellence in dealing with the optimization techniques and these are inspired by the nature, biological evolution and behavior of social colonies.

Divide and conquer is one of the techniques used in these algorithms. Paper [9] describes the ant colony optimization for solving travelling salesman problem.

The principle used for finding the shortest possible optimum route between cities is based on previously investigated results. An effective adaptive routing algorithm [10] can help minimizing path congestion through load balancing. To predict temporal network congestion, Ant Colony Optimization (ACO) based routing [11] was proposed to identify the near future non-congested path to a desired target according to historical network information.

Ant colony optimization

The chemical substance pheromone plays an important role in finding the routes for the destination in ACO.

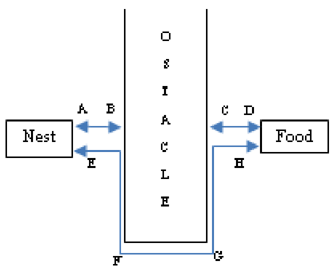

Fig. 1. Two paths followed by ants

Suppose two ants are located at a nest as shown in figure.1, they may follow either the route A-B-C-D or E-F-G-H to reach the food. The pheromone intensity will be more in the route A-B-C-D compared to E-F-G-H as the distance is shorter. As the probability of other ants following A-B-C-D is more, it will have more pheromone intensity.

The main disadvantage of ant colony optimization is that it consumes more time when compared to other traditional algorithms to find the shortest path in a larger network. In order to overcome this disadvantage, implementation of the concept of foraging area is done in ant colony optimization algorithm. Foraging area in a network is to divide the complete network into 2 or more parts and then perform the operations.

Genetic algorithm

In this algorithm a set of chromosomes are obtained which are named as population for candidates. The Fitness is calculated for these set of chromosomes for contention by using the total delay of chromosome during packet transmission. Each chromosome has a bunch of genes. In network [12] applications integers can be used for numbering the nodes as genes and route is represented by chromosomes.GA performs its operations iteratively to get a better solution for the candidate.

Traditionally the genetic [13] algorithm runs with different genetic operations, the performance of chromosome is observed and the optimal path is found from the list of good solutions. Consider a new child path and check whether that route exists or not, if it exists then that can be used for transmission by contending that new path too.

Genetic algorithm operations:

The GA differs from other optimization algorithms through the following three operations.

Chromosome Selection

In this operation the chromosomes are selected out of the population. This selection is based on the fitness factor or by random selection. This gives a better set of chromosomes to perform further operations. This method is called as "the second population for candidates".

There are different types of selection:

Elitism

Roulette wheel

Tournament selection

Crossover

This operation is completely unique compared to the other algorithms. In this operation the best known paths of second population are selected for matching. These paths are the parents for performing crossover and the new paths are generated by matching the parents. These paths are then compared or searched in the population. As the new path exists then the fitness of that path is compared with the second generation population.

There are different types of crossover:

One-point crossover

Multipoint crossover

Mutation

Many times the mutation is not performed by the GA as it is a tweak in an existing set of chromosomes. The probability of performing this operation in GA is very less. This tweak may generate a new unknown route from population and it is considered if it is a better solution compared to other routes in the second generation population. This mutation is used to diversify the population.

Beehive algorithm

Beehive algorithm takes less time to find route from source to destination, and it saves time as it does not find alternate routes. The route generated may be optimal or may not be optimal. This algorithm divides the entire network into segments and the search will be segment based.

III. DESIGN AND IMPLEMENTATION

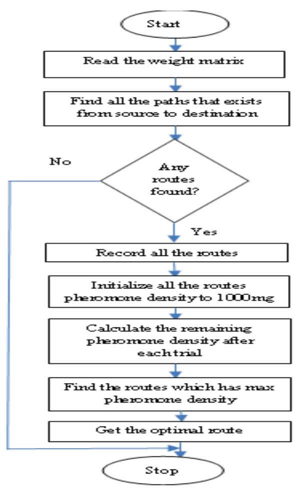

Fig. 2. Flowchart of ACO algorithm

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Steps involved in ACO algorithm implementation are as follows:

Step1: START

Step2: Identify the source and destination in a network.

Step3: Find all the possible routes from source to destination.

Step4: If routes are not found display message saying no routes available. Go to Step 10.

Step5: The routes are stored in a file

Step6: Initiate 1000mg by default for all the routes that are present in a file.

Step7: Now calculate pheromone density.

Step8: Compute maximum pheromone density.

Step9: The route which has the maximum pheromone density is displayed as the best optimal route.

Step 10: STOP

The flow chart of ACO is shown in figure 2.

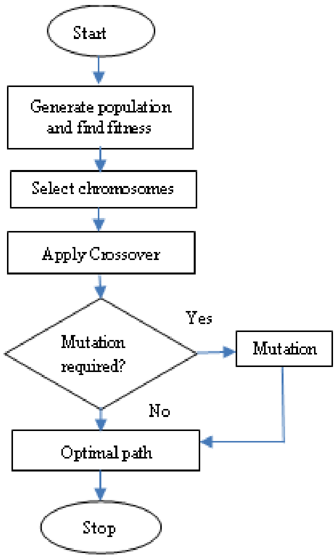

Fig. 3. Flowchart for of genetic algorithm

Steps involved in the implementation of genetic algorithm

Step1: Get all the chromosomes available.

Step2: Generate the initial population.

Step3: Find the fitness for each chromosome in population.

Step4: Select the chromosome by different types.

Step5: Sort the second generated population by fitness and perform the crossover function

Step6: Get the probability of each chromosome becoming an optimal path in a second generated population.

Step7: Perform the mutation operation

The flow chart of genetic algorithm is represented in figure 3.

Steps involved in implementation of beehive algorithm

Step1: Divide the network into n segments.

Step2: Start traversing from source through first segment.

Step3: Search for destination.

Step4: If the destination is not found go to next segment and repeat step2

Step5: If the destination is found stop traversing

Step6: Find the fitness for the generated path.

The process of obtaining optimal path in Beehive algorithm is shown in figure 4.

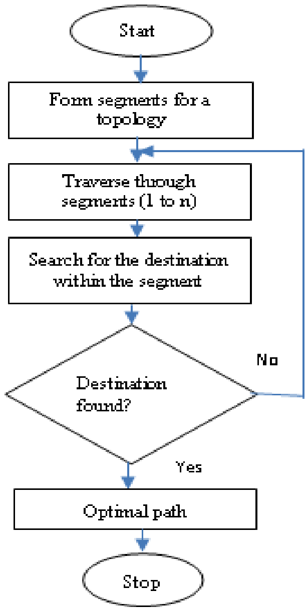

Fig. 4. Flowchart for Beehive algorithm

Now to determine the most suitable path for the data to travel, it under goes a process as described in figure 5. Following sequence will opt the best solution out of the available ones:

Select the topology with weight matrix

Select the source and destination to find the optimal paths.

Set the parameters which enable the topology.

Getting the set of optimal paths and finding the most suitable optimal path.

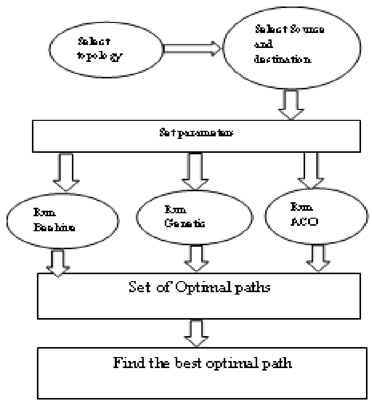

Fig. 5. Sequence design

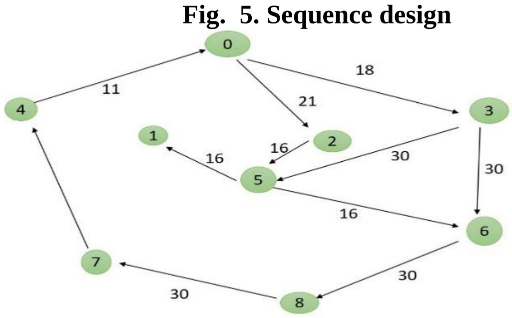

Fig. 6. Network topology

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Consider the topology as shown in figure 6. To apply the algorithms and to obtain the most optimal path for the source to destination. There are 9 nodes in the topology with different values for each link, considering the source and destination as 0 and 8 respectively.

The destination is not found initially as it is not in the first segment. The Beehive search results in the first segment are recorded as in second column of Table 1. In second segment the search for the destination is obtained from the intermediate nodes as in column 3 of Table 1.

Table- I: Beehive search result

Pa th	First Segment	Second Segment	Total Weight
1	0→2	0→2→5→6→8	94
2	0→3	0→3	Unable to proceed
3	0→4	0→4→7→8	46

By observing column 4 in Table 1, we realize that path 3 is the best.

The search result of GA is as depicted in Table 2.

Table- II: Genetic Algorithm Search Results

Final Iteration	Fitness Value
0→3→6→8	2.066

The search result of ACO is as depicted in Table 3.

Table- III: ACO Search Results

Final Trail	Pheromone Density
0→4→7→8	212.75

Comparing Table 1, 2 and 3 the most optimal path is found to be in GA.

The process continues for 10 iterations and the observations are recorded.

IV. Simulation Results

Consider a topology with dynamically changing value with fixed number of nodes in it. The weight matrix represents the delay between the nodes. The assumptions made while implementing the algorithm are:

In ACO, the time factor to calculate pheromone density is not considered.

In ACO, the algorithm below the pheromone density initially fixed for each route is 1000mg.

In GA roulette wheel selection is used to reduce the number of comparisons.

In GA one-point crossover is used to perform this operation.

For the first run in the simulation the ant colony optimization is selected as the best of the 3 algorithms based on delay as shown in table 4. The total delay obtained for the path chosen by ACO is with 32ms delay which is lesser than the other two paths.

Table- IV: Simulation Run 1

Algorith m	Fitness	H op Cou nt	Optimal path
ACO	Pheromo ne=194.6	4	0→1→5→ 11→16
GA	Fitness= 0.1176	4	0→2→7→12 →16
Beehive algorithm	Total weight=45	4	0→2→6→12 →16

Table- V: Simulation Run2

Algorith m	Fitness	Hop coun t	Optimal paths
ACO	Pheromone=194 .6	4	0→1→5→11→16
GA	Fitness=0.222	4	0→1→5→11→16
Beehive algorith m	Total weight=48	5	0→1→4→10→15→ 16

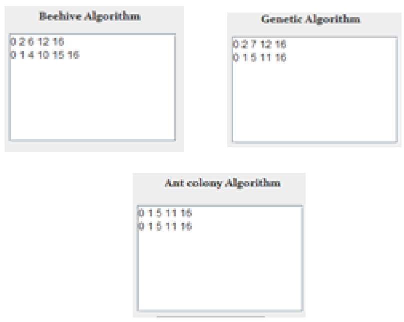

Fig. 7. Topology corresponding to simulation Run 2.

Tracing of second run is depicted in table 5. The optimal routes of individual algorithms and the best out of these is also shown. Here it was observed that ACO and GA had equally performed with same delay of 32ms. The corresponding output of the three algorithms is as shown in figure 7.

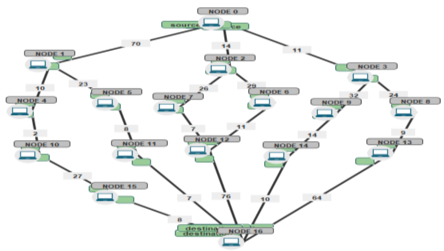

Fig. 8. The source and destination are selected as 0 and 16 out of 17 nodes in a network with its topology.

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The topology considered for simulation run 2 is as shown in figure 8.In the second run iteration the topology values change dynamically. So the routes found by each individual algorithm will change with the updated topology. For the above iteration out of these algorithms the best of the optimal paths is selected by comparing.

These runs go on to continue for 10 iterations. By simulation, the ACO algorithm finds the most optimal path without taking time into consideration. In the simulation, the ant colony optimization algorithm finds the optimal path 6 out of 10 times, Beehive algorithm finds the optimal path 3 out of 10, and the genetic algorithm finds the optimal path 1 out of 10 so, the percentage of these algorithms finding the optimal path is:

ACO=60%, Beehive = 30% and GA=10%. So the ant colony optimization algorithm is better for dynamically changing networks.

V. CONCLUSION

In this paper we have observed that 60% of time ACO outperformed GA and Beehive for smaller networks with dynamically changing parameters. For larger networks GA will be suitable as the optimality of the route depends on the crossover iterations. The paper draws conclusion that selection of an fault tolerant algorithm always depends on the size of the network and criterion to be satisfied.

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