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Solving Network Routing Problem Using Artificial Intelligent Techniques

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Authors' contributions

This work was carried out in collaboration between all authors. Author AO designed the study, wrote the protocol and supervised the work. Author AHB carried out all laboratories work and performed the statistical analysis. Authors AHB and AKD managed the analyses of the study. Author AKD wrote the first draft of the manuscript. Authors AKD and AHB managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.

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Abstract

The rapid revolution of communication networks requires a solution of network routing problem to be addressed in packet switched network. In the recent years, researchers have been solving routing problem in other to maintain continuous network transmission without any loss of packets. Until now research has shown that most routing devices get distorted when new nodes are added, shortest path and new direction need to be determined when connections goes down in between the network nodes, congestion control and delay factor needs to be put in mind when finding solution to the problem so as to ensure smooth network transmission. In other to solve these problems, Ant colony optimization techniques is used and improved. The Algorithm is simulated using Visual Basic.Net 2012 (VB 11.0) object oriented language. Experimental result show that our method allows network to activate new route if there is service time out, congestion or bottleneck in the existing route and shortest path will also be determined. Several Tests are carried out to ensure the efficiency of the algorithm; Mathematical expression is also generated to locate the route path in this study.

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1 Introduction

Network routing is very important in data communication network and they are usually common in wide area network WAN, most especially it occurs during transmission of internet or intranet over a large network computers in an environment or metropolis, city or particular region. The brain behind the network routing also deals with the principle that send data from source to destination or end users. The major path it follows and medium is what is determined by the routing processes.

A router is a device or, in some cases, software in a computer, that determines the next network nodes to which a packet should be forwarded to its destination. For those that has a high-speed internet connection such as cable at home and business computer users, satellite, or DSL (Digital Subscriber Line), a router can be configured to behave as a hardware firewall to prevent the both software and the device from going down [1].

With the increasing growth rate of the internet, the old 32 digit IPV4 (IP Version IV) number scheme, which play major role in Internet routing is no longer unique because it has a limited number of public ends [2], but due to the invention of IP version VI the limitation of the version IV will no longer be a problem as it has a large number of public end which makes it easy for network and data to be transmitted without multiple routing process. In the meantime, there is need for the routing system of network transfer to be properly managed. Routing problem cannot be solved by simply installing more router memory and increasing the size of the routing tables [3]. Other factors related to the capacity problem are explained in study [4].

To solve this problems, this paper adopts an algorithm that can be used in Solving Network Routing Problems using Artificial Intelligence Techniques. Moreover, we employed Ant Colony Optimization technique to dynamically construct routing tables automatically to guide traffic on the network. Experimental results show that our method considerably improved network routing problem and increase network performance.

The remainder of this paper is organised as follows. Section 2 describes related work done in Artificial Intelligence which tackles routing problems. Section 3 present the architecture and design of the proposed system. Section 4 presents the algorithm performance evaluation test. Section 5 outlines the conclusion and future work.

2 Related Work

This section, outlines some of the work done in Artificial Intelligence which tackles routing problems.

2.1 Shortest path algorithms

Shortest Path Algorithms (SPA) are very fundamental in much of the work on routing. The number of SPAs which have been developed and published runs into the hundreds and there are new variants still appearing. The best known algorithms such as Dijkstra's and Bellman-Ford algorithm, run in low order polynomial time [5]. The standard Dijkstra's algorithm, for example, run in time $O(V1gV + E1gV)$. Although the algorithms are low-order polynomial. So many difficulties may arise when using SPAs to run a network such as [6]: Routing many demands, Metrics for QoS, Distribution.

2.2 Algorithmic resource allocation methods

Much of the AI research effort on scheduling and optimization techniques in this area has been directed towards problems such as the Travelling Salesman Problem or towards shortest path problem [6]. There would seem to be considerable scope, however, in adapting some of these sophisticated search techniques to solving at least off-line routing problems. Until now, many researches discuss routing techniques based on Genetic Algorithms and Simulated Annealing [7]. Some treat routing as a multi-criterion optimization problem and presents results of applying utility-theoretic heuristics to grid networks. Others describe the application of Constraint Satisfaction (CSP) techniques combined with abstract problem representations to routing with bandwidth constraints (again for off-line problems).

2.3 Genetic algorithm

In the field of artificial intelligence, a genetic algorithm (GA) is a search heuristic that mimics the process of natural selection. This heuristic (also sometimes called a metaheuristic) is routinely used to generate useful solutions to optimization and search problems [8]. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

2.4 Distributed AI and agent based routing

Since routing involves complex distributed control and information representation, techniques from Distributed Artificial Intelligence have been proposed for Addressing routing problems [9]. Papers by Susan Conry and colleges address circuit restoral problems. In the circuit restoral problem, failed connection due to link or node failures in the network, need to be re-routed [10]. This is treated as a special case of the off-line routing problem which needs to be solved very quickly (the failed connections form a set of demands which needs to be re-allocated).

3 Methodology

The aim of this study is to propose an algorithm that can be used in Solving Static Network Routing Problems using the Artificial Intelligence Technique (Ant Colony Optimization).

ACO algorithms can be applied in the network routing problems to find the shortest path. In a network routing problem, a set of artificial ants (packets) are simulated from a source to the destination [11]. The forward ants are selecting the next node randomly for the first time taking the information from the routing table and the ants who are successful in reaching the destination are updating the pheromone deposit at the edges visited by them by an amount (C/L), where L is the total path length of the ant and C a constant value that is adjusted according to the experimental conditions to the optimum value. The next set of the ants can now learn from the pheromone deposit feedback left by the previously visited successful ants and will be guided to follow the shortest path.

$$P_{ij} = \frac{\tau_{ij}^{\alpha} . \rho_{ij}^{\beta}}{\sum \tau_{ij}^{\alpha} . \rho_{ij}^{\beta}} \tag{1}$$

3.1 Ant colony optimisation routing technique

This section will demonstrate the routing feature of the Ant Colony Optimization Algorithm. Three various scenarios are given when an ant (data packet) get to a junction (food source).

Scenario 1- Junction has empty paths: When an ant comes to a new junction that has not been traversed, it randomly selects the next path it will take.

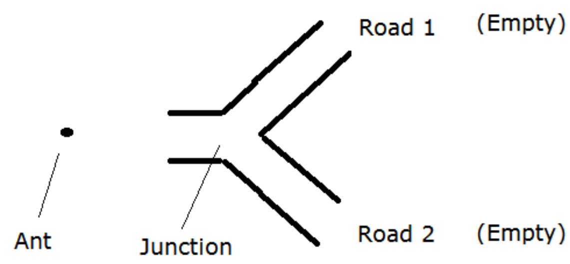

Fig. 1. Scenario 1

Scenario 2- Junction is partially empty: When an ant comes to a new junction and one of the roads leading away from that junction contains ant pheromone deposits (put by an earlier ant that passed through that path), then that path is taken by the ant.

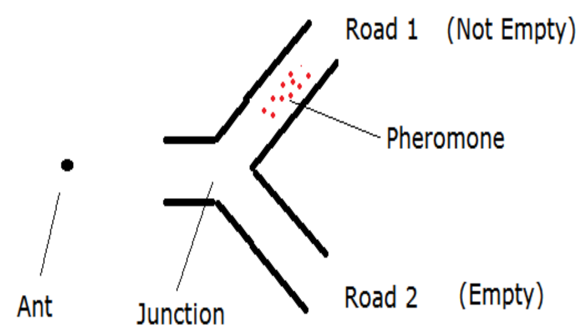

Fig. 2. Scenario 2

Scenario 3- Junction is not empty: When an ant comes to a new junction and both of the roads leading away from that junction contain ant pheromone deposits (put by earlier ants that passed through those paths), then the path with the higher phromone deposit is taken by the ant.

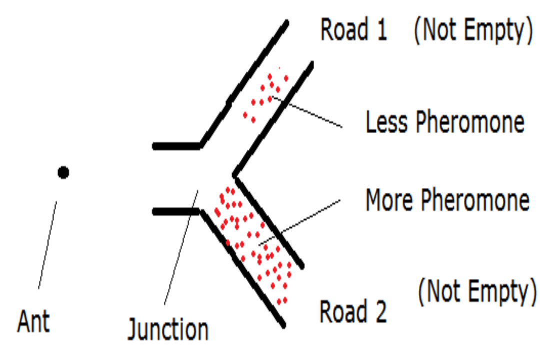

Fig. 3. Scenario 3

The flow chart of the ant colony optimization that the simulation will use is illustrated below.

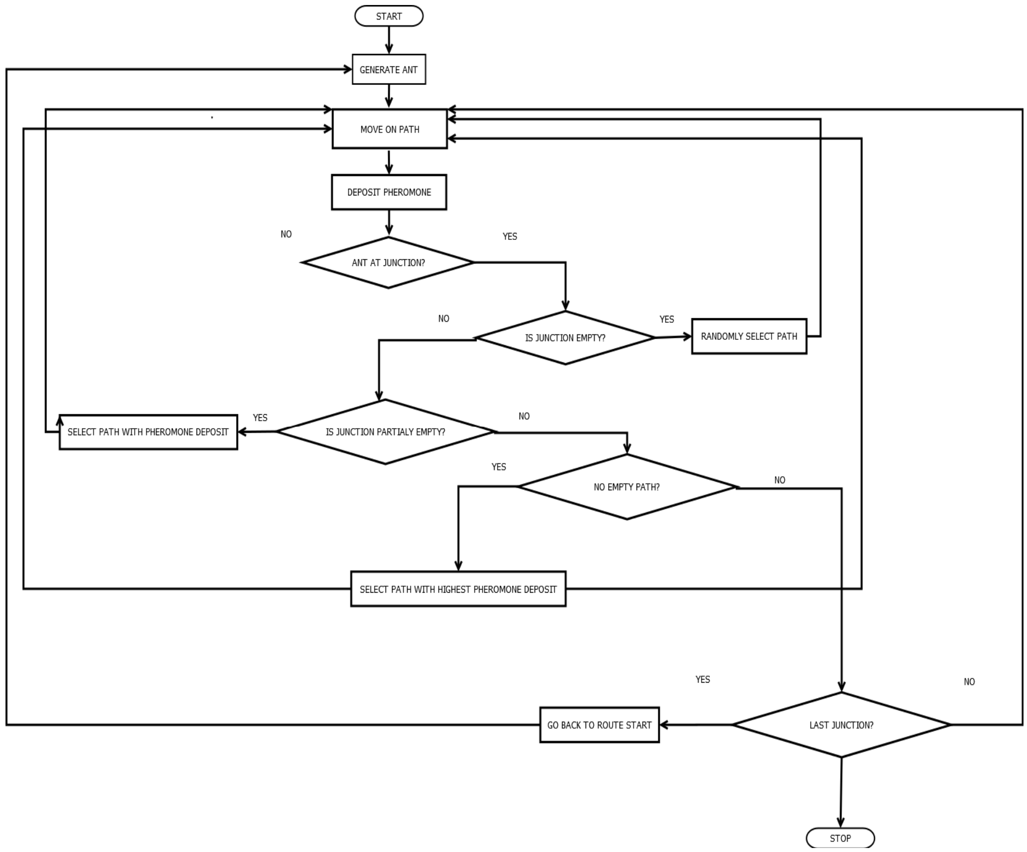

Fig. 4. ACO simulation flow chart of the new algorithm

3.2 Routing path calculation for the improved algorithm

The calculation of the shortest/routing path is done as follows:

1. Generate Ants/Packets at starting point A
2. Check the value of the pheromone for the adjacent points
3. Go to the point that has the highest pheromone value
4. If no point has the highest value then randomly select point
5. Increase the pheromone value of that point by 1
6. Decrease the pheromone value of the based on the formula

Pv(Point) = Pv(Point) - 1 * (currenttimenow - currenttime2millisecsago).

Where Pv is an integer array and point is the index of the point.

From the formula above the value of the Pv(Point) will be decreased by every 2 milliseconds.

7. Repeat Steps 2 to 6 until the last node is reached
8. Generate the next generation of ants/packet and repeat step 1 to 8

The new calculation above was proposed by this study in other to solve the shortest/routing path on the network.

4 Implementation / Algorithm Performance Test

The aim of this paper is to employ the use of AI Algorithm for the determination of the routing shortest paths in a network. For the purpose of this study, the Ant Optimization Algorithm will be used to demonstrate dynamic routing in a packer circuit network.

Three test was carried out on a network system of 20 nodes, they are presented in the table below:

Table 1. Test carried out on a network system of 20 nodes

Test ID	Description
Test 1	Test for the algorithm to find the shortest path along the network of 20 nodes. i. Where the nodes represent the pheromone in the network. ii. Total path length of the 20 nodes is 48733 m.
Test 2	Test for the algorithm to find the shortest path along the network with 2 nodes removed (Total 18 nodes). i. Where the nodes represent the pheromone in the network. ii. Total path length of the 18 nodes is 33289 m.
Test 3	Test for the algorithm to find the shortest path along the network with 2 more nodes removed (Total 16 nodes), i. Where the nodes represent the pheromone in the network. ii. Total path length of the 18 nodes is 20015 m

Below are the snapshots of the tests of the simulation program for the Ant Optimization Algorithm:

System Setup: The simulation window of the program is set up with twenty node represented by the black circles as shown in the figure below:-

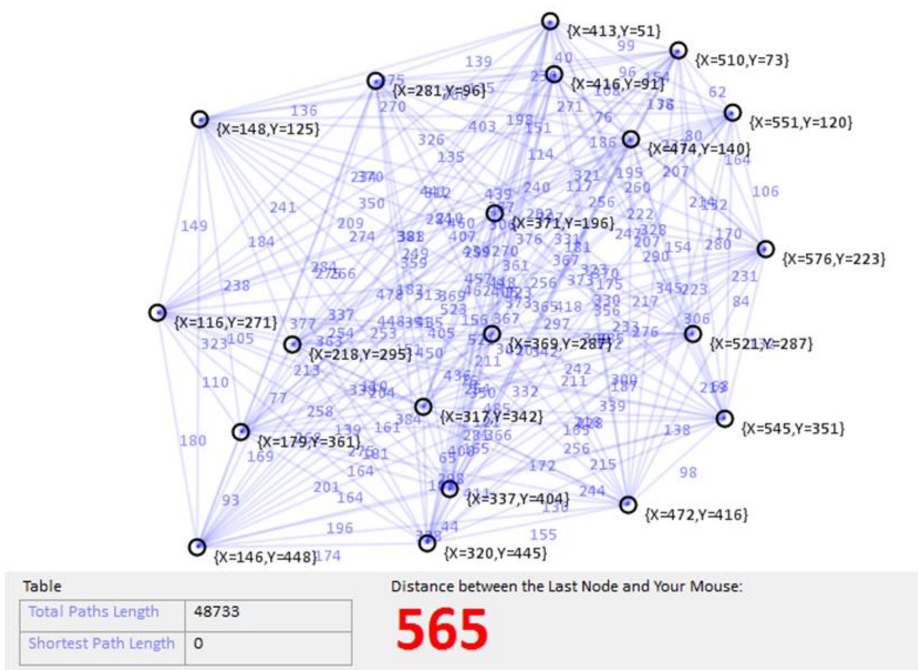

Fig. 5. System setup displaying the 20 test nodes with distance between each node

Test 1: Test for the algorithm to find the shortest path along the network. The best path is shown in red:-

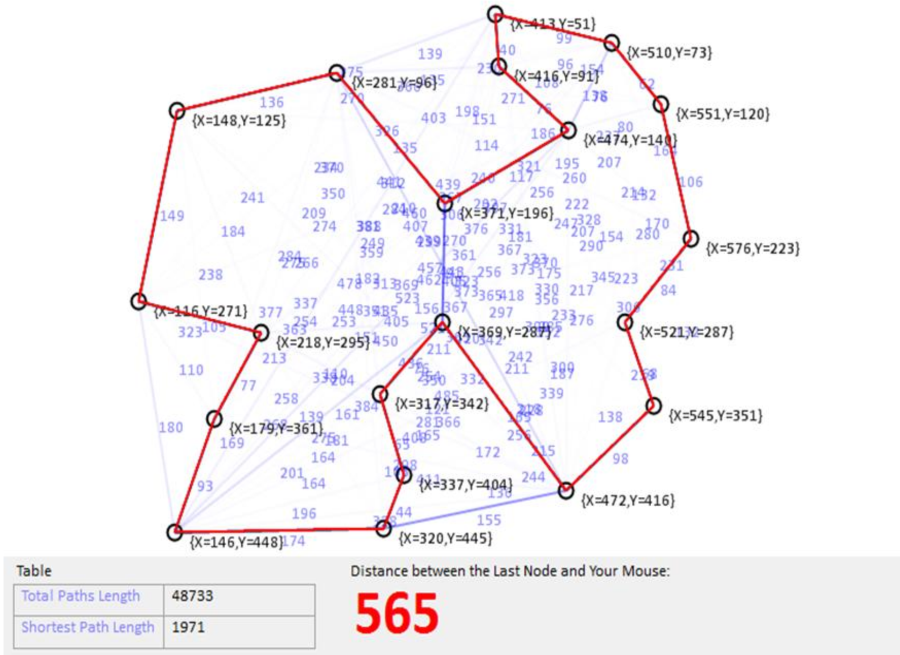

Fig. 6. Test 1 show the routing path calculated in 4.1

Test 2: Test for the algorithm to find the shortest path along the network with 2 nodes removed (Total 18 nodes). The best path is shown in red:-

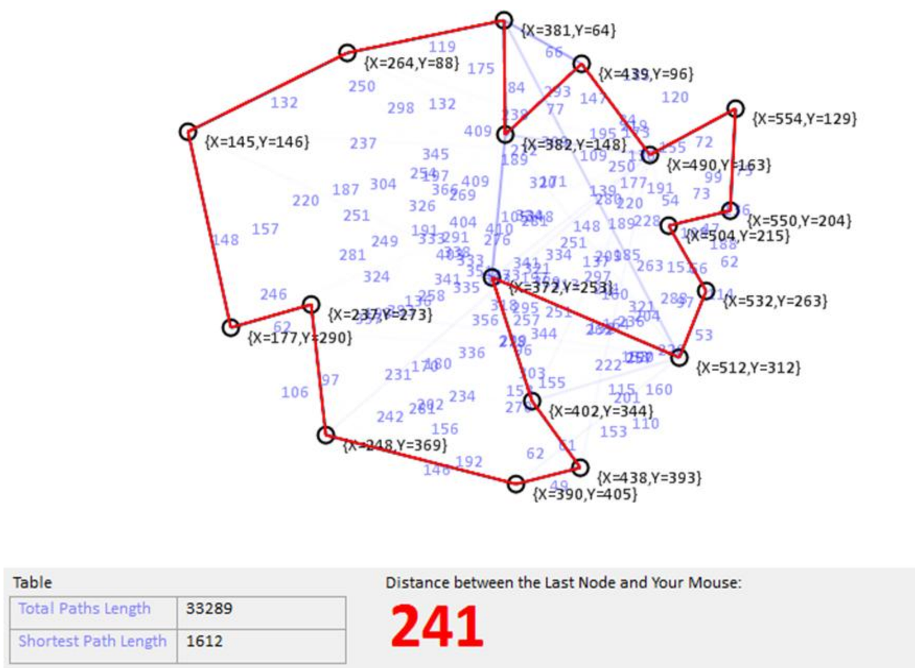

Fig. 7. Test 2

Test 3: Test for the algorithm to find the shortest path along the network with 2 more nodes removed (Total 16 nodes). The shortest path is shown in red:-

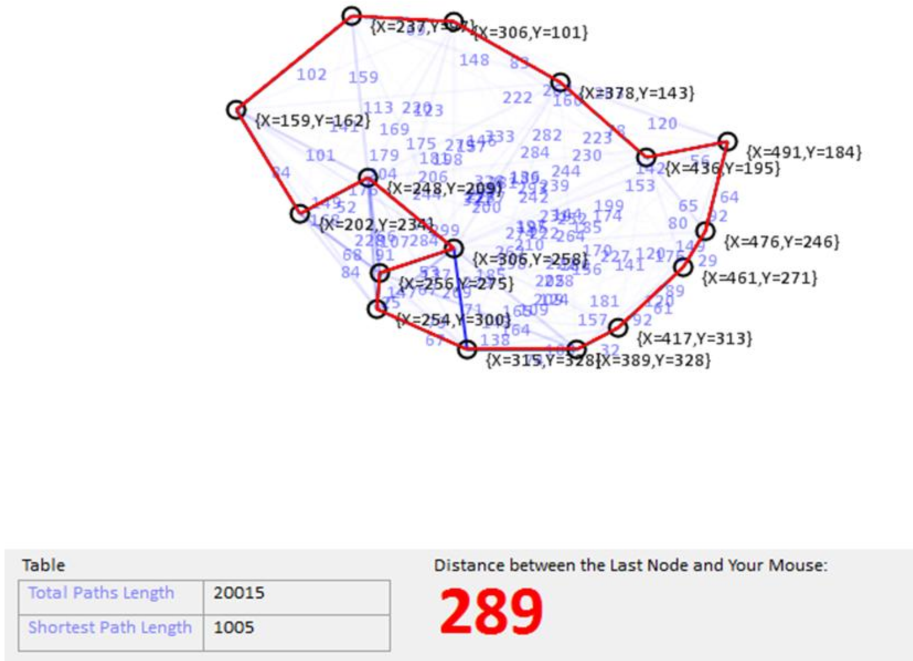

Fig. 8. Test 3

From the results of the tests, it can be seen that in all the cases of reduction of the size of the network, the system was able to find the path which the network will be routed.

This shows that the algorithm will make the network: Highly Adaptive, Efficient, and Scalable.

5 Test Result Evaluation

This section presents the evaluation of the developed network system. The evaluation was carried out on the 3 test performed on the network.

Table 2. System evaluation result

Tests	Total routing path length (meters)	New routing path length (meters)	Description
Test 1	48733	1971	New shorter route is determined
Test 2	33289	1612	New shorter route is determined
Test 3	20015	1005	New shorter route is determined

6 Conclusion and Future Work

The aim of this research was to employ the use of Artificial Intelligence Improved Ant colony Optimization (IACO) for the determination of the routing paths in a network, and best route in case of congestion. As Packet Switching networks require dynamic routing schemes to ensure that the changes to the network are updated on the routing table, there is a need to use an algorithm that will know the best shortest path to take based on the availability of node on the network at the time. Thus this research sought to use the Ant Colony Optimisation technique which is based on the food finding behaviour of ants.

For the future, implementation of the proposed algorithm in a router on a computer network in order to test and verify the efficiency of the algorithm in the real world situation is recommended.

Competing Interests

Authors have declared that no competing interests exist.

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