ANT COLONY OPTIMIZATION TECHNIQUE FOR FINDING ENERGY EFFICIENT PATH IN WSN

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ABSTRACT

The routing protocol play a very important role in calculating, choosing and selecting the relevant path for transferring the data from the source to the destination efficiently. There are already many accepted routing algorithms used to find the shortest path and also to increase the throughput of the network. In this paper, I will explain the algorithm for selecting the shortest. The goal of every network routing algorithm is to direct traffic from source to the destination maximizing the network performance. The performance measure that is usually taken into account is the throughput (bits delivered per time unit) and number of packets successfully reaching the destination. However, in my implementation I have taken the performance measure as shortest path for the no. of iterations. The optimal solution for choosing the best shortest path is to select the one with the smallest total cost. In this paper an energy efficient path in the WSNs using a method which is based on Ant Colony Optimization (ACO) algorithms, aiming to minimize the consumption of power, increase the length of the network lifetime. Here routing protocol based on Ant Colony Optimization, where ability of Ants to select the shortest path among few possible paths connecting their nest to a food site is used for routing. The goal is to prolong the network lifetime as well as to find the best path from the source node to the sink node based on Ant Colony Optimization (ACO).

Keywords: *Ant Colony Optimization, wireless sensor network, shortest path, network lifetime*

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1. INTRODUCTION

Recent trends in WSN routing have been towards strengthening existing approaches by considering more detailed network properties. The routing protocols play a very important role in selecting the relevant path for data transmission from the source to the destination efficiently. There are already many routing algorithms are available to find the shortest path and also to increase the output of the network. In this paper, we are proposing a routing algorithm which may be applied in small network structure with balanced node. The goal of every network routing algorithm is to direct the traffic from source to the destination maximizing the network performance.

Algorithms for wireless sensor network do not offer some of the sensor networks requirements such as high power battery, memory, and the routing tables grow up with the network length and do not support diffusion communication. These are the main reasons why it is necessary to design new algorithms to improve energy efficiency.

1.1 Literature survey

Selcuk Okdem presented a new protocol providing an effective multi-path data transmission method to achieve reliable communications in the case of node faults. The proposed approach compared to EEABR protocol using an event-based simulator. The results show that proposed approach offers significant reductions of energy consumption which is used as a performance metric for different sized WSNs [1]. Anand Seetharamet proposed a protocol which ensures that a near energy utilization occurs thereby increasing network lifetime [2]. Nada M. A. Proposed Hybrid algorithm to solve combinatorial optimization problem by using Ant Colony and Genetic programming algorithms [3]. Amritha Sampathet proposed an effective algorithm for selecting cluster heads in mobile ad hoc networks using ant colony optimization [4].

Dr. S. A. Ladhakeet presented the researches done have shown that ant based routing protocols can remove at least one or several problems in the area such as battery life, scalability, maintainability, survivability, adaptability and so on [5]. Bhawna Talware proposed Ant based Mesh Ad hoc on demand distance vector routing protocol termed as AM-AODV in which Ant-like mobile agents from ACO under mesh topology are used in conjunction with Ad hoc on demand distance vector protocol (AODV) [6].

Dr. T. Karthi keyanet proposed Ant miner and Ant miner algorithms were experimented with different training datasets. The same have been applied for real dataset which were rendezvous in and around the erode district and pre-processed for proposed work [7].

K. Syed Ali Fathimaet presented a new protocol for WSN routing Operations by using ACO algorithm to optimize routing paths, providing an effective multi-path data transmission to obtain reliable communications in the case of node faults [8].

Er. Sarbjeet Kauret presented an Ant Colony Optimization based algorithmic approach to find the shortest path in the network using dynamic system [9].

Linga Raj Ket presented a new objective for maximizing the network lifetime using ACO-MNCC algorithm to increase network lifetime and balance the node power consumption and as long as possible[10].

Anjali introduced a heuristic way to reduce energy consumption in WSNs routing process using Ant Colony Optimization. The three Ant Colony Optimization algorithms, the Ant System, Ant Colony System and improved AS and their application in WSN routing process were introduced [11].

Dr. V. Raghunatha Reddy proposed to increase the lifetime of a network by trust level computation and Ant Colony Optimization (ACO) algorithm for routing. Initially, the trust level of nodes is computed by the one hop neighbour and then the optimal route is selected by the ACO algorithm [12]. Varnika Bains have explained an adaptation of Ant Colony Optimization (ACO) technique demonstrated for network routing. This approach belongs to the class of routing algorithms inspired by the behaviour of the ant colonies in locating and storing food. The effectiveness of the heuristic algorithm is supported by the performance evaluations [13]. Debasmita Mukherjeeet presented the application of Ant Colony Optimization Technique in different network models with different number of nodes and structure to find the shortest path with optimum throughput. Three variations of the Ant Colony Optimization Technique, ACO1, ACO2 and ACO3 has been proposed and applied on different standard network models and the results hasbeen analyzed and concluded [14].

Adamu Murtala Zungeru have compared the performance of ant based routing protocols in wireless sensor networks that utilize the behaviour of ants mode of communication in routing decision [15]. Rajamani Sethuram presented an ant colony optimization (ACO) framework to simultaneously solve multiple Boolean SAT instances. Results of experiments on scanned versions of ISCASÊ89 benchmark circuits indicate that ACO algorithm can solve large number of SAT instances using very short CPU time [16].

2. SYSTEM OVERVIEW

Since many problems are too complex to solve them to optimality in a reasonable amount of time, finding algorithms that use problem-specific knowledge to achieve a good albeit not optimal solution in an appropriate amount of time is an important issue. One of the most-studied problems is the Traveling Salesman Problem (TSP), defines as finding a shortest closed tour through a given list of cities. For example the problem of finding a shortest closed tour through all 24,978 cities of Sweden was solved in May 2004, but needed more than one year to be computed and proven. One can easily see that this is not a practically usable approach, as the computation time exceeds the time constraints for most problems. We found Ant Colony Optimization (ACO) algorithms to be a promising approach to obtaining good results for the TSP in an appropriate amount of time.

We have already explained how an ant is able to find the shortest path. This section will show how this simple mechanism is used to solve the more complex task of finding a reasonable solution to the Traveling Salesman Problem.

2.1 The Traveling Salesman Problem

Consider a set of N cities whereby the lengths of connections between pairs of cities are known a priori. Starting from a particular city, a salesman traverses through all other cities and returns to the starting city under the condition that to each city he visits once only. The objective of the TSP is to find the shortest tour taken by the salesman.

Ant colony optimization is an iterative algorithm. In an iterative step, each ant of the colony builds a solution by walking from vertex to vertex on the graph with the constraint of not visiting any vertex that has been visited before. The solution construction and the pheromone updating are two main steps for the ACO. In the solution construction step, an ant selects the next vertex to be visited according to a stochastic mechanism that is biased by the pheromone. After the solution construction step, the pheromone is updated on the basis of the quality of the solutions.

2.3 Ant Colony Optimization for Solving the Travelling Salesman Problem

The base of ACO is to simulate the real behaviour of ants in nature. The functioning of an ant colony provides indirect communication with the help pheromones, which ants excrete. Pheromones are chemical substances which attract other ants searching for food. The attractiveness of a given path depends on the quantity of pheromones that the ant feels. Pheromones excretion is governed by some rules and has not always the same intensity. The quantity of pheromones depends on the attractiveness of the route. The use of more attractive route ensures that the ant exudes more pheromones on its way back and so that path is more also attractive for other ants.

The important characteristic of pheromones is evaporation. This process depends on the time. When the way is no longer used, pheromones are more evaporated and the ants begin to use other paths. What is important for ACO algorithm the moving of ants. This motion is not deterministic, but it has stochastic character, so the ants can find the path, which is firstly unfavourable, but which is ultimately preferable for food search. The important characteristic is that a few individuals continuously use non-preferred path and look for another best way. ACO was formulated based on experiments with double path model, where the quantification was made similar to Monte Carlo method. The base of this simulation was two artificial connections between the anthill and a food source.

The simulation demonstrated that ants are able to find the shorter these two paths. A significant impact of this simulation was to quantify the behaviour of ants. For practical use of ACO, it was necessary to project virtual ants. It was important to set their properties. These properties help virtual ants to scan the graph and find the shortest tour. Virtual ants do not move continuously; they move in jumps, which means that, after a time unit, they will always be in another graph node. The absolved path is saved in ant memory. The created cycles are detected in ant memory. In the next tour, the ant decides on the base of pheromones power. Just because the property of pheromone evaporation, pheromones on shortest edges are stronger, because of the fact that the ant goes across these edges faster.

3. Implementation Details

The setup is the following:

A group of m artificial ants are moving from city to city along the TSP graph. They decide to which city to go next based on:

- The set of cities they have not visited so far on their tour
- The amount of pheromone on the edges between cities
- A probabilistic function of the weight of an edge which enables the artificial ants to determine the closest-by cities.

Thus, ants prefer close cities connected by edges with a high level of pheromone. At the beginning of the algorithm; m artificial ants are placed on randomly selected cities. By choosing a path, the artificial ants leave artificial pheromone on it.

After all ants have finished one tour each, the edges of the shortest tour receive some additional pheromone which is inversely proportional to the tour length. It is appropriate to use the inverse of the distances, since nearby cities should be weighted higher than far away ones.

3.1 Design of the Solution

Moving of virtual ant depends on the amount of pheromone on the graph edges. The probability *pik* of transition of a virtual ant from the node *i* to the node *k* is given by formula (1). We assume the existence of internal ant's memory.

$$p_i^k = \frac{\tau_i^\alpha + \eta_i^\beta}{\Sigma(\tau_{N^i}^\alpha + \eta_{N^i}^\beta)} \quad \text{…. (1)}$$

where

τi? - indicates the attractiveness of transition in the past

ηi? - adds to transition attractiveness for ants,

Ni - set of nodes connected to point i, without the last visited point before i,

3.2 Reverse journey

Virtual ant is using the same reverse path as the path to the food resource based on his internal memory, but in opposite order and without cycles, which are eliminated. After elimination of the
cycles, the ant puts the pheromone on the edges of reverse path according to formula (2).

$$\tau_{ij}^{t+1} = \tau_{ij}^{t} + \Delta\tau^{t} \quad \text{….. (2)}$$

where

τijt- value of pheromone in step t,

Δτ- value by ants saved pheromones in step t.

Values Δτ can be constant or they can be changed depends of solution quality.

3.3 Evaporation of Pheromones

At last, the pheromones on the edges are evaporated. The evaporation helps to find the shortest path and provide that no other path will be assessed as the shortest. This evaporation of pheromones has an intensity ρ (3).

$$\tau_{ij}^{t+1} = (1-\rho)\tau_{ij}^{t} \quad \text{….. (3)}$$

This formula is applied on all graph edges with intensity ρ (interval (0, 1)). On this knowledge we can compose an algorithm of ACO, which can be used for solving the travelling salesman problem. It is necessary to keep information about quantity of pheromones τij in memory, which has stochastic character and actually represents state of graph scan. Further on, there is a need to memorize the edge costs, or information derived from this information (ηij). Information of pheromones value τij is changing during the simulation, but values of ηij stay the same during the calculation. Virtual ants use this information during their moving across the graph. On the basis of these considerations, we can describe the ACO algorithm as system of steps

1. Ants scan graph G. The aim of this scan is to find an optimal solution
2. Every ant has its own memory, which is used for saving information about travelled path (for example about travelled nodes). This memory can also serve to ensure constraints or to evaluate of the solution.
3. The process begins in state xsk and has one or more ending constraints ek. Let the actual state of an ant be the state xr = (xr–1, i) and no ending constraint is complied, so the ant moves to node j in neighbourhood of the state Nk(xr) and the ant moves to the new state (xr, j) X. In case that some ending constraint is complied with, the ant ends with process of scan. The transition to a state that represents unacceptable solution is usually banned by appropriate implementation of internal ant memory.
4. The next ant motion depends on the probability, which is calculated on the base of pheromone quantity on edges of graph, and it also takes into consideration its local memory and the acceptance of this step.
5. If the ant can to add new component of graph GC, it can update the value of corresponding pheromone information (information is bound with corresponding edge, or aim node).
6. The ant can update pheromone values after reverse path construction by editing associate pheromone values.

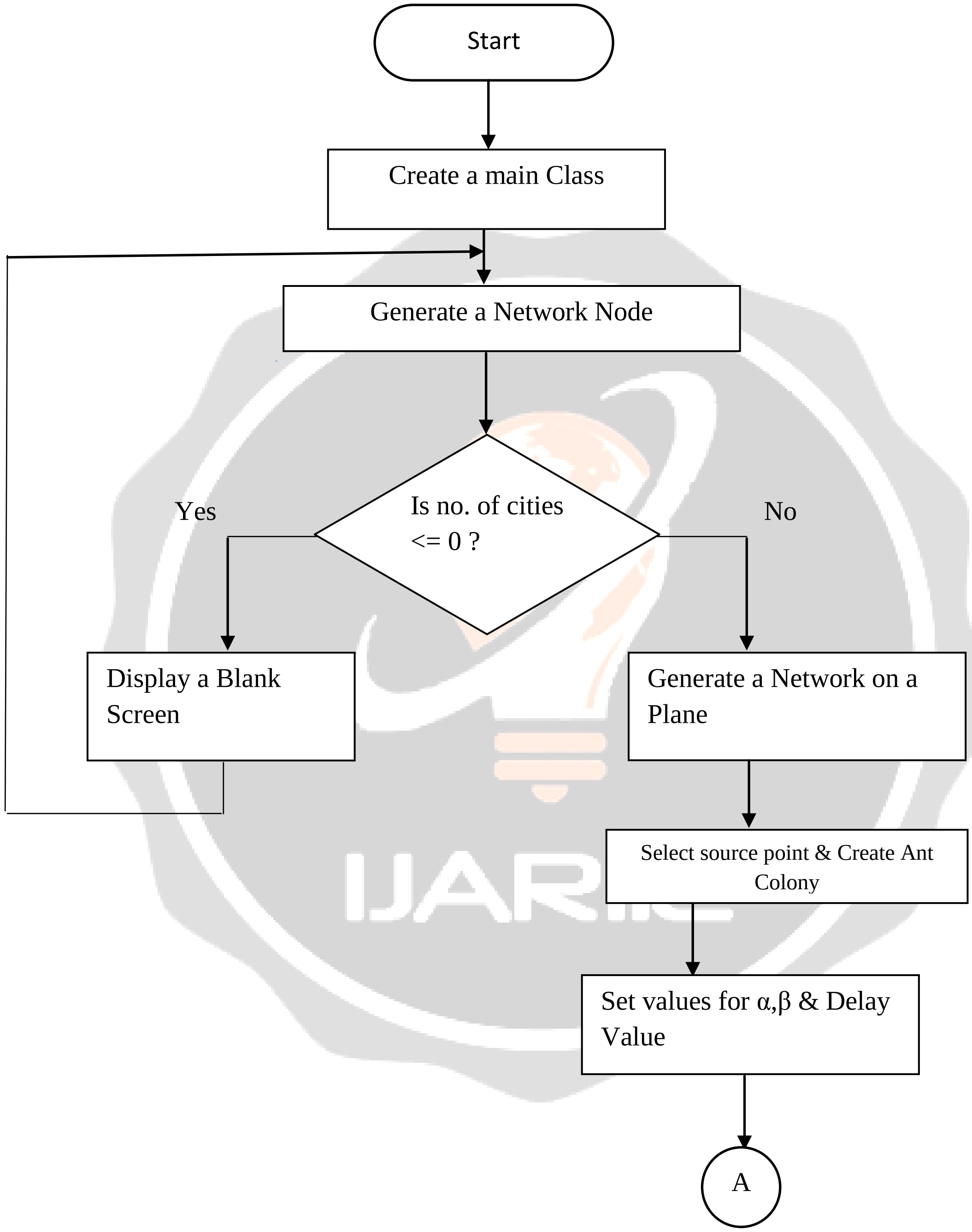
4. SOFTWARE DETAILS

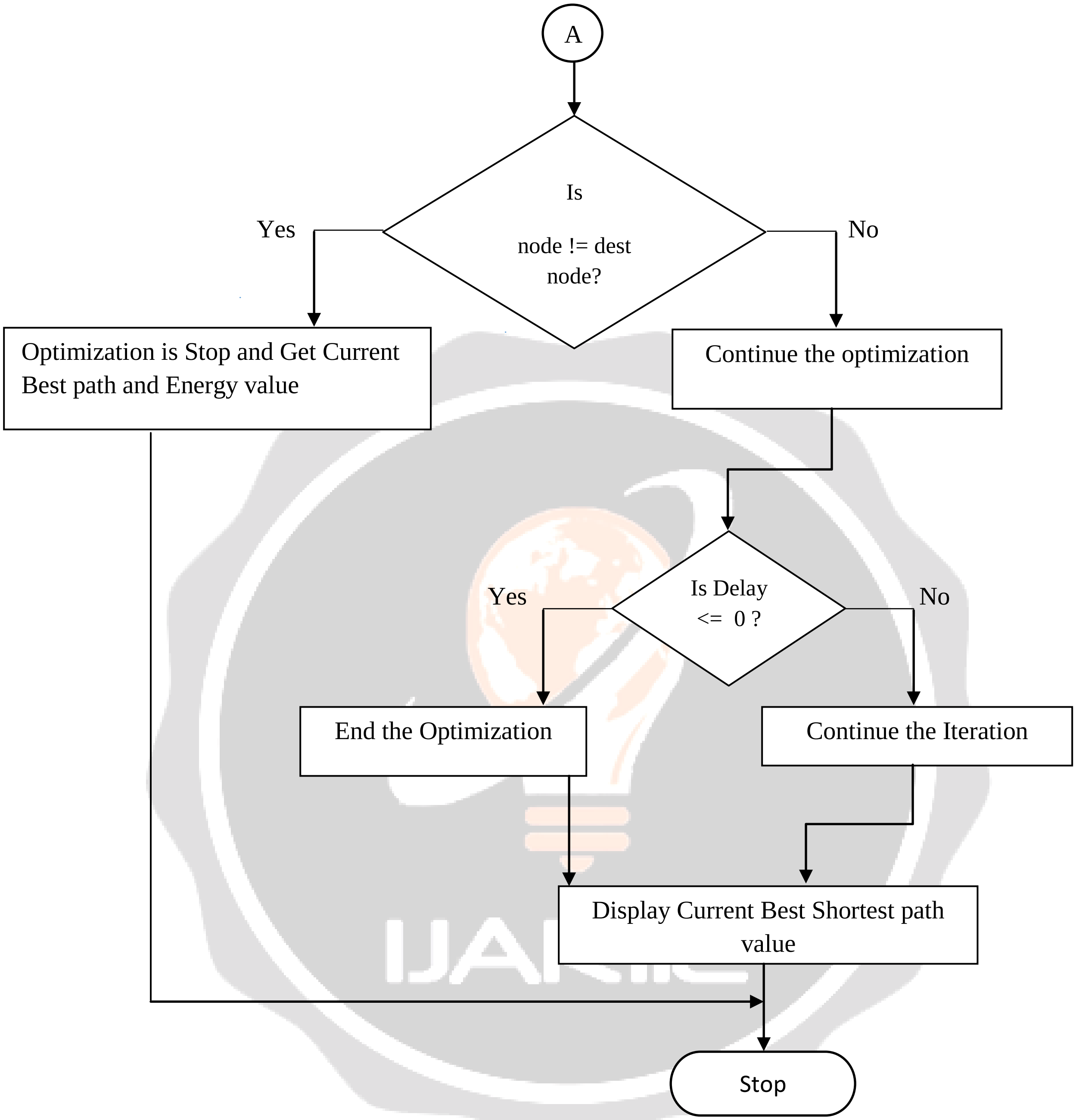
All the tests were carried out in a simulation environment prepared in Java programming using NetBeans 6.9 IDE platform.

4.1 ACO Algorithm for TSP

```
Step1: start
Step2: Declare avariable
Step3: create a class which extends Javax.swing.jframe class
Step4: Genrate network node
        If node <=0
                display blank screen
        Else
                        display node on screen
Step5: create ant colony
        If click==”ok”
            get the x,y co-ordinate at each node & draw a edge between them
        Else
              close the dilogue box
Step6: run optimization
Step7: set epoch & delay value
Step8: if time>=epochs
        Optimization is stop Optimization and get cureent best shortest path & energy conservation value
        Else
                continue the optimization until the timer==epoch
Step9: if delay<==0
        Directly display end point & optimization is stop
        Else
                continue the interaction
Step10: display a current best shortest path & energy conservation value
Step11: stop
```

4.1 Flow chart





4.2 Steps for Simulation:

1) Run Project into Net Beans IDE 6.9
2) Create a Class Network Routing Main Window which extend javax.swing.JFrame class.
3) Generate unique Serial Version UID of a Current Class for Compilation.
4) Declare variable of project with a private access modifier.
5) Click on Action Listener class of Generate Network Nodes menu item.
6) Dialogue box is display which contain manual fields for Number of nodes.
7) While clicking on Ok and Apply button value of JSpinner is forwarded towards the genNode() method.
8) Create a Class Method genNode() for Generating Random Nodes.
9) Pass the number of Nodes value to the ACO_Logic java Class.
10) Generate a Network Nodes on Network Routing Main Window by using Network Routing Frame Components java class.
11) If Node are generated then Display a message Network Node are Generated.

12) While Clicking on Close button of Dialogue box, Dialogue box is closed.
13) Click on Action Listener Class of Create Ant Colony menu item.
14) Call the createAnts() methods and Generate Create Ant Colony dialogue box.
15) Enter the proper value of each and every fields.
16) By clicking on Ok and Apply button all fields value are pass to the getValue() and getText() method.
17) getText() method is parse to the integer data type.
18) While clicking on close button Create Ant Colony dialogue box is close.
19) Click on Action Listener Class of Run Optimization menu item.
20) Generate the dialogue box Run Optimization.
21) Set the epochs(Time to Run Optimization in ms) and delay.
22) By clicking on Ok or Apply button value is assign to getValue() method and pass to the runAnts() method.
23) Epochs value is assign to the timer.
24) When value of timer is less than the epochs, then runAnt() functions thread is start.
25) When value of timer >= epochs, then Optimization is stop and we get current best shortest path.
26) When value of delay <= 0 then we are at the end point, we get current best shortest path and Energy Conservation value of ACO Algorithm.
27) While clicking on Stop Optimization menu item, timer will be stop.
28) We get the current best shortest path and Energy Conservation value at current time.
29) Create a Object of Network Routing Main Window java Class.
30) Assign a Inherit Method to object of Network Routing Main Window.
31) Display Network Routing ACO Frame on Screen.

5. RESULTS & DISCUSSION

The results of proposed ant colony optimization system is shown below.

Table: Summary of results of ACO simulations

No. of Iterations	Number of Cities	Number of Ants	Best Current Cost
1000	10	10	2.39
500	20	10	3.62
200	10	20	3.37

6. CONCLUSION

Based on the experiments, it can be concluded that the quality of solutions depends on the number of ants. The lower number of ants allows the individual to change the path much faster. The higher number of ants in population causes the higher accumulation of pheromone on edges, and thus an individual keeps the path with higher concentration of pheromone with a high probability. The great advantage over the use of exact methods is that ACO algorithm provides relatively good results and is therefore able to find an acceptable solution in a comparatively short time, so it is useable for solving problems occurring in practical applications.

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