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A Case Study for Determining Shortest Route Travelled by a Mail-Van of Indian Post Office in Bengaluru Using Ant Colony Algorithm

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***Abstract* -Minimizing the Distance/Cost/Time is a major challenge for a problem like Travelling Salesman in order to obtain the best shortest path. A case study has been carried out to determine shortest route of a mail van moving at various post offices to collect the post related goods. The Ant Colony Optimization algorithm is a meta-heuristic technique aiming to search for an optimal path, based on the behaviour of ants seeking a path between their colony and a source of food. In this problem Ant Colony Optimization is used to determine the shortest path travelled by the mail van. Collecting route distances travelled by the Mail van in order to collect posts from different post offices. The data was collected from the Postal Mail Motor Service, Vasanth Nagar, Bangalore, India. A program is also developed to determine the number of shortest path for route, the results that are obtained are encouraging.**

***Keywords* -Ant Colony Optimization (ACO), Travelling Salesman Problem (TSP)**

I. INTRODUCTION

Ant Colony Optimization principles are based on the natural behaviour of ants. In their daily life, one of the tasks ants have to perform is to search for food, in the vicinity of their nest. While walking in such a quest, the ants deposit a chemical substance called Pheromone in the ground. This is done with two objectives. On the one hand, it allows ants to find their way back to the nest. And on the other hand, it allows other ants to know the way they have taken, so that the others can follow them. The curiosity is that, because hundreds or even thousands of ants have this behaviour, if one could see the pheromone laid in the ground as a kind of light, the ground would be a large network with some of the arcs brighter than the others. Within the paths created by those arcs would surely be the shortest path between the nest and the food source. This behaviour can be seen as a kind of communication between the ants. If the path has a large concentration of pheromone, this is probably due to its shorter length that allowed ants to travel faster, resulting in a larger number of travels through the path therefore with much more ants depositing pheromone on it.

Furthermore, over time the pheromone evaporates and thus its concentration reduces. The more time it takes for the ant to travel from the nest to the food source and back to the nest, the more time the pheromones have to evaporate. This system is thus based both on the positive feedback, i.e. depositing of pheromone attracts other ants to use the same path which will increase the pheromone quantity, and on negative feedback, i.e. dissipating of the pheromone through evaporation leads to lower levels of pheromone thus discouraging other ants.

II. LITERATURE SURVEY

Initially proposed by Marco Dorigo in 1992 in his PhD thesis the first algorithm was aiming to search for an optimal path in a graph, based on the behaviour of ants seeking a path between their colony and a source of food. The original idea has since diversified to solve a wider class of numerical problems, and as a result, several problems have emerged, drawing on various aspects of the behaviour of ants. The Ant System goes way back in the 1959, where Pierre-Paul Grassé invented the theory of Stigmergy to explain the behaviour of nest building in the termites. Stigmergy is a mechanism of indirect coordination between agents or action. In 1996, Hoos and Stutzle invented the MAX-MIN Ant System. The MAX-MIN Ant System (MMAS) algorithm achieves a strong exploitation of search history by allowing only the best solutions to add pheromone during the pheromone trail update.

III. PROBLEM DEFINITION

The mail van of Indian Post Office in Bangalore City is collecting and delivering the postal goods covering 12 sub post offices. After discussing with the concerned authorities in the post office we found that there is a scope for applying a suitable algorithm for determining the shortest route.

There are several mail vans that are moving in different routes, however due to the scope for route number 8, particular route of the mail van has been taken as a case study.

The case study involves 2 primary objectives

1. Collecting route distances travelled by the Mailvan in order to collect posts from different post offices. The data was collected from the Postal Mail Motor Service, Vasanth Nagar, Bangalore.
2. Determine the sequence number of shortest distance possible to cover all the stations.

IV. METHODOLOGY

Initially each ant is placed on some randomly chosen city. An ant k currently at city i choose to move to city j by applying the following probabilistic transition rule:

$$p_{ij}^{k}(t)=\begin{cases}\dfrac{[\tau_{ij}(t)]^{\alpha}[\eta_{ij}]^{\beta}}{\sum_{k\in allowed_k}[\tau_{ik}(t)]^{\alpha}[\eta_{ik}]^{\beta}} & \text{if } j\in \text{allowed}_k\\ 0 & \text{otherwise}\end{cases}$$

Where,

η_{ij} = heuristic visibility of edge (i, j)

τ_{ij} = trail

• α - Parameter related to the weight of the pheromone concentration in the probability function. Higher values of α emphasize difference in pheromone value.

• β - Parameter weighting the relative importance of heuristic information in the probability function. Higher values of β emphasize difference in heuristic values.

After all the ants complete their tour the pheromone is required to be updated using

Where

$$\tau_{ij}(t+1)=(1-\rho)\tau_{ij}(t)+\Delta\tau_{ij}(t)$$

$$\Delta\tau_{i,j}^{k}=\begin{cases}\dfrac{Q}{L_k} & if(i,j)\in \text{bestTour}\\ 0 & \text{otherwise}\end{cases}$$

Q = arbitrary constant

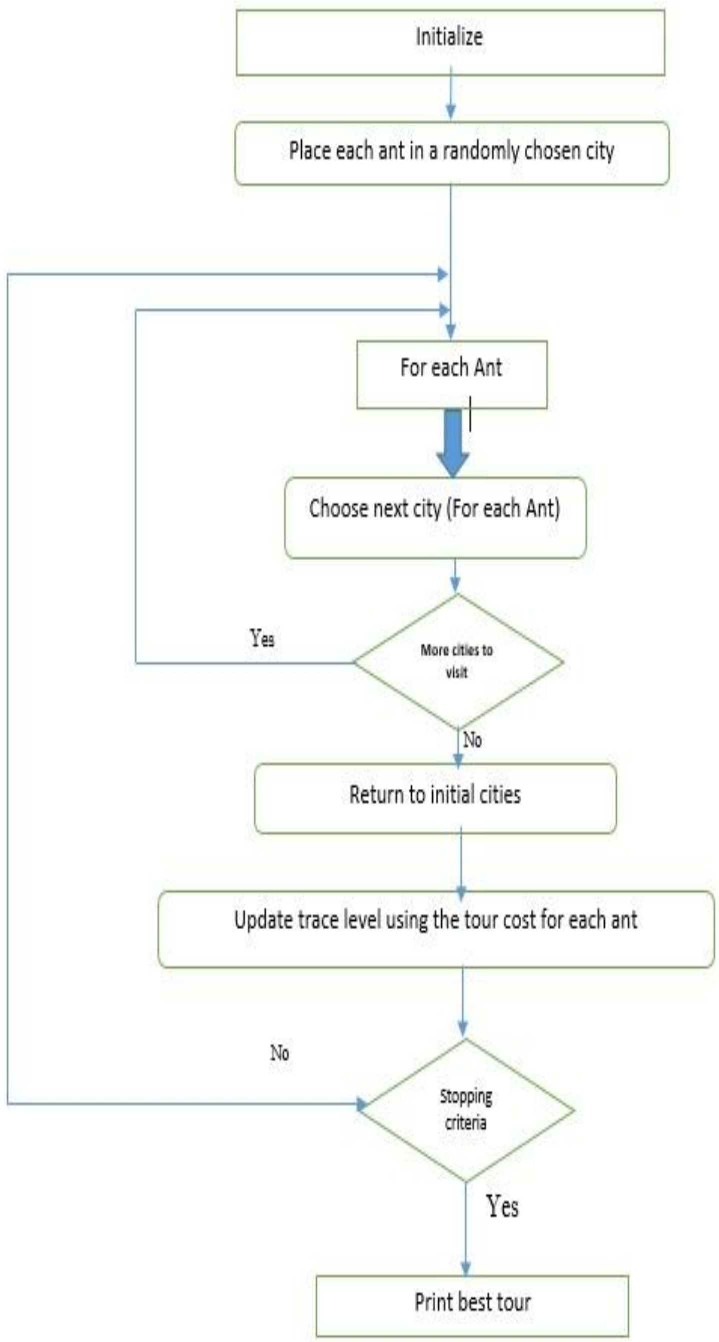
L_k = length of tour performed by ant k

Table: 1
Present Sequence of Station and arrival, Departure timing of the mailval considered for Case study.

TOTAL DISTANCE TRAVELLED: 88KMS

Station Nos.	Name of the Station	Arrival Time	Departure Time
01	BG City TMO	06:00	06:20
02	Wilson Garden	06:40	06:45
03	Adugodi	06:50	06:55
04	D R CCollege	07:05	07:10
05	Koramangal VI Block	07:20	07:25
06	Koramangala III Block	07:35	07:40
07	Bommanahalli	07:50	07:55
08	HSR Layout	08:05	08:10
09	Bellandur	08:30	08:35
10	Carmelram	08:55	09:00
11	Sarjapur	09:25	10:00
12	Basavanagudi	10:35	10:40
13	Chamarajapet/CSD/PSD	11:00	11:10
14	BG City TMO	11:30	11:40

Flowchart for ACO:



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V. RESULT & DISCUSSION

The results obtained from the ACO has been analyzed and found that the present adopted route by Post Office is 88 kms and ACO obtained result is 76kms.

However computer output obtained from ACO in the last iteration no 10, which shows that there are 13 different sequences which also give the same output of 76km .This gives the flexibility for the problem to adopt any sequence depending upon the requirements.

VI. CONCLUSION

It is seen from the iterations that all ants converge to the shortest path which gives the most optimal distance to cover all the sub post offices. The selection of next city after each iteration is shown which is based on the maximum probability rule. Though all the routes give the shortest path after final iteration, the most suitable route (one which has richer pheromone level) is selected.

Table: 2
Distance Matrix between the Stations (in KM)

Station Nos	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	0	6.5	8.4	8.9	10.4	13.8	12.4	12.9	19.7	17.6	31.4	5	3.5
2	7.4	0	1.9	3.2	3.8	5.2	6.8	7.4	12.2	11.4	25.4	3.5	5.7
3	8.8	3.1	0	2.8	1.9	3.3	4.9	5.5	10.4	12.2	23.6	5.9	6.8
4	11.7	2.8	2.5	0	2.3	2.9	4.5	5.1	9.9	9.1	16.7	5.6	7.9
5	10.8	5.2	2.1	2.6	0	2	4.6	5.2	8.1	7.3	21.3	8	8.9
6	12.4	5.7	3.7	3.3	2.4	0	3.6	3.1	6.6	5.7	13.3	8.3	10.4
7	14.6	7.5	5.9	5.1	5.6	4.8	0	2	7.3	6.4	20.5	10.3	11.6
8	14.2	7.1	5.5	4.7	4.3	3.1	1.9	0	5.6	7.4	18.8	9.9	11.2
9	18.9	12.1	10.5	9.7	8.9	6.6	7.2	5.7	0	2.1	16.2	14.9	17.2
10	18	11.2	9.6	8.8	7.6	5.7	6.3	4.8	2.1	0	14.1	14	15.2
11	31.3	24.2	22.6	21.9	21.7	19.8	20.3	18.8	16.2	14.1	0	27	28.3
12	6.6	3.4	5.3	5.9	7	7.6	9.3	9.8	14.7	13.8	27.9	0	2.7
13	3.7	6.6	6.9	7.6	8.7	9.4	11	11.6	16.4	15.6	29.7	3.3	0

Table: 3
Computer Generated Final Output using ACO

Sequence Nos.	Sequence of Station numbers to be visited														Distance Travelled in KM
1	1	7	8	9	10	11	6	5	3	4	2	12	13	1	76
2	9	10	11	6	5	3	4	2	12	13	1	7	8	9	76
3	4	2	12	13	1	7	8	9	10	11	6	5	3	4	76
4	8	9	10	11	6	5	3	4	2	12	13	1	7	8	76
5	12	13	1	7	8	9	10	11	6	5	3	4	2	12	76
6	6	5	3	4	2	12	13	1	7	8	9	10	11	6	76
7	8	9	10	11	6	5	3	4	2	12	13	1	7	8	76
8	10	11	6	5	3	4	2	12	13	1	7	8	9	10	76
9	6	5	3	4	2	12	13	1	7	8	9	10	11	6	76
10	6	5	3	4	2	12	13	1	7	8	9	10	11	6	76
11	1	7	8	9	10	11	6	5	3	4	2	12	13	1	76
12	12	13	1	7	8	9	10	11	6	5	3	4	2	12	76
13	13	1	7	8	9	10	11	6	5	3	4	2	12	13	76

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