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Solving Traveling Salesmen Problem using Ant Colony Optimization Algorithm

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Abstract

Ant Colony Optimization is a new meta-heuristic technique used for solving different combinatorial optimization problems. ACO is based on the behaviors of ant colony and this method has strong robustness as well as good distributed calculative mechanism. ACO has very good search capability for optimization problems. Travelling salesman problem is one of the most famous combinatorial optimization problems. In this paper we applied the ant colony optimization technique for symmetric travelling salesperson problem. Analysis are shown that the ant select the rich pheromone distribution edge for finding out the best path.

Keywords: Ant colony optimization; Travelling salesman problems; Algorithm models

Introduction

Ant Colony Optimization (ACO) is a relatively new meta-heuristic and successful technique in the field of swarm intelligence. This technique was first introduced by Dorigo and his colleagues [1,2]. This technique is used for many applications especially problems that belong to the combinatorial optimization. ACO algorithm models represent the behavior of real ant colonies in establishing the shortest path between food sources and nests. The ants release pheromone on the ground while walking from their nest to food and then go back to the nest. The ants move according to the richer amount of pheromones on their path and other ants would be followed and will tend to choose a shorter path which would have a higher amount of pheromone. Artificial ants imitate the behavior of real ants, but can solve much more complicated problem than real ants can.

ACO has been widely applied to solving various combinatorial optimization problems such as traveling salesman problem (TSP), job-shop scheduling problem (JSP), vehicle routing problem (VRP), quadratic assignment problem (QAP), etc. [3]. Although ACO has a powerful capacity to find out solutions to combinatorial optimization problems, it has the problems of stagnation, premature convergence and the convergence speed of ACO is always slow. These problems will be more obvious when the problem size increases (Figure 1).

The traveling salesman problem (TSP) is the problem of finding a shortest closed tour which visits all the cities in a given set. In a symmetric TSP the distance between two cities is the same regardless of the direction of travel whereas in the asymmetric TSP the distance is different with regards to the direction of travel [4]. This paper restricts attention to symmetric TSPs in which cities are on a plane and a path (edge) exists between each pair of cities. The definition of a TSP is: given N cities, if a salesman starting from his home city is to visit each city exactly once and then return home, find the order of a tour such that the total distances (cost/time/money/energy etc) traveled should be minimum. A complete weighted graph G = (N, E) can be used to represent a TSP, where N is the set of n cities and E is the set of edges (paths) fully connecting all cities. Each edge $(i,j) \in E$ is assigned a cost d_{ij} , which is the distance between cities i and j [5-7].

Methodology of Ant Colon Optimization Model

The Ant System was first introduced and applied to TSP by

Marcodorigo et al. 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:

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

where n_{ii} is the heuristic visibility of edge (i, j), generally it is a value of 1/d,, where d, is the distance between city i and city j. City J is a set of cities which remain to be visited when the ant is at city i. α and β are two adjustable positive parameters that control the relative weights of the pheromone trail and of the heuristic visibility. If $\alpha=0$, the closed vertex i more likely to be selected. This is responding to a classical stochastic greedy algorithm. If $\beta {=} 0,$ only pheromone amplification is at work: This method will lead the system to a stagnation situation, i.e. a situation in which all the ants generate a sub-optimal tour. So the trade-off between edge length and pheromone intensity is necessary. After each ant completes its tour, the pheromone amount on each path will be adjusted according to equation $(1-\rho)$ is the pheromone decay parameter $(0 < \rho < 1)$ where it represents the trail evaporation when the ant chooses a city and decides to move. Number of ants represented by m, L_k is the length of the tour performed by ant k and Q is an arbitrary constant [8,9]. After all the ants complete their tour the pheromone is required to be updated using

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

Where

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$$\Delta \tau_{ij}(t) = \sum_{k=1}^{m} \Delta \tau_{ij}^{\ k}(t)$$

Tour Length:
$$\Delta \tau_{i,j}^k = \begin{cases} \frac{Q}{L_k} & \text{if } (i,j) \in \text{tour}_k \\ 0 & \text{otherwise} \end{cases}$$

Methodology

In this paper a symmetric travelling salesman problem is presented for five cities. The distance of each city is given in the Table 1 and their visibility for each edge is shown in Table 2 and 3.

Parameter selection

No of Ants=5

 $\alpha = 0.7$, $\beta = 0.7$, Q = 1, Number of iteration=5

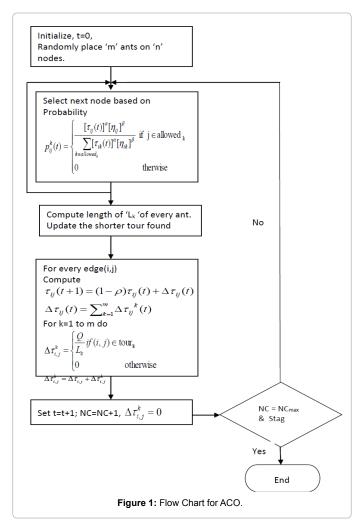
Initially pheromone (τ) distribution for each edge=1

Results and Discussion

Ant colony optimization methodology is presented for symmetric cities of travelling salesmen problem in this paper. A detailed procedure for city selection for respective ant is presented in the Tables 4-8 for iteration 1 to 5. The selection of next city is based on the maximum probability within the set of possible selection of the cities for next move. This is marked as '*' in the respective iteration. In the Table 4, ant 2, 3 and 5 gives the minimum distance with the initially assumed pheromone which is one for each edge. The minimum distance remain same for the ant 2, 3 and 5 for iteration 2, however the pheromone (τ) distribution is different because of updating the pheromone in the iteration 2 for each edge based on the updating rule. In the iteration 4, the ant 1, 2, 3 and 5 are selected the best path with minimum distance. However in the iteration 5, all the ants are converged to the minimum distance. The pheromone (τ) distribution for iteration, 2, 3, 4 and 5 are updated for each iteration. The distribution of the pheromone (τ) for each edge is shown in the beginning of the respective table.

Cities/ Cities	A	В	С	D	E
Α	∞	3	6	2	3
В	3	∞	5	2	3
С	6	5	∞	6	4
D	2	2	6	∞	6
E	3	3	4	6	∞

Table 1: Distance (dij) of cities.



Cities/ Cities	Α	В	С	D	E
Α	∞	0.33	0.16	0.5	0.33
В	0.33	∞	0.2	0.5	0.33
С	0.16	0.2	∞	0.16	0.25
D	0.5	0.5	0.16	∞	0.16
E	0.33	0.33	0.25	0.16	∞

Table 2: Visibility of edge = 1/dij.

Ant	1	2	3	4	5
City	Α	В	С	D	E

Table 3: Randomly select the first City by each ant.

Pheromo	ne	<u>Distrib</u> u	tion					
		City	Α	В	С	D	E	
		Α	0	1	1	1	1	
		В	1	0	1	1	1	
		С	1	1	0	1	1	
		D	1	1	1	0	1	
		Е	1	1	1	1	0	
Selection	of	Citios fo	r rocno	rtivo ant				
City	Ţ	T ^a	Cost(n)	1/n	(1/n) ^β	Τ ^α (1/n) ^β	ΣΤ ^α (1/n) ^β	Probability
'	ľ	ľ	` '	ľ	,	((-//	2 (-,,	next city
Ant 1 Pat	th							,
Selection	of	Second	City					
AB	1	1.000	3	0.3333	0.4635	0.4635	1.8278	0.2536
AC	1	1.000	6	0.1667	0.2853	0.2853	1.8278	0.1561
*AD	1	1.000	2	0.5000	0.6156	0.6156	1.8278	0.3368
AE	1	1.000	3	0.3333	0.4635	0.4635	1.8278	0.2536
Selection	of	third Cit	.y	•	•	•	•	
*DB	1	1.000	2	0.5000	0.6156	0.6156	1.1862	0.5190
DC	1	1.000	6	0.1667	0.2853	0.2853	1.1862	0.2405
DE	1	1.000	6	0.1667	0.2853	0.2853	1.1862	0.2405
Selection	of	fourth C	ity	•	•	•		
ВС	1	1.000	5	0.2000	0.3241	0.3241	0.7876	0.4115
*BE	1	1.000	3	0.3333	0.4635	0.4635	0.7876	0.5884
—								
Sele <u>ction</u>	of	last City		•	•			
Selection *EC			4	0.2500	0.3789	0.3789	0.3789	1.0000
*EC	1	1.000	_	0.2500 B	0.3789 E	0.3789 C	0.3789 A	1.0000
*EC Path for Distance	1 ant	1.000	4					1.0000 Total= 17
*EC Path for Distance Ant 2 Pat	1 ant th	1.000 1: A	4 D 2	В	E	С	Α	
*EC Path for Distance Ant 2 Path Selection	ant th	1.000 1: A	4 D 2 City	B 2	E 3	C 4	A 6	Total= 17
*EC Path for Distance Ant 2 Path Selection BA	ant th of	1.000 1: A Second 1.000	4 D 2 City 3	B 2	E 3	C 4	A 6 1.8666	Total= 17 0.2483
*EC Path for Distance Ant 2 Pai Selection BA BC	ant th of:	1.000 1: A Second 1.000 1.000	4 D 2 City 3 5	0.3333 0.2000	0.4635 0.3241	0.4635 0.3241	A 6 1.8666 1.8666	Total= 17 0.2483 0.1736
*EC Path for Distance Ant 2 Par Selection BA BC *BD	1 ant th of 1 1 1	1.000 1: A Second 1.000 1.000	4 D 2 City 3 5 2	0.3333 0.2000 0.5000	0.4635 0.3241 0.6156	0.4635 0.3241 0.6156	1.8666 1.8666 1.8666	0.2483 0.1736 0.3298
Path for Distance Ant 2 Par Selection BA BC *BD BE	1 ant th of 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000	4 D 2 City 3 5 2 3	0.3333 0.2000	0.4635 0.3241	0.4635 0.3241	A 6 1.8666 1.8666	Total= 17 0.2483 0.1736
Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection	1 ant th of: 1 1 1 1 of:	1.000 1: A Second 1.000 1.000 1.000 1.000 third Cit	2 City 3 5 2 3	0.3333 0.2000 0.5000 0.3333	E 3 0.4635 0.3241 0.6156 0.4635	0.4635 0.3241 0.6156 0.4635	1.8666 1.8666 1.8666	0.2483 0.1736 0.3298 0.2483
Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection	1 th of 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 third Cit	4 D 2 City 3 5 2 3 Y 2	0.3333 0.2000 0.5000 0.3333	0.4635 0.3241 0.6156 0.4635	0.4635 0.3241 0.6156 0.4635	1.8666 1.8666 1.8666 1.8666	Total= 17 0.2483 0.1736 0.3298 0.2483 0.5190
Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection *DA DC	1 ant th of: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 third Cit 1.000	4 D 2 City 3 5 2 3 y 2 6	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405
Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection *DA DC DE	1 ant th of 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 third Cit 1.000 1.000	4 D 2 City 3 5 2 3 Sy 2 6 6 6	0.3333 0.2000 0.5000 0.3333	0.4635 0.3241 0.6156 0.4635	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853	1.8666 1.8666 1.8666 1.8666	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405
Path for Distance Ant 2 Par Selection BA BC *BD BE Selection *DA DC DE Selection	1 ant th of 1 1 1 1 1 1 1 of 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 third Cit 1.000 1.000 1.000 fourth C	4 D 2 City 3 5 2 3 3 Cy 2 6 6 6 City	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405
Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection *DA DC DE Selection AC	1 ant th of 1 1 1 1 1 1 of 1 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 fourth C	4 D 2 City 3 5 2 3 Sy 2 6 6 City 6	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 1.1862 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.2405
Path for Distance Ant 2 Pai Selection *BD BE Selection DE Selection AC *AE	1 ant th of 1 1 1 1 of 1 1 1 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	4 D 2	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.2405
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection *DA DC DE Selection AC *AE Selection	th of 1 1 1 1 1 of 1 1 of of 1 1 1 of	1.000 1: A Second 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	4 D 2	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853 0.2853	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 1.1862 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.3810 0.6189
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection *DA DC DE Selection AC *AE Selection *EC	1 ant th of 1 1 1 1 of 1 1 of 1 1	1.000 1: A Second 1.000	4 D 2	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.1667	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 0.7488 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.2405
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection *DA DC DE Selection AC *AE Selection *EC Path for	1 ant th of 1 1 1 1 of 1 1 of 1 ant ant	1.000 1: A Second 1.000	City 3 5 2 3 3 Y 2 6 6 6 City 6 5 3 5 6 D	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.1667	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 E	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 1.1862 0.7488 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.3810 0.6189
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection AC *AE Selection AC Path for Distance	1 ant th of 1 1 1 1 of 1 1 1 of 1 ant	1.000 1: A Second 1.000	4 D 2	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.1667	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853	0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 0.7488 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.3810 0.6189
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection AC AC Selection AC Path for Distance Ant 3 Pai	1 ant th of 1 1 1 1 of 1 1 ant th	1.000 1: A Second 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 2: B	City 3 5 2 3 3 Y 2 6 6 6 City 6 3 3 City 7 2 2 6 7 City 7	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.1667	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 E	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 1.1862 0.7488 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.3810 0.6189
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection AC *AE Selection AC *AE Selection AC *AE Selection Selection AC *AE Selection Selection Selection AC Selection Selection AC Selection Selection	1 ant th of 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 2.000 1.000 2.000 1.000	4 D 2	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.1667 A	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 E 3	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 1.1862 0.7488 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.2405 0.3810 0.6189 1.0000
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection AC *AE Selection AC *AE Path for Distance Ant 3 Pai Selection CA	1 ant th of: 1 1 1 of 1 1 ant th of: 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 2.000 1.000	4 D 2	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.1667 A 2	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 E 3	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 1.1862 0.7488 0.7488 0.2853 B 5	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.2405 0.3810 0.6189 1.0000 Total= 16
*EC Path for Distance Ant 2 Pai Selection BA BC *BD BE Selection AC *AE Selection AC *AE Selection AC *AE Selection Selection AC *AE Selection Selection Selection AC Selection Selection AC Selection Selection	1 ant th of 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1.000 1: A Second 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 2.000 1.000 2.000 1.000	4 D 2	0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.1667 A	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 E 3	0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.2853 0.2853	1.8666 1.8666 1.8666 1.8666 1.1862 1.1862 1.1862 0.7488 0.7488	0.2483 0.1736 0.3298 0.2483 0.5190 0.2405 0.2405 0.3810 0.6189 1.0000

City	v T	Τ ^α	Cost(n)	1/n	(1/n) ^β	T^{α} (1/n) $^{\beta}$	$\Sigma T^{\alpha} (1/n)^{\beta}$	Probability o
								next city
		•			•	•	•	
Selection	on of	third City						
*E	A 1	1.000	3	0.3333	0.4635	0.4635	1.2122	0.3823
EB	1	1.000	3	0.3333	0.4635	0.4635	1.2122	0.3823
ED	1	1.000	6	0.1667	0.2853	0.2853	1.2122	0.2354
Selection	on of	fourth Cit	y	•				
AB	1	1.000	3	0.3333	0.4635	0.4635	1.0790	0.4295
*A	D 1	1.000	2	0.5000	0.6156	0.6156	1.0790	0.5705
		last City						
*D		1.000	2	0.5000	0.6156	0.6156	0.6156	1.0000
Path fo	r ant	3: C	E	Α	D	В	С	
Distand	_		4	3	2	2	5	Total=16
Ant 4 P								
_		Second C						
*D	—	1.000	2	0.5000	0.6156	0.6156	1.8017	0.3417
DB	+-	1.000	2	0.5000	0.6156	0.6156	1.8017	0.3417
DC	_	1.000	6	0.1667	0.2853	0.2853	1.8017	0.1583
DE	_	1.000	6	0.1667	0.2853	0.2853	1.8017	0.1583
		third City						
*A	_	1.000	3	0.3333	0.4635	0.4635	1.2122	0.3823
AC	_	1.000	6	0.1667	0.2853	0.2853	1.2122	0.2354
AE		1.000	3	0.3333	0.4635	0.4635	1.2122	0.3823
	_	fourth Cit						
ВС	_	1.000	5	0.2000	0.3241	0.3241	0.7876	0.4115
*В		1.000	3	0.3333	0.4635	0.4635	0.7876	0.5884
_	_	last City		1	1	T		
*E	_	1.000	4	0.2500	0.3789	0.3789	0.3789	1.0000
Path fo		4: D	Α	В	E	С	D	
Distanc			2	3	3	4	6	Total=18
Ant 5 P								
_	_	Second C	 	lo 0000	lo .co.	0.460=	1 5040	0.0040
*E		1.000	3	0.3333	0.4635	0.4635	1.5912	0.2913
EB	_	1.000	3	0.3333	0.4635	0.4635	1.5912	0.2913
EC	-	1.000	4	0.2500	0.3789	0.3789	1.5912	0.2381
ED Street		1.000	6	0.1667	0.2853	0.2853	1.5912	0.1793
_		third City	2	0.2222	0.4635	0.4005	4 2042	0.2227
AB		1.000	3	0.3333	0.4635	0.4635	1.3643	0.3397
AC	_	1.000	6	0.1667	0.2853	0.2853	1.3643	0.2091
*A	_	1.000	2	0.5000	0.6156	0.6156	1.3643	0.4512
		fourth Cit	-	0 =000	0.04=0	0.64=6		0.0000
*D		1.000	2	0.5000	0.6156	0.6156	0.9009	0.6833
DC		1.000	6	0.1667	0.2853	0.2853	0.9009	0.3167
			-	0.2000	0.224	10.2244	1 0 2241	4.0000
Selection	CI1	1.000	5	0.2000	0.3241	0.3241	0.3241	1.0000
	<u> </u>							
Selection	-	5: E	Α	D	В	С	E	

Table 4: Iteration-1.

Pherom	one Distr	ibution	-		-	-	_	1
			Α	В	С	D	E	
		Α	0	0.5	0.5	0.625	0.625	
		В	0.5	0	0.5625	0.625	0.5	
		С	0.5	0.625	0	0.5	0.6875	
		D -	0.5625	0.5625	0.5	0	0.5	
		E	0.5625	0.5	0.5	0.5	0	
Selectio	on of Citie	s for resp	ective ar	<u>nt</u>				
City	τ	Τ ^α	Cost(n)	1/n	(1/n) ^β	Ţ ^α (1/n) ^β	$\sum_{\alpha}^{\alpha} (1/n)^{\beta}$	Probability
. L_	<u> </u>							of next cit
Ant 1 P								
	n of Seco					L		
AB	0.500	0.6156	3	0.3333	0.4635	0.2853	1.2374	
AC *AD	0.500	0.6156	6	0.1667	0.2853	0.1756	1.2374	_
*AD	0.625	0.7196	2	0.5000	0.6156	0.4430	1.2374	
AE	0.625	0.7196	3	0.3333	0.4635	0.3335	1.2374	0.2695
	on of third		1	n E000	0.6156	0.4115	0.7637	0.5305
*DB	0.563	0.6685	2	0.5000	0.6156	0.4115	0.7627	_
DC DE	0.500	0.6156	6	0.1667 0.1667	0.2853	0.1756	0.7627	0.2303
	n of four		0	0.1007	0.2855	0.1756	0.7627	0.2303
BC	0.563	0.6685	5	0.2000	0.3241	0.2167	0.5020	0.4316
*BE	0.500	0.6156	3	0.3333	0.4635	0.2167	0.5020	
	n of last (3	0.5555	0.4055	0.2033	0.302	0.5065
*EC	0.500	0.6156	4	0.2500	0.3789	0.2333	0.2333	1.0000
_	r ant 1:	_		B	0.5763 E	0.2333 C	A A	1.0000
Distanc			2	2	3	4	6	Total = 17
Ant 2 P						•		1010. 27
	n of Seco	nd City						
ВА	0.5	0.6156	3	0.3333	0.4635	0.2853	1.2303	0.2319
ВС	0.5625	0.6685	5	0.2000	0.3241	0.2167	1.2303	0.1761
*BD	0.625	0.7196	2	0.5000	0.6156	0.4430	1.2303	0.3601
BE	0.5	0.6156	3	0.3333	0.4635	0.2853	1.2303	0.2319
Selectio	n of third	City	•	•	•	•	•	•
*DA	0.5625	0.6685	2	0.5000	0.6156	0.4115	0.7627	0.5395
DC	0.5	0.6156	6	0.1667	0.2853	0.1756	0.7627	0.2303
	_ ^ -					L	h =co=	0.2202
DE	0.5	0.6156	6	0.1667	0.2853	0.1756	0.7627	0.2303
	0.5 on of four		6	0.1667	0.2853	0.1756	0./62/	0.2303
	on of four		6	0.1667	0.2853	0.1756	0.5091	
Selectio	n of four	th City						
AC *AE Selectio	on of four	0.6156 0.7196	6	0.1667	0.2853 0.4635	0.1756 0.3335	0.5091 0.5091	0.3449
Selection AC *AE	0.5 0.625	0.6156 0.7196	6	0.1667	0.2853	0.1756	0.5091	0.3449
AC *AE Selectio	0.5 0.625 on of last 0	0.6156 0.7196 0.6156 0.7196	6 3	0.1667 0.3333	0.2853 0.4635 0.3789	0.1756 0.3335	0.5091 0.5091 0.2333 B	0.3449 0.6551
AC *AE Selectio *EC Path for	0.5 0.625 on of last 0 0.5 r ant 2:	0.6156 0.7196 0.6156 0.7196	6 3	0.1667 0.3333 0.2500	0.2853 0.4635 0.3789	0.1756 0.3335 0.2333	0.5091 0.5091 0.2333	0.3449 0.6551 1.0000
Selection AC *AE Selection *EC Path for Distance Ant 3 P	0.5 0.625 on of last 0 0.5 r ant 2:	0.6156 0.7196 City 0.6156 B	6 3 4 D	0.1667 0.3333 0.2500 A	0.2853 0.4635 0.3789	0.1756 0.3335 0.2333 C	0.5091 0.5091 0.2333 B	0.3449 0.6551 1.0000
Selection *AE Selection *EC Path for Distance Ant 3 Poselection	on of four 0.5 0.625 on of last C 0.5 r ant 2: I e ath	th City 0.6156 0.7196 City 0.6156 B	6 3 4 D	0.1667 0.3333 0.2500 A 2	0.2853 0.4635 0.3789 E 3	0.1756 0.3335 0.2333 C 4	0.5091 0.5091 0.2333 B 5	0.3449 0.6551 1.0000 Total = 16
Selection AC *AE Selection *EC Path for Distance Ant 3 P. Selection CA	on of four 0.5 0.625 on of last C 0.5 r ant 2: le e ath	th City 0.6156 0.7196 City 0.6156 B	6 3 4 D 2	0.1667 0.3333 0.2500 A 2	0.2853 0.4635 0.3789 E 3	0.1756 0.3335 0.2333 C 4	0.5091 0.5091 0.2333 B 5	0.3449 0.6551 1.0000 Total = 16
Selection *AE Selection *EC Path for Distance Ant 3 Posselection	0.5 0.625 on of last 0 0.5 r ant 2: le ath on of Seco 0.5 0.625	th City 0.6156 0.7196 ity 0.6156 0.6156 0.6156 0.7196	6 3 4 D 2	0.1667 0.3333 0.2500 A 2 0.1667 0.2000	0.2853 0.4635 0.3789 E 3 0.2853 0.3241	0.1756 0.3335 0.2333 C 4 0.1756 0.2333	0.5091 0.5091 0.2333 B 5 0.8572 0.8572	0.3449 0.6551 1.0000 Total = 16 0.2049 0.2721
Selection AC *AE Selection *EC Path for Distance Ant 3 P. Selection CA	on of four 0.5 0.625 on of last C 0.5 r ant 2: le e ath	th City 0.6156 0.7196 City 0.6156 B	6 3 4 D 2	0.1667 0.3333 0.2500 A 2	0.2853 0.4635 0.3789 E 3	0.1756 0.3335 0.2333 C 4	0.5091 0.5091 0.2333 B 5	0.3449 0.6551 1.0000 Total = 16

City	Ţ	T ^α	Cost(n)	1/n	(1/n) ^β	Ţ ^α (1/n) ^β	Σ[^α (1/n) ^β	Probabilit of next cit
Selection	of third (^itv						
*EA	0.5625	0.6685	3	0.3333	0.4635	0.3098	0.7707	0.4020
EB	0.5025	0.6156	3	0.3333	0.4635	0.2853	0.7707	0.3702
ED	0.5	0.6156	6	0.3333	0.4033	0.2833	0.7707	0.2279
Selection			U U	0.1007	0.2033	0.1730	0.7707	0.2273
AB	0.5	0.6156	3	0.3333	0.4635	0.2853	0.7283	0.3917
*AD	0.625	0.7196	2	0.5000	0.6156	0.4430	0.7283	0.6083
Selection	of last Ci	ty						
*DB	0.5625	0.6685	2	0.5000	0.6156	0.4115	0.4115	1.0000
Path for a	nt 3: C		E	Α	D	В	С	•
Distance			4	3	2	2	5	Total = 16
Ant 4 Pat	h						-	
Selection		d City						
*DA	0.5625	0.6685	2	0.5000	0.6156	0.4115	1.1742	0.3504
DB	0.5625	0.6685	2	0.5000	0.6156	0.4115	1.1742	0.3504
DC	0.5	0.6156	6	0.1667	0.2853	0.1756	1.1742	0.1496
DE	0.5	0.6156	6	0.1667	0.2853	0.1756	1.1742	0.1496
Selection						1		
AB	0.5	0.6156	3	0.3333	0.4635	0.2853	0.7944	0.3591
AC	0.5	0.6156	6	0.1667	0.2853	0.1756	0.7944	0.2211
*AE	0.625	0.7196	3	0.3333	0.4635	0.3335	0.7944	0.4198
Selection								
EC	0.5	0.6156	5	0.2000	0.3241	0.1995	0.4848	0.4115
*EB	0.5	0.6156	3	0.3333	0.4635	0.2853	0.4848	0.5885
Selection								
*BC	0.5625	0.6685	4	0.2500	0.3789	0.2533	0.2533	1.0000
Path for a				E	В	С	D	
Distance			2	3	3	5	6	Total = 19
Ant 5 Pat	h						-	
Selection	of Secon	d Citv						
*EA	0.5625	0.6685	3	0.3333	0.4635	0.3098	1.0040	0.3086
EB	0.5	0.6156	3	0.3333	0.4635	0.2853	1.0040	0.2842
EC	0.5	0.6156	4	0.2500	0.3789	0.2333	1.0040	0.2323
ED	0.5	0.6156	6	0.1667	0.2853	0.1756	1.0040	0.1749
Selection	of third (•	•	•	•		•
AB	0.5	0.6156	3	0.3333	0.4635	0.2853	0.9039	0.3156
AC	0.5	0.6156	6	0.1667	0.2853	0.1756	0.9039	0.1943
*AD	0.625	0.7196	2	0.5000	0.6156	0.4430	0.9039	0.4901
Selection								
*DB	0.5625	0.6685	2	0.5000	0.6156	0.4115	0.5871	0.7009
DC	0.5	0.6156	6	0.1667	0.2853	0.1756	0.5871	0.2991
Selection				0.2007	0.2000	0.2700	0.5072	0.2332
*BC	0.5625	0.6685	5	0.2000	0.3241	0.2167	0.2167	1.0000
	ant 5: F		A	D	В	С	E	
Path for a	3			-		•	-	
Path for a Distance * Selecter			3	2	2	5	4	Total = 16

Table 5: Iteration-2.

				А	В	С	D	Е	
			Α	0	0.25	0.25	0.4375	0.4375	
			В	0.25	0	0.34375	0.4375	0.25	
			C	0.25	0.4375	0	0.25	0.53125	
			D	0.34375	0.34375	0.25	0	0.25	
			E	0.34375	0.25	0.25	0.25	0	
Colocti	ion /	of Cities fo	or rocno	tivo ant		•	•		
	ity	T	T ^a	Cost(n)	1/n	(1/n) ^β	Τ ^α (1/n) ^β	ΣΤ ^α (1/n) ^β	Probability
	-					` '	' ' '	_ , , ,	of next city
∟ Ant 1 F	Path					!			U. Heat day
		of Second	l Citv						
Al	_		0.3789	3	0.3333	0.4635	0.1756	0.8887	0.1976
A	-		0.3789	6	0.1667	0.2853	0.1081	0.8887	0.1216
- ⊢	AD		0.5606	2	0.5000	0.6156	0.3451	0.8887	0.3883
Al		0.4375		3	0.3333	0.4635	0.2598	0.8887	0.2924
 Selecti	ion (of third Ci	ity	!					
_	DB		0.5606	2	0.5000	0.6156	0.3451	0.5613	0.6148
D	c		0.3789	6	0.1667	0.2853	0.1081	0.5613	0.1926
DI	E	0.25	0.3789	6	0.1667	0.2853	0.1081	0.5613	0.1926
 Selecti	ion (of fourth	Citv	!		!			
В	_		0.4736	5	0.2000	0.3241	0.1535	0.3291	0.4664
*[BE	0.25	0.3789	3	0.3333	0.4635	0.1756	0.3291	0.5336
Selecti	ion (of last Cit	У						
*[EC	0.5313	0.6423	4	0.2500	0.3789	0.2434	0.2434	1.0000
Path fo	or a	nt 1: A	1	В	E	С	Α .		
Distan	ce			2	2	3	4	6	Total = 17
Ant 2 F	Path	1							
Selecti	ion (of Second	l City						
B/	Α	0.25	0.3789	3	0.3333	0.4635	0.1756	0.8499	0.2066
BO	С	0.3438	0.4736	5	0.2000	0.3241	0.1535	0.8499	0.1806
*[BD	0.4375	0.5606	2	0.5000	0.6156	0.3451	0.8499	0.4061
ВІ	E	0.25	0.3789	3	0.3333	0.4635	0.1756	0.8499	0.2066
Selecti	ion (of third Ci	ity						
*[DA	0.4375	0.5606	2	0.5000	0.6156	0.3451	0.5613	0.6148
D	С	0.25	0.3789	6	0.1667	0.2853	0.1081	0.5613	0.1926
DI	E	0.25	0.3789	6	0.1667	0.2853	0.1081	0.5613	0.1926
_		of fourth					•		
Α	C	0.25	0.3789	6	0.1667	0.2853	0.1081	0.3679	0.2938
*/	٩E	0.4375	0.5606	3	0.3333	0.4635	0.2598	0.3679	0.7063
_		of last Cit							
	EC		0.6423	4	0.2500	0.3789	0.2434	0.2434	1.0000
Path fo	or a	nt 2:	В	D	Α	E	С	В	
Distan				2	2	3	4	5	Total = 16
Ant 3 F									
_		of Second							
C/	_		0.3789	6	0.1667		0.1081	0.6413	0.1686
CI	-		0.5606	5	0.2000	0.3241	0.1817	0.6413	0.2834
1 4	nΓ	0.25	0.3789	6	0.1667	0.2853	0.1081	0.6413	0.1686
CI	CE		0.6423	4	0.2500	0.3789	0.2434	0.6413	0.3795

	Ţ	Ţ ^α	Cost(n)	1/n	(1/n) ^β	Ţ ^α (1/n) ^β	$\Sigma T^{\alpha} (1/n)^{\beta}$	Probability
								of next city
Selection	n of third	City						
*FA		0.5606	3	0.3333	0.4635	0.2598	0.5436	0.4780
EB		0.3789	3	0.3333	0.4635	0.1756	0.5436	0.3231
ED	0.25		6	0.1667	0.2853	0.1081	0.5436	0.1989
_	of fourt			0.2007	0.2033	0.1001	0.5 150	0.1303
AB		0.3789	3	0.3333	0.4635	0.1756	0.5207	0.3373
*AD	0.4375		2	0.5000	0.6156	0.3451	0.5207	0.6628
	of last C 0.4375		2	0.5000	0.6156	0.3451	0.3451	1.0000
Path for a		C.	E	Α	D	B	C 0.5 151	1.0000
Distance		•	4	3	2	2	-	Total = 16
Ant 4 Pat	h			<u> </u>				
	of Secon	d Citv						
*DA	0.3438		2	0.5000	0.6156	0.2915	0.7993	0.3647
DB		0.4736	2	0.5000	0.6156	0.2915	0.7993	0.3647
DC		0.3789	6	0.1667	0.2853	0.1081	0.7993	0.1353
DE	0.25	0.3789	6	0.1667	0.2853	0.1081	0.7993	0.1353
Selection	of third	City						
AB	0.25	0.3789	3	0.3333	0.4635	0.1756	0.5032	0.3490
AC	0.25	0.3789	6	0.1667	0.2853	0.1081	0.5032	0.2148
*AE	0.3438	0.4736	3	0.3333	0.4635	0.2195	0.5032	0.4362
Selection	of fourth	City						
EC	0.25	0.3789	5	0.2000	0.3241	0.1228	0.2984	0.4115
*EB	0.25	0.3789	3	0.3333	0.4635	0.1756	0.2984	0.5885
Selection	of last Ci	ity			•	•		
*BC	0.4375	0.5606	4	0.2500	0.3789	0.2124	0.2124	1.0000
) a 4 la 4 a 4	ant 4:	D	Α	E	В	С	D	
ath for a			2	3	3	5	6	Total = 19
Path for a Distance			4	•				
	th							
Distance Ant 5 Pa	th of Secon	d City						
Distance Ant 5 Pa	of Secon	0.4736	3	0.3333	0.4635	0.2195	0.7365	0.2980
Distance Ant 5 Par Selection	of Secon 0.3438 0.25	0.4736 0.3789		-	0.4635	0.1756	0.7365	0.2385
Oistance Ant 5 Par Selection *EA EB EC	of Secon 0.3438 0.25 0.5	0.4736 0.3789 0.6156	3 3 4	0.3333 0.3333 0.2500	0.4635 0.3789	0.1756 0.2333	0.7365 0.7365	0.2385 0.3167
Ant 5 Par Selection *EA EB EC ED	of Secon 0.3438 0.25 0.5 0.25	0.4736 0.3789 0.6156 0.3789	3	0.3333	0.4635	0.1756	0.7365	0.2385
Ant 5 Pa Selection *EA EB EC ED	of Secon 0.3438 0.25 0.5 0.25 of third	0.4736 0.3789 0.6156 0.3789	3 3 4 6	0.3333 0.3333 0.2500 0.1667	0.4635 0.3789 0.2853	0.1756 0.2333 0.1081	0.7365 0.7365 0.7365	0.2385 0.3167 0.1468
Ant 5 Pa Selection *EA EB EC ED	of Secon 0.3438 0.25 0.5 0.25 of third 0.25	0.4736 0.3789 0.6156 0.3789 City 0.3789	3 3 4 6	0.3333 0.3333 0.2500	0.4635 0.3789	0.1756 0.2333	0.7365 0.7365	0.2385 0.3167
Ant 5 Par Selection *EA EB EC ED Selection AB AC	of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.25	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789	3 3 4 6	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853	0.1756 0.2333 0.1081 0.1756 0.1081	0.7365 0.7365 0.7365 0.5753 0.5753	0.2385 0.3167 0.1468 0.3053 0.1879
Ant 5 Par Selection *EA EB EC ED Selection AB AC *AD	of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.25 0.25	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789 0.4736	3 3 4 6	0.3333 0.3333 0.2500 0.1667	0.4635 0.3789 0.2853 0.4635	0.1756 0.2333 0.1081 0.1756	0.7365 0.7365 0.7365 0.5753	0.2385 0.3167 0.1468 0.3053
Ant 5 Par Selection *EA EB EC ED Selection AB AC *AD Selection	of Secon 0.3438 0.25 0.5 0.25 of third 0 0.25 0.25 0.3438 of fourth	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789 0.4736	3 3 4 6	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
Ant 5 Par Selection *EA EB EC ED Selection AB AC *AD Selection *DB	of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.25 0.3438 of fourth 0.3438	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789 0.4736	3 3 4 6 3 6 2	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
Ant 5 Par Selection *EA EB EC ED Selection AB AC *AD Selection *DB DC	of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.25 0.3438 of fourth 0.3438	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789	3 3 4 6	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
Ant 5 Para Selection *EA EB EC ED Selection AB AC *AD Selection DC Selection	of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.3438 of fourth 0.3438 0.25 of last C	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789	3 3 4 6 2 2	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.5000 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156 0.2853	D.1756 D.2333 D.1081 D.1756 D.1081 D.1756 D.1081 D.2915 D.2915 D.1081	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068 0.7295 0.2705
Ant 5 Par Selection *EA EB EC ED Selection AB AC *AD Selection *DB DC	of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.25 0.3438 of fourth 0.3438	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789	3 3 4 6 2 2	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.5000 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
Ant 5 Para Selection *EA EB EC ED Selection AB AC *AD Selection DC Selection	of Secon 0.3438 0.25 0.5 0.25 0.25 of third (0.25 0.3438 of fourth 0.3438 0.25 of last C 0.4375	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789	3 3 4 6 2 2	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.5000 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156 0.2853	D.1756 D.2333 D.1081 D.1756 D.1081 D.1756 D.1081 D.2915 D.2915 D.1081	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068 0.7295 0.2705
Ant 5 Pa Ant	of Secon 0.3438 0.25 0.5 0.25 0.25 of third (0.25 0.3438 of fourth 0.3438 0.25 of last C 0.4375	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789 ity 0.4566	3 4 6 3 6 2 2 5	0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.1667 0.2000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156 0.2853	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915 0.2915 0.1081 0.1817	0.7365 0.7365 0.7365 0.7365 0.5753 0.5753 0.3996 0.3996 0.1817	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068 0.7295 0.2705

Table 6: Iteration-3.

Phe	romo	one distrib	oution						
		i		ı				,	
				Α	В	С	D	E	
			Α	0	0.25	0.25	0.4375	0.4375	
			В	0.25	0	0.34375	0.4375	0.25	
			С	0.25	0.4375	0	0.25	0.53125	
			D	0.34375	0.34375	0.25	0	0.25	
			E	0.34375	0.25	0.25	0.25	0	
Selec	ction	of Cities f	or respec	tive ant					
	City	Ţ	Ţ ^α	Cost(n)	1/n	(1/n) ^β	Ţ ^α (1/n) ^β	$\sum T^{\alpha} (1/n)^{\beta}$	Probabilit
L									of next cit
	1 Patl								
Selec	ction	of Second	City						
- 1	AB		0.3789	3	0.3333		0.1756	0.8887	0.1976
- 1	AC		0.3789	6	0.1667	0.2853	0.1081	0.8887	0.1216
- 1	*AD		0.5606	2	0.5000	0.6156	0.3451	0.8887	0.3883
	AE		0.5606	3	0.3333	0.4635	0.2598	0.8887	0.2924
-		of third C							
-	*DB		0.5606	2	0.5000	0.6156	0.3451	0.5613	0.6148
- 1	DC		0.3789	6	0.1667	0.2853	0.1081	0.5613	0.1926
L	DE		0.3789	6	0.1667	0.2853	0.1081	0.5613	0.1926
Selec	ction	of fourth	City						
L	BC		0.4736	5	0.2000	0.3241	0.1535	0.3291	0.4664
L	*BE	*	0.3789	3	0.3333	0.4635	0.1756	0.3291	0.5336
_		of last Cit							
L	*EC		0.6423	4	0.2500	0.3789	0.2434	0.2434	1.0000
	for a	nt 1: /	4	В	E	C	Α		
Dista				2	2	3	4	6	Total = 17
	2 Patl								
-	_	of Second			0.000	lo 100=	lo 4== c		0.0000
- 1	BA		0.3789	3	0.3333	0.4635	0.1756	0.8499	0.2066
- 1	ВС	0.3438		5	0.2000	0.3241	0.1535	0.8499	0.1806
- 1	*BD		0.5606	2	0.5000	0.6156	0.3451	0.8499	0.4061
L	BE		0.3789	3	0.3333	0.4635	0.1756	0.8499	0.2066
-		of third C			0.5000	0.0450	0.0454	0.5640	0.6440
- 1	*DA		0.5606	2	0.5000	0.6156	0.3451	0.5613	0.6148
- 1	DC		0.3789	6	0.1667	0.2853	0.1081	0.5613	0.1926
L	DE	0.25		6	0.1667	0.2853	0.1081	0.5613	0.1926
	_	of fourth			lo 400=	lo 20=0	lo	0.00=0	0.0000
- 1	AC * A F		0.3789	6	0.1667	0.2853	0.1081	0.3679	0.2938
	*AE		0.5606	3	0.3333	0.4635	0.2598	0.3679	0.7063
_		of last Cit	,		0.2500	0.2200	lo 2424	0.2424	1 0000
L	*EC		0.6423	4	0.2500	0.3789	0.2434	0.2434	1.0000
		nt 2:	В	D	A	E	C	B -	.
				2	2	3	4	5	Total = 16
	k Patl		l City						
Ant 3		ot Second	LILV						
Ant 3	ction	of Second		6	0.1667	0.2853	0.1081	0.6413	0.1686
	ction CA	0.25	0.3789	6	0.1667	0.2853	0.1081 0.1817	0.6413	0.1686
Ant 3 Selec	ction	0.25 0.4375		6 5 6	0.1667 0.2000 0.1667	0.2853 0.3241 0.2853	0.1081 0.1817 0.1081	0.6413 0.6413	0.1686 0.2834 0.1686

	Ţ	Ţ ^α	Cost(n)	1/n	(1/n) ^β	Ţ ^α (1/n) ^β	$\Sigma T^{\alpha} (1/n)^{\beta}$	Probabilit
								of next city
Selection	n of third	City						
*FA		0.5606	3	0.3333	0.4635	0.2598	0.5436	0.4780
EB	_	0.3789	3	0.3333	0.4635	0.1756	0.5436	0.3231
ED	0.25		6	0.1667	0.2853	0.1081	0.5436	0.1989
_	n of fourt							
AB		0.3789	3	0.3333	0.4635	0.1756	0.5207	0.3373
*AD	0.4375		2	0.5000	0.6156	0.3451	0.5207	0.6628
	٠							
	n of last C 0.4375		2	0.5000	0.6156	0.3451	0.3451	1.0000
Path for		С	E	Α	D	В	С	
Distance			4	3	2	2	5	Total = 16
Ant 4 Pat	th						-	
Selection	of Secon	d City						
*DA		0.4736	2	0.5000	0.6156	0.2915	0.7993	0.3647
DB	0.3438	0.4736	2	0.5000	0.6156	0.2915	0.7993	0.3647
DC	0.25	0.3789	6	0.1667	0.2853	0.1081	0.7993	0.1353
DE	0.25	0.3789	6	0.1667	0.2853	0.1081	0.7993	0.1353
election	of third	City					!	
AB	0.25	0.3789	3	0.3333	0.4635	0.1756	0.5032	0.3490
AC	0.25	0.3789	6	0.1667	0.2853	0.1081	0.5032	0.2148
*AE	0.3438	0.4736	3	0.3333	0.4635	0.2195	0.5032	0.4362
election	of fourth	n City					!	
EC	0.25	0.3789	5	0.2000	0.3241	0.1228	0.2984	0.4115
*EB	0.25	0.3789	3	0.3333	0.4635	0.1756	0.2984	0.5885
election	of last C	ty				•	•	
*BC	0.4375	0.5606	4	0.2500	0.3789	0.2124	0.2124	1.0000
, , , , , , , , , , , , , , , , , , , 	ant 4:	D	Α	E	В	С	D	
ath for			2	3	3	5	6	Total = 19
Distance								
Distance Ant 5 Pa Selection	th of Secon	_						
Oistance Ant 5 Pa Selection *EA	th of Secon 0.3438	0.4736	3	0.3333		0.2195	0.7365	0.2980
Ant 5 Pa Selection *EA EB	th of Secon 0.3438 0.25	0.4736 0.3789	3	0.3333	0.4635	0.1756	0.7365	0.2385
Ant 5 Pa Selection *EA EB EC	th of Secon 0.3438 0.25 0.5	0.4736 0.3789 0.6156	3 3 4	0.3333 0.2500	0.4635 0.3789	0.1756 0.2333	0.7365 0.7365	0.2385 0.3167
Ant 5 Pa Selection *EA EB EC ED	th of Secon 0.3438 0.25 0.5 0.25	0.4736 0.3789 0.6156 0.3789	3	0.3333	0.4635	0.1756	0.7365	0.2385
Ant 5 Pa Selection *EA EB EC ED	th of Secon 0.3438 0.25 0.5 0.25 of third	0.4736 0.3789 0.6156 0.3789	3 3 4 6	0.3333 0.2500 0.1667	0.4635 0.3789 0.2853	0.1756 0.2333 0.1081	0.7365 0.7365 0.7365	0.2385 0.3167 0.1468
Ant 5 Pa Selection *EA EB EC ED Selection	th of Secon 0.3438 0.25 0.5 0.25 of third 0.25	0.4736 0.3789 0.6156 0.3789 City 0.3789	3 3 4 6	0.3333 0.2500 0.1667 0.3333	0.4635 0.3789 0.2853 0.4635	0.1756 0.2333 0.1081 0.1756	0.7365 0.7365 0.7365 0.5753	0.2385 0.3167 0.1468 0.3053
Ant 5 Pa Selection *EA EB EC ED Selection AB AC	th of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.25 0.25	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789	3 3 4 6	0.3333 0.2500 0.1667 0.3333 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853	0.1756 0.2333 0.1081 0.1756 0.1081	0.7365 0.7365 0.7365 0.5753 0.5753	0.2385 0.3167 0.1468 0.3053 0.1879
Ant 5 Pa Selection *EA EB EC ED Selection AB AC *AD	th of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.25 0.25 0.3438	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789 0.4736	3 3 4 6	0.3333 0.2500 0.1667 0.3333	0.4635 0.3789 0.2853 0.4635	0.1756 0.2333 0.1081 0.1756	0.7365 0.7365 0.7365 0.5753	0.2385 0.3167 0.1468 0.3053
Ant 5 Pa Selection *EA EB EC ED Selection AB AC *AD	th of Secon 0.3438 0.25 0.25 of third 0.25 0.25 0.3438 of fourth	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789 0.4736	3 3 4 6	0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
EANT 5 Pa Selection *EA EB EC ED Selection AB AC *AD *DB	th of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.3438 of fourth 0.3438	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.3789 0.4736	3 4 6 3 6 2	0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
Distance Ant 5 Pa Selection *EA EB EC ED Selection AB AC *AD Selection *DB DC	th of Secon 0.3438 0.25 0.5 0.25 0.25 0.25 0.3438 0.3438 0.25	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789	3 3 4 6	0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
Ant 5 Pa Ant 6 Pa Ant	th of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.3438 of fourth 0.3438 0.25 of last Ci factorial control of the	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789	3 3 4 6 3 6 2	0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156 0.2853	D.1756 D.2333 D.1081 D.1756 D.1081 D.1756 D.1081 D.2915 D.2915 D.1081	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068 0.7295 0.2705
Distance Ant 5 Pa Selection *EA EB EC ED Selection AB AC *AD Selection *DB DC	th of Secon 0.3438 0.25 0.5 0.25 of third 0.25 0.3438 of fourth 0.3438 0.25	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789 ty	3 3 4 6 3 6 2	0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156	0.1756 0.2333 0.1081 0.1756 0.1081 0.2915	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068
*EA EB EC ED Gelection AB AC *AD Selection *DB DC	th of Secon 0.3438 0.25 0.5 0.25 of third 0.3438 of fourth 0.3438 0.25 of last C 0.4375	0.4736 0.3789 0.6156 0.3789 City 0.3789 0.4736 0.4736 0.4736 0.3789	3 3 4 6 3 6 2	0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156 0.2853	D.1756 D.2333 D.1081 D.1756 D.1081 D.1756 D.1081 D.2915 D.2915 D.1081	0.7365 0.7365 0.7365 0.5753 0.5753 0.5753 0.3996 0.3996	0.2385 0.3167 0.1468 0.3053 0.1879 0.5068 0.7295 0.2705

Table 7: Iteration-4.

			Α	В	С	D	E	
		Α	0	0.0625	0.0625	0.3594	0.2969	
		В	0.0625	0	0.2422	0.3594	0.0625	
		С	0.0625	0.2969	0	0.0625	0.4141	
		D	0.1797	0.1797	0.0625	0	0.0625	
		E	0.2422	0.0625	0.125	0.0625	0	
Coloction	of Citios	for respe	ctivo ant					
City	T	T ^a	Cost(n)	1/n	(1/n) ^β	Ţ ^α (1/n) ^β	Σ[^α (1/n) ^β	Probability of next cit
Ant 1 Pat	:h		•	•	•	•	•	
Selection	of Secon	nd City						
AB	0.0625	0.1436	3	0.3333	0.4635	0.0665	0.6063	0.1098
AC	0.0625	0.1436	6	0.1667	0.2853	0.0410	0.6063	0.0676
*AD	0.3594	0.4885	2	0.5000	0.6156	0.3007	0.6063	0.4960
AE	0.2969	0.4274	3	0.3333	0.4635	0.1981	0.6063	0.3267
Selection	of third	City						
*DB	0.3594	0.4885	2	0.5000	0.6156	0.3007	0.3826	0.7859
DC	0.0625	0.1436	6	0.1667	0.2853	0.0410	0.3826	0.1071
DE	0.0625	0.1436	6	0.1667	0.2853	0.0410	0.3826	0.1071
Selection	of fourtl	h City				•		
*BC	0.2342	0.3620	5	0.2000	0.3241	0.1173	0.1839	0.6381
						0.11.0	0.1033	0.0301
BE	0.0625	0.1436	3	0.3333	0.4635	0.0665	0.1839	0.3619
BE	0.0625	0.1436	3		_	-		
		0.1436	3		_	-		
	0.1250			0.3333	0.4635	0.0665	0.1839	0.3619
*CE	0.1250	0.2333	4	0.3333	0.4635	0.0665	0.1839	0.3619 1.0000
*CE Path for a Distance Ant 2 Pat	0.1250 ant 1:	0.2333 A	4 D	0.3333 0.2500 B	0.4635 0.3789 C	0.0665 0.0884 E	0.1839 0.0884 A	0.3619 1.0000
*CE Path for a Distance Ant 2 Pat	0.1250 ant 1:	0.2333 A	4 D	0.3333 0.2500 B	0.4635 0.3789 C	0.0665 0.0884 E	0.1839 0.0884 A	0.3619 1.0000
*CE Path for a Distance	0.1250 ant 1: h of Secor	0.2333 A	4 D	0.3333 0.2500 B	0.4635 0.3789 C	0.0665 0.0884 E	0.1839 0.0884 A	0.3619 1.0000
*CE Path for a Distance Ant 2 Pat Selection	0.1250 ant 1: h of Secor	0.2333 A	4 D 2	0.3333 0.2500 B 2	0.4635 0.3789 C 5	0.0665 0.0884 E 4	0.1839 0.0884 A 3	0.3619 1.0000 Total = 16
*CE Path for a Distance Ant 2 Pat Selection BA BC	0.1250 ant 1: th of Secor	0.2333 A and City 0.1436	4 D 2	0.3333 0.2500 B 2 0.3333	0.4635 0.3789 C 5	0.0665 0.0884 E 4	0.1839 0.0884 A 3 0.5539	0.3619 1.0000 Total = 16 0.1201
*CE Path for a Distance Ant 2 Pat Selection BA BC	0.1250 ant 1: h of Secor 0.0625 0.2422	0.2333 A and City 0.1436 0.3706	4 D 2 2 3 5	0.3333 0.2500 B 2 0.3333 0.2000	0.4635 0.3789 C 5 0.4635 0.3241	0.0665 0.0884 E 4 0.0665 0.1201	0.1839 0.0884 A 3 0.5539 0.5539	0.3619 1.0000 Total = 16 0.1201 0.2169
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 City	4 D 2 2 3 5 2	0.2500 B 2 0.3333 0.2000 0.5000	0.4635 0.3789 C 5 0.4635 0.3241 0.6156	0.0665 0.0884 E 4 0.0665 0.1201 0.3007	0.1839 0.0884 A 3 0.5539 0.5539 0.5539	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 City	4 D 2 2 3 5 2	0.2500 B 2 0.3333 0.2000 0.5000	0.4635 0.3789 C 5 0.4635 0.3241 0.6156	0.0665 0.0884 E 4 0.0665 0.1201 0.3007	0.1839 0.0884 A 3 0.5539 0.5539 0.5539	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 City 0.4885 0.1436	3 5 2	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665	0.1839 0.0884 A 3 0.5539 0.5539 0.5539	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection *DA DC DE	0.1250 ant 1: th of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625	0.2333 A dd City 0.1436 0.3706 0.4885 0.1436 City 0.4885 0.1436 0.1436	3 5 2 3	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.5539	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection *DA DC DE Selection	0.1250 ant 1: th of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625 of fourtl	0.2333 A dd City 0.1436 0.3706 0.4885 0.1436 City 0.4885 0.1436 0.1436 h City	3 5 2 3 5	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.5539 0.3826	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071
*CE Path for a Distance Ant 2 Path Selection BA BC *BD BE Selection *DA DC DE Selection AC	0.1250 ant 1: th of Secon 0.0625 0.2422 0.3594 0.0625 of third 0.0625 0.0625 of fourti	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 h City 0.1436	3 5 2 3 5	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.5539 0.3826	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071
*CE Path for a Distance Ant 2 Path Selection BA BC *BD BE Selection *DA DC DE Selection AC	0.1250 ant 1: th of Secon 0.0625 0.2422 0.3594 0.0625 of third 0.0625 0.0625 of fourtl	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 h City 0.1436	3 5 2 3 5 2 3	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071
*CE Path for a Distance Ant 2 Path Selection BA BC *BD BE Selection *DA DC DE Selection AC	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.0625 0.0625 of fourtl 0.0625 0.0625 0.0625	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 0.4274	3 5 2 3 5 2 3	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection *DA DC DE Selection AC *AE Selection	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625 0.0625 of fourtl 0.0625 0.2969 of last C	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 0.4274	3 5 2 3 5 2 3	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.6156 0.2853 0.2853	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection *DA DC DE Selection AC *AE Selection	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 0.1437	3 5 2 3 5 2 3	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410 0.0410 0.1981	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826 0.3826	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071 0.1714 0.8287
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection DC DE Selection AC *AE Selection *EC	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625 0.0625	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 ib City 0.1436 0.4274 ity 0.5394	3 5 2 3 5 2 3 6 6 6	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.2500	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.4635	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410 0.0410 0.1981	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826 0.2390 0.2390	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071 0.1714 0.8287
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection DC DE Selection AC *AE Selection *EC Path for a	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625 0.0625 0.0625 0.2969 of last C 0.4141 ant 2:	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 ib City 0.1436 0.4274 ity 0.5394	3 5 2 3 5 2 3 6 6 6	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.2500 A	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.4635 0.3789 E	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410 0.0410 0.1981 0.2044 C	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826 0.3826 0.2390 0.2390	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071 0.1714 0.8287
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection DE Selection AC *AE Selection AC *AE Distance	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625 0.0625 0.0625 0.0625 0.2969 of last C 0.4141 ant 2:	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 B 0.1436 0.1436 0.1436 0.1436 0.1436	3 5 2 3 5 2 3 6 6 6	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.2500 A	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.4635 0.3789 E	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410 0.0410 0.1981 0.2044 C	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826 0.3826 0.2390 0.2390	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071 0.1714 0.8287
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD BE Selection AC *AE AC *AAE	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625 0.0625 0.2969 of last C 0.4141 ant 2:	0.2333 A d City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 B 0.1436 0.1436 0.1436 0.1436 0.1436	3 5 2 3 5 2 3 6 6 6	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.2500 A	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.4635 0.3789 E	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410 0.0410 0.1981 0.2044 C	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826 0.3826 0.2390 0.2390	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071 0.1714 0.8287
*CE Path for a Distance Ant 2 Pat Selection *BA BC *BD *BB Selection AC *AE Selection *CE Path for a Distance Ant 3 Pat Selection	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625 0.0625 0.0625 0.2969 of last C 0.4141 ant 2:	0.2333 A and City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.1436 0.4274 ity 0.5394 B	3 5 2 3 5 2 3 6 6 6	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.2500 A 2	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.2853 0.2853 0.2853 0.4635 0.3789 E 3	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.0410 0.0410 0.1981 0.2044 C 4	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826 0.2390 0.2390 0.2044 B 5	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071 0.1714 0.8287 1.0000 Total = 16
*CE Path for a Distance Ant 2 Pat Selection BA BC *BD *BB Selection AC *AE Selection AC *AE Selection *CA	0.1250 ant 1: h of Secor 0.0625 0.2422 0.3594 0.0625 of third 0.3594 0.0625 0.0625 0.0625 0.2969 of last C 0.4141 ant 2: h of Secor 0.0625	0.2333 A and City 0.1436 0.3706 0.4885 0.1436 0.1436 0.1436 0.1436 0.1436 0.4274 b and City 0.1436 0.4274	3 5 2 3 5 2 3 6 6 6	0.3333 0.2500 B 2 0.3333 0.2000 0.5000 0.3333 0.5000 0.1667 0.1667 0.3333 0.2500 A 2	0.4635 0.3789 C 5 0.4635 0.3241 0.6156 0.4635 0.2853 0.2853 0.2853 0.3789 E 3 0.2853	0.0665 0.0884 E 4 0.0665 0.1201 0.3007 0.0665 0.3007 0.0410 0.0410 0.1981 0.2044 C 4	0.1839 0.0884 A 3 0.5539 0.5539 0.5539 0.5539 0.3826 0.3826 0.3826 0.2390 0.2390 0.2044 B 5	0.3619 1.0000 Total = 16 0.1201 0.2169 0.5429 0.1201 0.7859 0.1071 0.1071 0.1714 0.8287 1.0000 Total = 16

	Ţ	Ţα	Cost(n)	1/n	(1/n) ^β	$T^{\alpha} (1/n)^{\beta}$	$\sum T^{\alpha} (1/n)^{\beta}$	Probability
								of next cit
Selection	of third Ci	itv						
*EA	0.2969	0.4274	3	0.3333	0.4635	0.1981	0.3056	0.6482
EB	0.0625	0.1436	3	0.3333	0.4635	0.0665	0.3056	0.2178
ED	0.0625	0.1436	6	0.1667	0.2853	0.0410	0.3056	0.1340
Selection			l o	0.1007	0.2033	0.0410	0.3030	0.1340
AB	0.0625	0.1436	3	0.3333	0.4635	0.0665	0.3673	0.1812
*AD	0.3594	0.4885	2	0.5000	0.6156	0.3007	0.3673	0.8187
Selection of	of last City	v						
*DB	0.3594	0.4885	2	0.5000	0.6156	0.3007	0.3007	1.0000
Path for ar			L ²	0.3000 A	D.0130	B	C 0.3007	1.0000
	IL 3. (•	4	3	2	2	-	Total = 16
Distance Ant 4 Path			4	3			<u> </u>	10tai = 10
Selection o		Citv						
*DA	0.1797	0.3007	2	0.5000	0.6156	0.1851	0.4522	0.4094
DB	0.1797	0.3007	2	0.5000	0.6156	0.1851	0.4522	0.4094
DC	0.0625	0.1436	6	0.1667	0.2853	0.0410	0.4522	0.0906
DE	0.0625	0.1436	6	0.1667	0.2853	0.0410	0.4522	0.0906
Selection o							00	
AB	0.0625	0.1436	3	0.3333	0.4635	0.0665	0.2793	0.2383
AC	0.0625	0.1436	6	0.1667	0.2853	0.0410	0.2793	0.1467
*AE	0.2422	0.3706	3	0.3333	0.4635	0.1718	0.2793	0.6150
Selection							0.0.00	******
*EC	0.1250	0.2333	5	0.2000	0.3241	0.0756	0.1422	0.5319
EB	0.0625	0.1436	3	0.3333	0.4635	0.0665	0.1422	0.4680
Selection o	of last City	'						
*CB	0.2969	0.4274	4	0.2500	0.3789	0.1619	0.1619	1.0000
		D .	Α.	E	<u> </u>	В	D	
Path for ar	nt 4:			•	4	5	2	Total = 16
	nt 4:	-	2	3	4			
Distance			2	3				
Distance Ant 5 Path		City	2	3				
Distance Ant 5 Path		City 0.3706	3	0.3333	0.4635	0.1718	0.3677	0.4672
Distance Ant 5 Path Selection c	of Second	, 		-				
Distance Ant 5 Path Selection c *EA	of Second 0.2422	0.3706	3	0.3333	0.4635	0.1718	0.3677	0.4672
Distance Ant 5 Path Selection c *EA EB	of Second 0.2422 0.0625	0.3706 0.1436	3	0.3333	0.4635 0.4635	0.1718 0.0665	0.3677 0.3677	0.4672 0.1810
Distance Ant 5 Path Selection c *EA EB EC ED	0.2422 0.0625 0.1250 0.0625	0.3706 0.1436 0.2333 0.1436	3 3 4	0.3333 0.3333 0.2500	0.4635 0.4635 0.3789	0.1718 0.0665 0.0884	0.3677 0.3677 0.3677	0.4672 0.1810 0.2404
Distance Ant 5 Path Selection c *EA EB EC ED	0.2422 0.0625 0.1250 0.0625	0.3706 0.1436 0.2333 0.1436	3 3 4	0.3333 0.3333 0.2500	0.4635 0.4635 0.3789	0.1718 0.0665 0.0884	0.3677 0.3677 0.3677	0.4672 0.1810 0.2404
Distance Ant 5 Path Selection c *EA EB EC ED Selection c	of Second 0.2422 0.0625 0.1250 0.0625 of third Ci	0.3706 0.1436 0.2333 0.1436 ty 0.1436	3 3 4 6	0.3333 0.3333 0.2500 0.1667	0.4635 0.4635 0.3789 0.2853	0.1718 0.0665 0.0884 0.0410	0.3677 0.3677 0.3677 0.3677	0.4672 0.1810 0.2404 0.1114
Distance Ant 5 Path Selection c *EA EB EC ED Selection c AB AC	of Second 0.2422 0.0625 0.1250 0.0625 of third Ci 0.0625	0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436	3 3 4 6	0.3333 0.3333 0.2500 0.1667	0.4635 0.4635 0.3789 0.2853	0.1718 0.0665 0.0884 0.0410	0.3677 0.3677 0.3677 0.3677	0.4672 0.1810 0.2404 0.1114
EB EC ED Selection of AB AC	of Second 0.2422 0.0625 0.1250 0.0625 of third Ci 0.0625 0.0625 0.1797	0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436 0.3007	3 3 4 6	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667	0.4635 0.4635 0.3789 0.2853 0.4635 0.2853	0.1718 0.0665 0.0884 0.0410 0.0665 0.0410	0.3677 0.3677 0.3677 0.3677 0.2926 0.2926	0.4672 0.1810 0.2404 0.1114 0.2274 0.1400
Distance Ant 5 Path Selection of EB EC ED Selection of AB AC *AD	of Second 0.2422 0.0625 0.1250 0.0625 of third Ci 0.0625 0.0625 0.1797	0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436 0.3007	3 3 4 6	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667	0.4635 0.4635 0.3789 0.2853 0.4635 0.2853	0.1718 0.0665 0.0884 0.0410 0.0665 0.0410	0.3677 0.3677 0.3677 0.3677 0.2926 0.2926	0.4672 0.1810 0.2404 0.1114 0.2274 0.1400
Distance Ant 5 Path Selection c *EA EB EC ED AB AC *AD Selection c	0.2422 0.0625 0.1250 0.0625 f third Ci 0.0625 0.0625 0.1797 of fourth (0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436 0.1436 0.3007	3 3 4 6	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156	0.1718 0.0665 0.0884 0.0410 0.0665 0.0410 0.1851	0.3677 0.3677 0.3677 0.3677 0.2926 0.2926	0.4672 0.1810 0.2404 0.1114 0.2274 0.1400 0.6327
Distance Ant 5 Path Selection c *EA EB EC ED Selection c AB AC *AD Selection c *DB DC	of Second 0.2422 0.0625 0.1250 0.0625 of third Cir 0.0625 0.1797 of fourth 0 0.1797 0.0625 of last City	0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436 0.3007 City 0.3007 0.1436	3 3 4 6 3 6 2	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156	0.1718 0.0665 0.0884 0.0410 0.0665 0.0410 0.1851	0.3677 0.3677 0.3677 0.3677 0.2926 0.2926 0.2926	0.4672 0.1810 0.2404 0.1114 0.2274 0.1400 0.6327
Distance Ant 5 Path Selection c *EA EB EC ED Selection c AB AC *AD Selection c *DB DC	of Second 0.2422 0.0625 0.1250 0.0625 of third Ci 0.0625 0.0625 0.1797 of fourth (0.1797 0.0625	0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436 0.3007 City 0.3007 0.1436	3 3 4 6 3 6 2	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000	0.4635 0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156	0.1718 0.0665 0.0884 0.0410 0.0665 0.0410 0.1851	0.3677 0.3677 0.3677 0.3677 0.2926 0.2926 0.2926	0.4672 0.1810 0.2404 0.1114 0.2274 0.1400 0.6327
Distance Ant 5 Path Selection of *EA EB EC ED AC *AB AC *AD Selection of *DB DC Selection of *BC	of Second 0.2422 0.0625 0.1250 0.0625 of third Ci 0.0625 0.1797 of fourth 0 0.1797 0.0625 of last City 0.2969	0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436 0.3007 City 0.3007	3 3 4 6 2	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.5000	0.4635 0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156	0.1718 0.0665 0.0884 0.0410 0.0665 0.0410 0.1851 0.1851	0.3677 0.3677 0.3677 0.3677 0.2926 0.2926 0.2926 0.2261	0.4672 0.1810 0.2404 0.1114 0.2274 0.1400 0.6327 0.8188 0.1812
Distance Ant 5 Path Selection of EB EC ED Selection of AB AC *AD Selection of *DB DC Selection of	of Second 0.2422 0.0625 0.1250 0.0625 of third Ci 0.0625 0.1797 of fourth 0 0.1797 0.0625 of last City 0.2969	0.3706 0.1436 0.2333 0.1436 ty 0.1436 0.1436 0.3007 City 0.3007 0.1436	3 3 4 6 2 2 2 5	0.3333 0.3333 0.2500 0.1667 0.3333 0.1667 0.5000 0.5000 0.1667	0.4635 0.3789 0.2853 0.4635 0.2853 0.6156 0.6156 0.2853	0.1718 0.0665 0.0884 0.0410 0.0665 0.0410 0.1851 0.1851 0.0410	0.3677 0.3677 0.3677 0.3677 0.2926 0.2926 0.2926 0.2261 0.2261	0.4672 0.1810 0.2404 0.1114 0.2274 0.1400 0.6327 0.8188 0.1812

Table 8: Iteration-5.

Conclusion

It is shown in the iteration number 5 that all the ants converge to the best path which gives minimum distance. The pheromone distribution for iteration and the next city selection based on maximum probability is determined in the iteration. It is evident from the analysis that the rich pheromone edge is converges the best path for the travelling salesmen problems.

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