**TRAVELLING SALESMAN OPTIMIZATION PROLEM USING ACO**

A Project Report

Submitted in the partial fulfillment of the requirements for the award of the degree of

# Bachelor of Technology in

Department of Computer Science and Engineering

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**Declaration**

The Project Report entitled “**TRAVELLING SALESMAN OPTIMIZATION PROLEM USING ACO**” is a record of bonafide work of V.Abhiram (2010030180), K.Sidharth Rao (2010030443),A .Raghavendra Goud (2010030394), R .Vivek Vardhan Reddy (2010030142) submitted in partial fulfillment for the award of B. Tech in the Department of Computer Science and Engineering to the K L University, Hyderabad. The results embodied in this report have not been copied from any other Departments/ University/ Institute.

**Certificate**

This is to certify that the Project Report entitled “TRAVELLING SALESMAN OPTIMIZATION PROLEM USING ACO” is being submitted by V.Abhiram (2010030180), K.Sidharth Rao (2010030443),A .Raghavendra Goud (2010030394), R .Vivek Vardhan Reddy (2010030142) submitted in partial fulfillment for the award of B. Tech in CSE to the K L University, Hyderabad is a record of bonafide work carried out under our guidance and supervision. The results embodied in this report have not been copied from any other departments/ University/Institute.

## Signature of the Supervisor

## Signature of the HOD Signature of the External Examiner

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**ABSTRACT**

Vehicle traffic congestion leads to air pollution, driver frustration, and costs billions of dollars annually in fuel consumption. Finding a proper solution to vehicle congestion is a considerable challenge due to the dynamic and unpredictable nature of the network topology of vehicular environments, especially in urban areas.

We tried to come up with a solution for this problem by using Ant colony optimization (ACO), which has been widely used for different combinatorial optimization problems. The traveling salesman problem (TSP) is one of the most important combinatorial problems. We present a bio-inspired algorithm, food search behavior of ants, which is a promising way of solving the Travel Salesman Problem.

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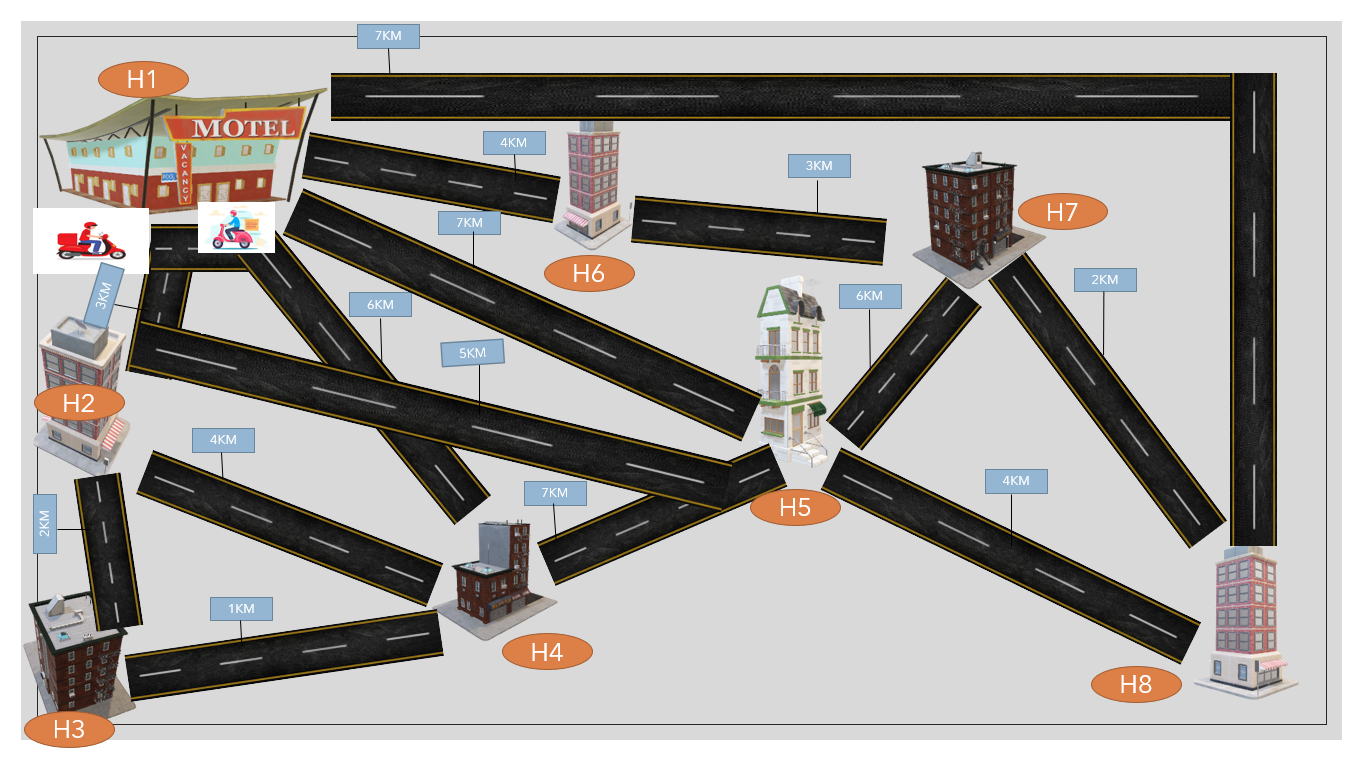
# **1.Introduction**

One of the most fundamental goals of machine learning is to provide learned approximations to combinatorial optimization problems of intractable complexities. Image segmentation, pose estimation, sequence alignment, parsing, machine translation, protein design, etc. could be defined as large-scale combinatorial problems, in which variables are assigned discrete values, based on a cost term that involves the observations and perhaps elements of the training data. Classical NP hard combinatorial problems pose a unique set of challenges. First, obtaining a training sample often requires solving the problem itself, which is feasible only at relatively small scales. Second, unlike perceptual data, these problems are often defined on unordered or specially structured inputs. Third, the feasible solutions are subject to a complex set of constraints. These challenges call for dedicated research and the design of differentiable architectures that can:

(i) well represent the invariances in the input, and

(ii) enforce the constraints on the output.

In addition to the scientific challenge of approximating these abstract problems with Machine Learning (ML), solving them has a practical value. The classical combinatorial optimization problems have numerous real-world applications, many of which are in management: resource allocation, optimal queuing, task planning, etc. The Multiple Traveling Salesmen Problem (mTSP), which is the focus of this work, is a generalization of the well-known Traveling Salesman Problem (TSP). Given a set of cities, m ≥ 1 salesmen, one depot where salesmen are initially located and to which they return, and a pairwise distance matrix, the objective of the mTSP is to determine a route for each salesman, such that the total length of the routes is minimized, and such that each city is visited exactly once by any of the salesmen. In comparison to the TSP, the mTSP has been the focus of relatively little research. However, as a natural generalization, it captures many more real-world problems, like Logistics Delivery, Food Delivery etc. So, in order to solve this complex problem, we are using ACO (Ant Colony Optimization) algorithm.

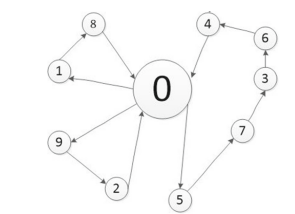
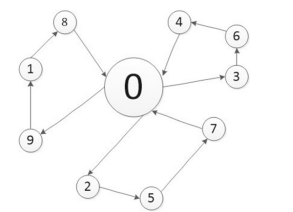
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**2.RELATED WORK**

A Multi-travelling salesman problem (MTSP) is characterized by more than one salesman and as a consequence, MTSP typically has a higher level of complexity compared to TSP.MTSP can be converted into TSP, and Gorenstein (1970) propose a basic strategy to achieve this, based on m salesmen, andm−1 virtual city. These are used to define a gap between different travelling salesmen, whilst the distance between the virtual cities is considered infinite. Yuan et al. (2013) discuss a new crossover operator called two-part chromosome crossover for the genetic algorithm in order to obtain nearoptimal solutions of MTSP. However, this method is affected by the growth of the chromosome length and the overall cost of the solution. Kalia Perumal et al. (2015) present the Modified Two-Part Chromosome Crossover to address MTSP by employing a genetic algorithm for nearby optimal solutions. However, this method allocates a different number of the cities for each salesman, and therefore, it cannot successfully address MTSP with workload balance. Osaba et al. Hossein Abadi et al. (2014) propose the Real-World Dial-a-Ride problem, which is modelled as a MTSP. In particular, they propose

GELS-GA, a new hybrid algorithm, which achieves optimal values even in highly complex scenarios. Finally, Alves and Lopes (2015) consider the workload balance of MTSP and develop GA to reduce both the overall distance and the difference between the distances travelled by each salesman.

**3.PROBLEM DEFINITION AND FORMULATION**

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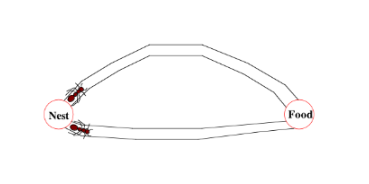
**Fig 1(a). mTSP Fig 1(b). mTSP with balance workload**

Typically, MTSP only aims to obtain the least total cost of distance or time. Fig. 1 depicts a scenario defined by 3 salesmen and 9 cities, where node 0 is the starting and ending point. As shown in Fig. 1a, there are two salesmen traversing two cities, respectively, whereas all the other ones are traversed by the third salesman. It is clear that the salesmen’s workloads are unbalanced. As discussed above, the main objective of MTSP is to minimize the overall distance travelled by all salesmen, which may cause an unbalanced workload problem. Figure 1b shows an ideal solution for MTSP with workload balance. In order to achieve a balanced allocation of workload, there are typically two different strategies. The first aims to balance the number of cities assigned to each salesman, whereas the second focuses on optimizing the balance of the distances travelled by each salesman.

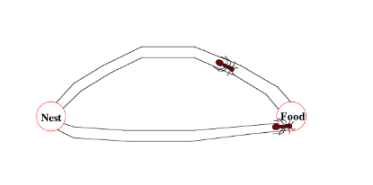
**4.ANT COLONY OPTIMIZATION**

Optimization problems are very important in the field of both scientific and industrial. Some real-life examples of these optimization problems are time table scheduling, nursing time distribution scheduling, train scheduling, capacity planning, traveling salesman problems, vehicle routing problems, Group-shop scheduling problem, portfolio optimization, etc. Many optimizations’ algorithms are developed for this reason. Ant colony optimization is one of them. Ant colony optimization is a probabilistic technique for finding optimal paths. In computer science and researches, the ant colony optimization algorithm is used for solving different computational problems. Ant colony optimization (ACO) was first introduced by Marco Dorigo in the 90s in his Ph.D. thesis. This algorithm is introduced based on the foraging behavior of an ant for seeking a path between their colony and source food. Initially, it was used to solve the well-known traveling salesman problem. Later, it is used for solving different hard optimization problems. Ants are social insects. They live in colonies. The behavior of the ants is controlled by the goal of searching for food. While searching, ants roaming around their colonies. An ant repeatedly hops from one place to another to find the food. While moving, it deposits an organic compound called pheromone on the ground. Ants communicate with each other via pheromone trails. When an ant finds some amount of food it carries as much as it can carry. When returning it deposits pheromone on the paths based on the quantity and quality of the food. Ant can smell pheromone. So, other ants can smell that and follow that path. The higher the pheromone level has a higher probability of choosing that path and the more ants follow the path, the amount of pheromone will also increase on that path.

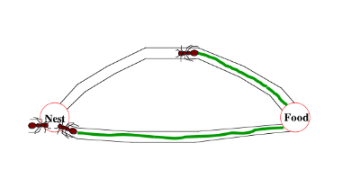
Let’s see an example of this. Let consider there are two paths to reach the food from the colony. At first, there is no pheromone on the ground. So, the probability of choosing these two paths is equal that means 50%. Let consider two ants choose two different paths to reach the food as the probability of choosing these paths is fifty-fifty.



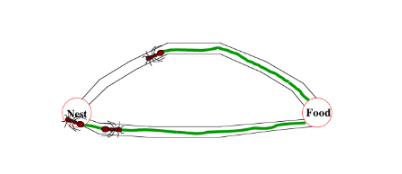
The distances of these two paths are different. Ant following the shorter path will reach the food earlier than the other.



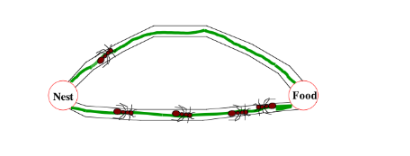
After finding food, it carries some food with itself and returns to the colony. When it tracking the returning path, it deposits pheromone on the ground. The ant following the shorter path will reach the colony earlier.



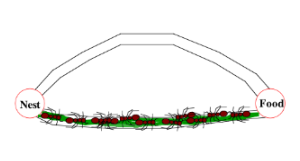
When the third ant wants to go out for searching food it will follow the path having shorter distance based on the pheromone level on the ground. As a shorter path has more pheromones than the longer, the third ant will follow the path having more pheromones.



By the time the ant following the longer path returned to the colony, more ants already have followed the path with more pheromones level. Then when another ant tries to reach the destination(food) from the colony it will find that each path has the same pheromone level. So, it randomly chooses one. Let consider it choose the above one(in the picture located below)



Repeating this process again and again, after some time, the shorter path has a more pheromone level than others and has a higher probability to follow the path, and all ants next time will follow the shorter path.



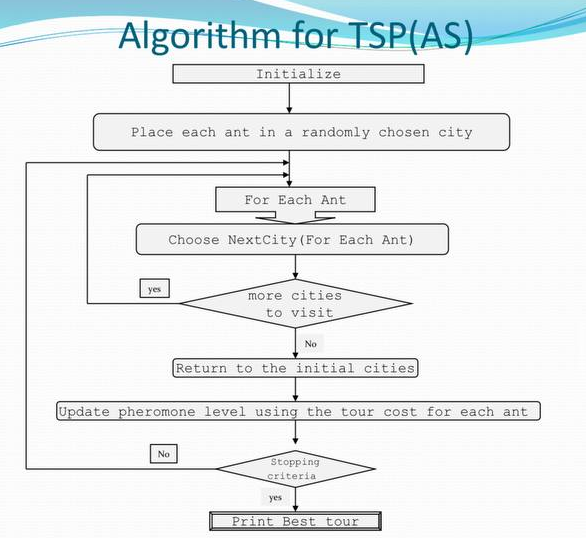
For solving different problems with ACO, there are three different proposed version of Ant-System:

**Ant Density**& **Ant Quantity:**Pheromone is updated in each movement of an ant from one location to another.

**Ant Cycle:**Pheromone is updated after all ants completed their tour.

**5. Working of Ant Colony Optimisation**

* First, divide the cities into clusters, then assign each ant to a random city.
* If there are more cities to travel, move the ants to next cities.
* After successful traversal of all cities, make ants to return to their initial position.
* Now, each ants in the colony constructs a solution based on previously deposited pheromone trails.
* Next ants will lay pheromone trails on the components of their chosen solution, depending on the solution’s quality.
* An ant will often follow the strongest pheromone trail when constructing a solution.
* However, for the ant to consider solutions other than the current best, a small amount of randomness is required in its decision process.
* In addition to this, a heuristic value is also computed and considered helping to guide the search process towards the best solutions.
* In the example of the multiple traveling salesman problem this heuristic will typically be the length of the edge between the destinations being considered - the shorter the edge, the more likely an ant will pick it.



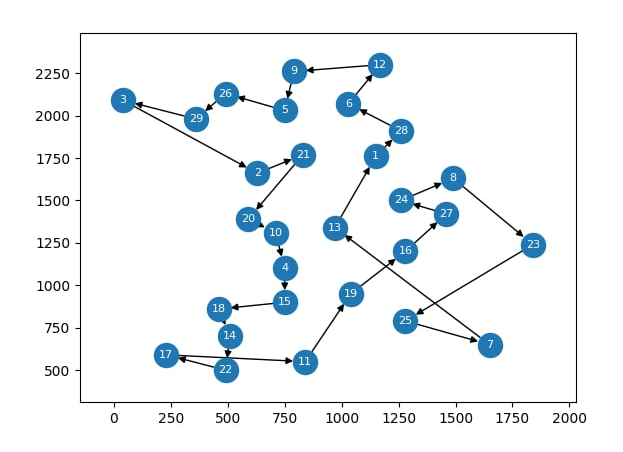
**6.Implementation**

NAME: bays29  
TYPE: TSP  
COMMENT: 29 cities in Bavaria, street distances (Groetschel,Juenger,Reinelt)  
DIMENSION: 29  
EDGE\_WEIGHT\_TYPE: EXPLICIT  
EDGE\_WEIGHT\_FORMAT: FULL\_MATRIX   
DISPLAY\_DATA\_TYPE: TWOD\_DISPLAY  
EDGE\_WEIGHT\_SECTION  
 0 107 241 190 124 80 316 76 152 157 283 133 113 297 228 129 348 276 188 150 65 341 184 67 221 169 108 45 167  
 107 0 148 137 88 127 336 183 134 95 254 180 101 234 175 176 265 199 182 67 42 278 271 146 251 105 191 139 79  
 241 148 0 374 171 259 509 317 217 232 491 312 280 391 412 349 422 356 355 204 182 435 417 292 424 116 337 273 77  
 190 137 374 0 202 234 222 192 248 42 117 287 79 107 38 121 152 86 68 70 137 151 239 135 137 242 165 228 205  
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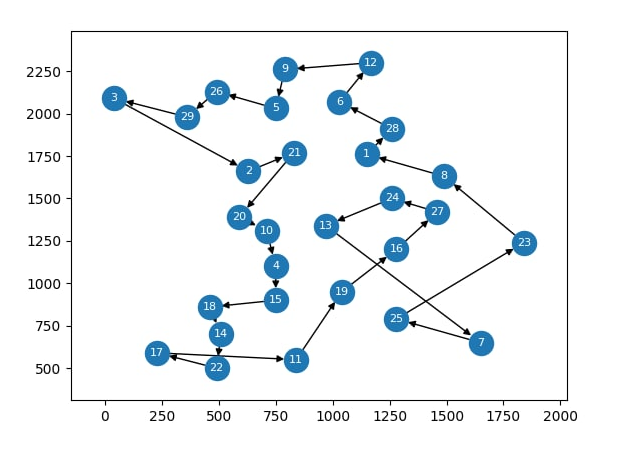
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 76 183 317 192 202 141 233 0 213 188 272 193 131 302 233 98 344 289 177 216 141 346 108 57 190 245 43 81 243  
 152 134 217 248 46 72 438 213 0 206 365 89 209 368 286 278 360 333 284 201 111 412 321 221 353 72 266 132 111  
 157 95 232 42 160 167 254 188 206 0 159 220 57 149 80 132 193 127 100 28 95 193 241 131 169 200 161 189 163  
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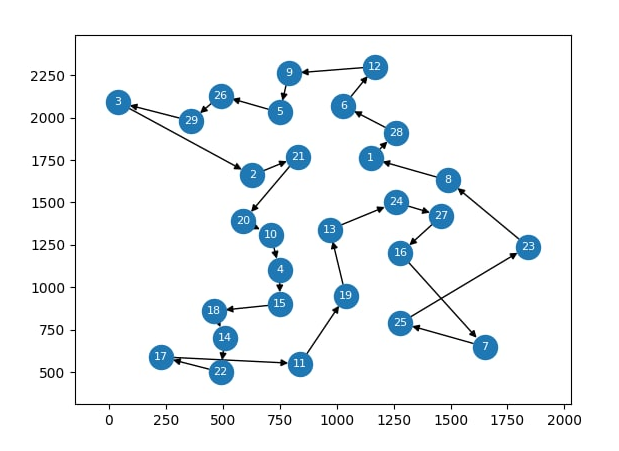
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 108 191 337 165 220 188 190 43 266 161 216 241 104 246 177 55 299 233 121 189 149 290 80 41 147 265 0 124 263  
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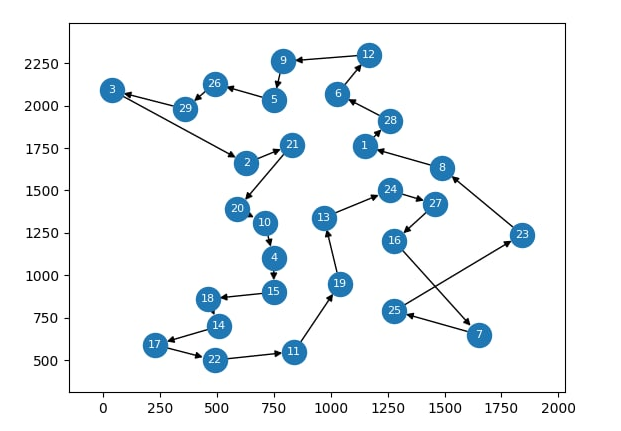
**Figure.1 Ant 1**



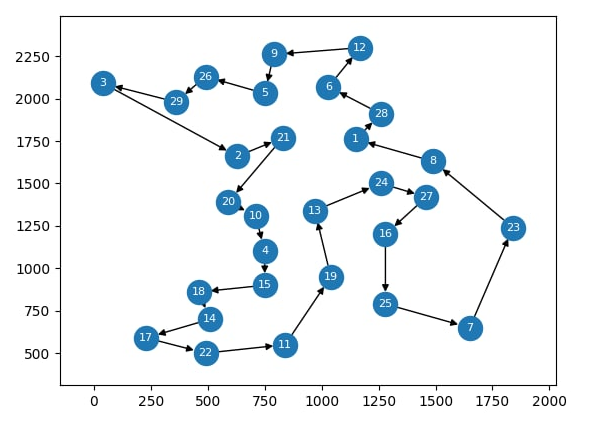
**Figure.2 Ant 2**



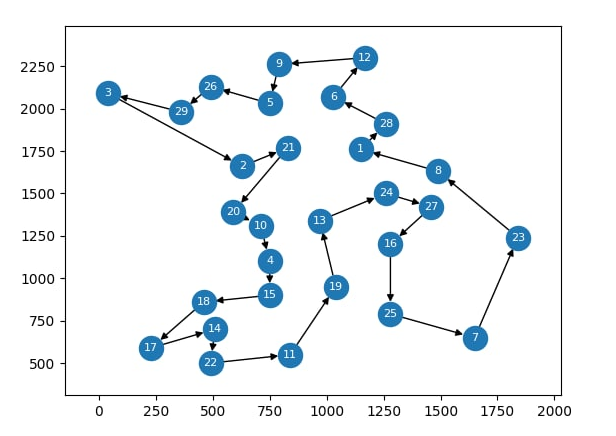
**Figure.3 Ant 3**



**Figure.4 Ant 4**

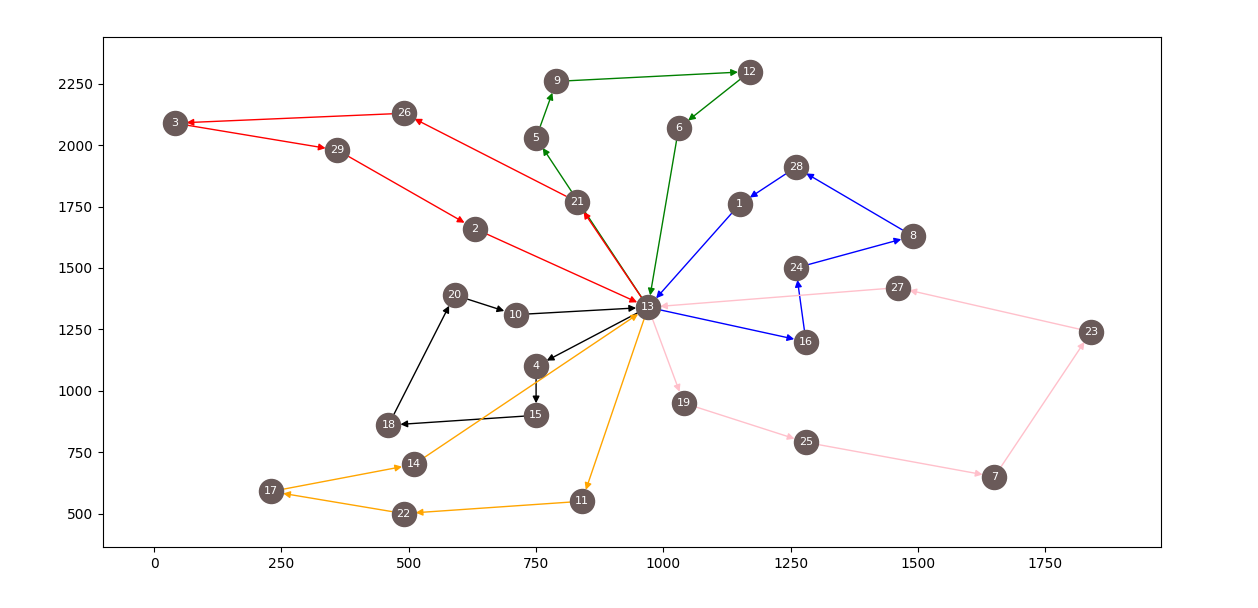


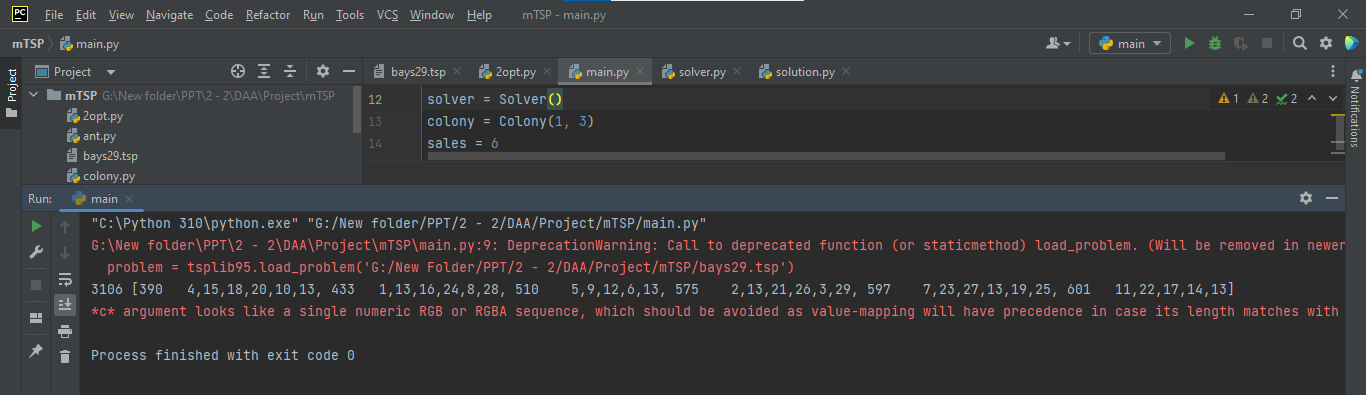
**Figure.5 Ant 5**

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**Figure.6 Ant 6**

**7.Results Discussion**





**8.Conclusion and Future Work**

In this project, we have presented a method for solving the multiple traveling salesman problem based on the ant colony optimization. The improved ACO has used the relationship between MTSP and 1-MST, and the simplified pheromone diffusion. The new pheromone update rules helped a lot to achieve a better solution. The experiment results have shown that the new method has quick convergence speed and can be well applied to find best solutions. In future, we decided to combine multi-objective TSP with parallel processing Parallel processing can improve algorithm speed and reduce algorithm execution time. This method may be greatly improving the speed of finding best solutions.

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