Distribution Optimization Using Ant Colony Optimization (ACO) Method Case Research: PT. Coca Cola Official Distributor of Surabaya Area

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ABSTRACT
PT.Coca-Cola Amatil Indonesia is a manufacturing company that produces beverages such as soft drinks, tea, milk, juice, isotonic and mineral water, located in Pandaan. This company has a distribution area that is spread almost all over Indonesia. In the Surabaya area, the company has 30 kiosks/salesmen as partners. The distribution of products in the Surabaya area is done through Take Order (TO) sales. The final product is distributed to consumers through third parties. The purpose of this research is to determine the distribution route with the shortest distance. The distribution problem experienced by this company is better known as the Traveling salesman problem (TSP). TSP is a combinatorial problem where when the problems faced are increasingly complex, the time needed is also getting longer. Several methods for solving TSP have been proposed. One of the best is the metaheuristic method, one of which is Ant Colony Optimization (ACO). In this research, the ACO method is used to solve the TSP problems encountered. The routes generated from the ACO method are 41.3 km which is 9.03% shorter than the actual route.

Keywords: Distribution problem, traveling salesman problem, ant colony optimization

Introduction
The traveling salesman problem (TSP) aims to find the shortest travel route with several destination cities with certain lines where each city is only allowed visited once and the trip ends with returning to the original city (Lukman et al., 2011). TSP is categorized as an NP-hard problem with a high number of possible solutions (Halim & Ismail, 2019) which means that the minimum expected time to obtain optimal solution is exponential (Brezina & Čičková, 2011). Therefore, a metaheuristic approach is proposed to produce the best solution.

Metaheuristic methods have been widely used in previous researches. For some problems, this method can even provide optimal results with a comparatively shorter calculation time (Rahmawati & Santosa, 2017). Some of the problems that can be solved using this method include the problem of machine scheduling (Kundakci & Kulak (2016) using the hybrid genetic algorithm method in the job shop scheduling problem, Utama et al. (2019) which uses cross entropy- genetic algorithm in flow shop scheduling problem to get minimal total tardiness, and also Ying and Lin (2020) who use simulated annealing for job shop scheduling without waiting time), project scheduling (Rahmawati & Santosa (2016) that uses cross entropy-genetic Algorithm for solving Resource-Constrained Project Scheduling Problem, Kadri and Boctor (2018) using genetic algorithm to solve the resource-constrained project scheduling problem with transfer times and also Lin et al. (2020) which used genetic programming hyper-heuristic approach to the multi-skill resource constrained project scheduling problem), as well as distribution problems (Erdianto et al. (2019) who used genetic algorithms and nearest neighbors to find distribution routes, Santosa et al. (2016) that...
used a hybrid cross entropy-genetic algorithm to solve multi-product inventory ship routing with a heterogeneous fleet model, Zang and Xiong (2018) that used ant colony optimization to find the best routes, and also Khadijah and Hasanah (2019) that used tabu search and differential evolution to find distribution routes and many more.

In this research, the ant colony optimization (ACO) method which is part of Metaheuristic Methods is used to solve the distribution problems that occur. ACO was chosen because ACO was proven could produce the best route for distribution problems (Fahmi et al., 2020).

Research Method

The method used to solve the TSP problem in this research is the Ant Colony Optimization (ACO) method. Table 1 below is the destination location data. There are 34 demand nodes in the Surabaya area in November 2019. The first node in the table, CCOD Surabaya, is the origin node which is the location of the distribution center in Surabaya.

Table 1. Demand in November 2019

| No | Kios                                      | Address                      |
|----|-------------------------------------------|------------------------------|
| 1  | CCOD SURABAYA                             | Rungkut Industri I no 27    |
| 2  | Kios Nada                                 | Wonorejo Timur no13         |
| 3  | Kop Sejahtera Bersama                     | Embong Trengguli no 5-7     |
| 4  | Toko Buku Immanuel                        | Pregolan no 27              |
| 5  | Depot Kanya Food                          | Wonorejo Selatan gg 6 no 17 |
| 6  | Toko Primagama                            | Wonorejo Selatan no 57      |
| 7  | Toko Mitra Abadi                          | Rungkut Madya no 245k       |
| 8  | Kolam Pancing Bumi Gacar                  | Wonorejo Selatan no 1       |
| 9  | Apotek Pradana                            | Perum. Rungkut Asri Timur no 24 |
| 10 | Toko Sams Bakery                          | Rungkut Madya no 157        |
| 11 | Toko Barokah Makur                        | Medokan Sawah no 52         |
| 12 | Apotek K-24 Medokan                       | Medokan Sawah no 9a         |
| 13 | Warung Salam                              | Wonorejo Timur no 1         |
| 14 | Toko Mandiri                              | Wonorejo no 1               |
| 15 | Salon Emelda                              | Nirwana Eksekutive bb 386a |
| 16 | Warung Kopi Cak Agus                      | Wonorejo Selatan no 142     |
| 17 | Toko Ibu Sumaji                           | Wonorejo Selatan 2 no 108   |
| 18 | Yamaha Lestari Jaya Motor                 | Raya Pandugo no 45          |
| 19 | Kedai Ayam Geprek EGP                    | Raya Pandugo no 76          |
| 20 | Yuan Cell                                 | Raya Pandugono no 39        |
| 21 | Toko Banana Speed                         | Rungkut Madya no 117        |
| 22 | Toko Sofi Jaya                            | Medokan Sawah no 119        |
| 23 | Toko Baru                                 | Medokan Kampung gg TK no 1  |
| 24 | Toko Putra Bangsa                         | Putra Bangsa no 1           |
| 25 | Toko Madinah                              | Taman Rivera Regency no 8   |
| 26 | Rujak Ibu Nono                            | Medayu Selatan 2 no 16      |

*To be continued...*
The ACO algorithm used in this research are (Hlaing & Khine, 2010):

**Procedure** ACO algorithm for TSP

**Set parameters**, initialize pheromone trails

**Loop**
- Each ant is positioned on a starting node
  **Loop**
    - Construct Solutions
    - Apply Local Search
    - Local_Pheromone_Update
  **Until** all ants have built a complete solution
    - Global_Pheromone_Update
  **Until** End_condition

**End** ACO algorithm for TSPs

**Result and Discussion**

Table 2 below is a distribution route generated by the ACO algorithm. From this table, it is known that the first destination of the route is the Kopi Satu shop. While the last stall on the route is the Sams and Bakery shop following the sequence generated by the ACO algorithm.

| No | Sequence | Kios                  | Address                        |
|----|----------|-----------------------|--------------------------------|
| 1  | 1        | CCOD SURABAYA         | Rungkut Industri I no 27       |
| 2  | 7        | Toko Annisa           | Rungkut Kidul YKP RK V Blok E  |
| 3  | 30       | Toko Banana Speed     | Rungkut Madya no 117           |
| 4  | 34       | Kolam Renang          | Rungkut Madya no 181           |
| 5  | 35       | Toko Sams Bakery      | Rungkut Madya no 157           |
| 6  | 3        | Toko Sofi Jaya        | Medokan Sawah no 119           |
| 7  | 4        | Toko Barokah Makur    | Medokan Sawah no 52            |
| 8  | 2        | Warung Kopi Satu      | Medokan Asri 5 no 18           |
| 9  | 13       | Warung Mas Bro        | Medokan Sawah no 116           |
| 10 | 14       | Rujak Ibu Nono        | Medayu Selatan 2 no 16         |
| 11 | 15       | Apotek K-24 Medokan   | Medokan Sawah no 9a            |
| 12 | 8        | Toko Madinah          | Taman Rivera Regency no 8      |
| No | Sequence | Kios                  | Address                           |
|----|----------|-----------------------|-----------------------------------|
| 13 | 16       | Waltel Ruzky          | Medokan Ayu gg 1C no 18           |
| 14 | 17       | Toko Baru             | Medokan Kampung gg TK no 1        |
| 15 | 5        | Toko Putra Bangsa     | Putra Bangsa no 1                 |
| 16 | 6        | Depot Kanya Food      | Wonorejo Selatan gg 6 no 17       |
| 17 | 18       | Toko Ibu Sumaji       | Wonorejo Selatan 2 no 108         |
| 18 | 19       | Toko Primagama        | Wonorejo Selatan no 57            |
| 19 | 20       | Salon Emelda          | Nirwana Eksekutive bb 386a        |
| 20 | 32       | Toko Cindy Jaya       | Raya Medokan Semampir ni 18       |
| 21 | 27       | Toko Buku Immanuel    | Pregolan no 27                    |
| 22 | 22       | Kop Sejahtera Bersama | Embong Trengguli no 5-7           |
| 23 | 11       | Kios Nada             | Wonorejo Timur no 13              |
| 24 | 26       | Warung Salam          | Wonorejo Timur no 1               |
| 25 | 12       | Toko Mandiri          | Wonorejo no 1                     |
| 26 | 25       | Kolam Pancing Bumi Gacar | Wonorejo Selatan no 1         |
| 27 | 28       | Warung Kopi Cak Agus  | Wonorejo Selatan no 142           |
| 28 | 24       | Kedai Ayam Geprek EGP | Raya Pandugo no 76                |
| 29 | 23       | Yuan Cell             | Raya Pandugono no 39              |
| 30 | 29       | Yamaha Lestari Jaya Motor | Raya Pandugo no 45               |
| 31 | 9        | Fotocopy Mitra Abadi  | Medokan Sawah no 2                |
| 32 | 31       | Apotek Pradana        | Perum. Rungkut Asri Timur no 24   |
| 33 | 33       | Warung Kopi Wolu      | Medokan Asri Timur no 10          |
| 34 | 10       | Toko Mitra Abadi      | Rungkut Madya no 245k             |
| 35 | 21       | Surya Fotocopy and Print | Rungkut Madya no 31             |

The total distribution distance generated by following the sequence obtained from the ACO algorithm is 41.3 km. The more iterations are generated, the more stable the results are obtained. From the results of running with the ACO algorithm (Figure 1), the results began to stabilize with a distance of 41.3 km on the 85th iteration.

![Figure 1. Iteration using ACO algorithm](image-url)
Conclusion
The results obtained from this research are the Ant Colony Optimization algorithm produced a total delivery distance of 41.3 km whereas if using the actual route, the total delivery distance is 45.4 km. The Ant Colony Optimization algorithm method is proven to be able to save a distance of 4.1 km with a saving percentage of 9.03%.

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