# Determining the Optimal Route for Newspaper Distribution by Using the Sweep Algorithm Method (Case Study: PT Aksara Solopos)

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## Abstract

The Vehicle Routing Problem (VRP) is a problem related to the distribution of products using the optimal and involving more than one vehicle by taking into account several obstacles in serving a number of agents according to the request of each related agent. The Capacitated Vehicle Routing Problem (CVRP) is one of the variations of VRP, namely by adding constraint in the form of vehicle capacity used in product distribution. This paper applies the formation of a CVRP model to the problem of the distribution route of the Solopos daily mail and its solution using the Sweep Algorithm method which aims to optimize the distribution route. The Sweep Algorithm is an algorithm consisting of two stages, the first stage is clustering agents, then the second stage is the formation of routes for each cluster with the Nearest Neighbor method. Based on the calculations carried out in solving CVRP problems using the Sweep algorithm, the results obtained that the total vehicle mileage is 216,5 km with a time windows of 6 hours 5 minutes.

## Keywords

Capacitated Vehicle Routing Problem (CVRP), Sweep Algorithm, Clustering, Nearest Neighbor, Distribution Route.

## 1. Introduction

The problems faced by the newspaper industry can be classified into 4 activity cycles from a supply chain point of view, namely the customer order cycle, replenishment cycle, manufacturing cycle and procurement cycle (Putri, 2018). This has led to a decrease in the circulation of newspapers faced by Indonesia and various countries.The solution to the problem to reduce the decline in newspaper circulation is that an optimal daily newspaper stock is needed to meet customer needs every day (Febriandini et al, 2017). So that with some of these problems it is important for newspaper companies to make an effective and efficient distribution schedule. The business process of the Newspaper Industry is described as follows:

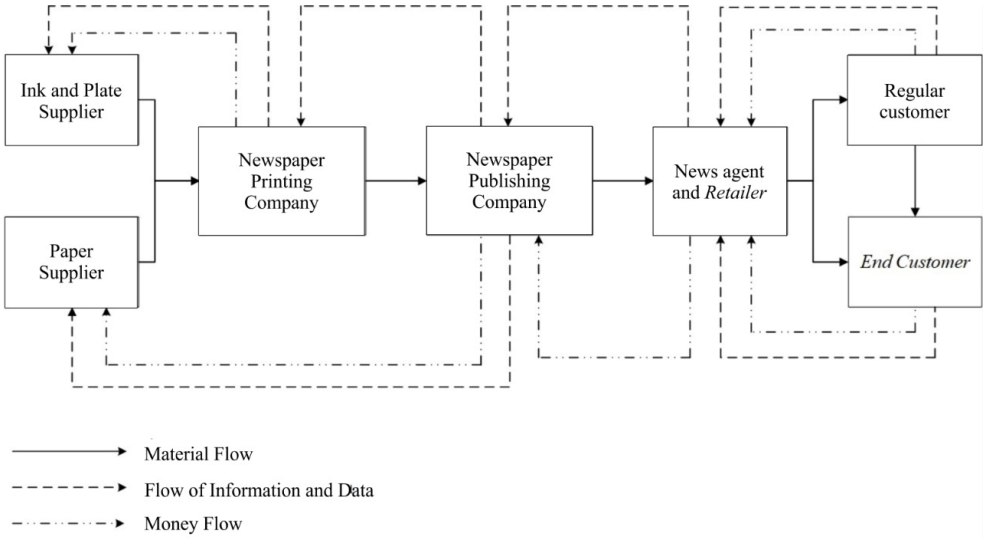


**Figure 1.** Business Processes of Newspaper Industry

Based on the figure 1, in the distribution of the Solopos daily newspaper, there are still some obstacles, such as the large number of agents with a wide area coverage, the delivery is not on time, and there is no fixed route in the distribution of the Solopos daily newspaper. PT Aksara Solopos is still distributing newspapers based on the grouping of agent areas without considering the route and capacity to be used, and does not consider the capacity of each fleet used. This problem is formulated into the Capacited Vehicle Routing Problem (CVRP) or commonly known as the problem in determining the route of distribution to several agents with the starting point and end point of distribution being at the same point. A company definitely needs a good distribution system in the distribution of its production (Saraswati et al, 2017). The existence of a good distribution system in a company will increase the quantity of sales stably (Cahyaningsih et al, 2015). So, from this a company needs to implement a good and efficient distribution system, especially for companies engaged in newspaper printing.

The production process at PT Aksara Solopos starts at 22.00 WIB until 02.30 WIB, where before that hour the process of compiling and searching for news must be carried out. Then, the product delivery process was continued at 03.00 WIB until 08.00 WIB (Saraswati et al, 2017). In the process of distributing the Solopos daily newspaper, it was carried out simultaneously to a number of agents spread across various regions. Through previous research, it was found that in the distribution of the Solopos daily newspaper, there were still several obstacles, such as the large number of agents with wide area coverage, delivery that was not on time, and there was no fixed route in the distribution of the Solopos daily newspaper. PT Aksara Solopos is still distributing newspapers based on the grouping of agents' areas without considering the route and capacity to be used, and not considering the capacity of each fleet used. This problem is formulated into the Capacited Vehicle Routing Problem (CVRP) or commonly known as the problem in determining the route of distribution to several agents with the starting point and end point of distribution being at the same point.

This study discusses solving problems using the Capacited Vehicle Routing Problem (CVRP) using the nearest neighbor method to determine the agent cluster in the distribution route, then sorting the agents based on the distribution route of the Solopos daily newspaper using the Sweep algorithm method. Thus, this study aims to determine an alternative solution in the form of determining the best and most optimal route for the distribution of the Solopos daily newspaper at PT Aksara Solopos.

## 2. Literature Review

Distribution is a process of distributing products from producers to consumers, where consumers are made a top priority for a company to optimize customer satisfaction (Kalriska, 2019). The ability to manage distribution networks is an important advantage for an industry (Pujawan and Mahendrawati, 2017).

Effective and efficient distribution and transportation are important so that products can be delivered to consumers on time and products are still in good condition (Kalriska, 2019). In the distribution system, it definitely requires a route to determine the distance that must be traveled and the costs that must be incurred by the company (Ruben & Imran, 2020). Thus, if the company chooses the optimal route, then the distribution system has minimal distance and the elements involved with distance will be minimal, such as transportation costs, travel time, and energy expended (Maisyaroh, 2017).

The distribution of daily newspapers has a unique distribution system, because the distribution of newspapers has a time window, so that the news listed in the newspaper is always up to date (Saraswati et al, 2017). Therefore, with a good and efficient distribution system at PT Aksara Solopos, it can increase sales of Solopos daily newspaper products. In the implementation of the distribution process, supply chain management is also needed starting from the production process, delivery, distribution, and finally the marketing of the product to the hands of consumers (Saraswati et al, 2017). The newspaper industry has the characteristics of a limited cycle, this requires the newspaper industry to be able to achieve high efficiency so that productivity can increase (Riskadayanti & Hisjam, 2019). Determination of distribution agents in several newspaper companies, most of which have the same agency area (Jodinesa et al, 2019). Determination of optimal vehicle routes can be used to distribute goods to agents originating from a depot with the aim of minimizing the total cost and travel time of a company (Cahyaningsih et al, 2015).

Many heuristic/metaheuristic methods have been developed to solve CVRP problems, for example the Tabu Search Algorithm (Barbazoglu & Ozgur, 1999). Imran and Okdinawati (2012) have developed the Variable Neighbor Search method, Tarantilis et al (2002) have developed the Threshold Accepting Algorithm, Gomez et al (2013) have conducted research related to the bee algorithm, while the Ant Colony Algorithm has also been developed by Yu et al ( 2009).

Several previous studies used as a reference for current research are Saraswati (2017) with the completion of the Capacited Vehicle Routing Problem with the Sweep algorithm, Ruben and Imran, 2020 with the completion of distribution routes using the Sweep and Local Search algorithms, Cahyaningsih (, 2015) with the completion of Capacited The Vehicle Routing Problem (CVRP) uses the Sweep algorithm. In the three studies, it was found that the three researched the Capacited Vehicle Routing Problem, with the results of the optimal distribution route using the Sweep algorithm method. Thus, companies need to develop a model to overcome routing problems by considering environmental aspects to minimize mileage which will minimize fuel and emissions produced and minimize demand differences (Ferreira & Steiner, 2021).

## 3. Data and Methodology

The research method stage carried out in this study was in the form of data collection stage, and continued with data processing, method application stage, and the last stage was the sweep algorithm implementation. The following is the flow of the research methodology carried out.

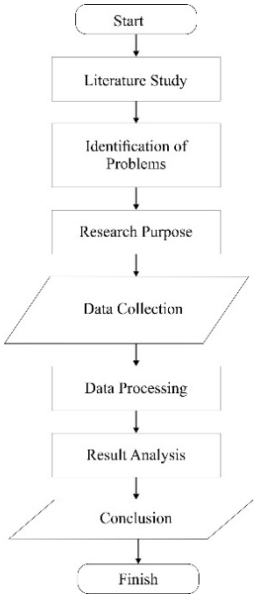


**Figure 2.** Research Methodology Flowchart

Data collection

The data collection method used is observation using previous journal data aka secondary data conducted by Saraswati (2017). The data used in this study are the number of fleets, the capacity of the fleet for delivery, the number of Solopos newsagents and the location of the agents, as well as the service time at each agent. The data is given the assumption that every order from an agent can be fulfilled by the company, the number of requests for each agent experiences a growth (trend) so that it increases by 10% and returns decreases by 5%, the fleet used has a capacity of 3000 copies, and the delivery time for each agent can be carried out at any time between 03.00 and 08.00. This study only focuses on the distribution of newsagents in the Kartasura-Klaten area.

Data processing

Data processing uses the help of the google maps application to find out the required travel time and the locations between agents. The location data between agents is obtained by searching for the locations of agents using google maps and then comparing them between agent 1 and the others, so that the distance between agents that will be visited by the newspaper distribution vehicle is obtained. Travel time data is obtained by calculating the time required for the distribution vehicle from the depot as the starting point (A0) to agent 1 (A1), then agent 1 to agent 2 (A2) and so on until agent 12 (A12) using google maps.

Application of the method

The sweep algorithm is applied in two phases, namely:

1. The clustering phase, the steps taken are:
    a. Determine the position of each agent and the location of the depot as a starting point for distribution using google maps
    b. Determine the distance of each agent from the initial depot using google maps.
    c. Forming a grouping (clustering) starting from the agent who has the closest to the furthest distance by considering the capacity of the vehicle.
    d. Ensure all agents involved have been grouped in this cluster.
    e. Grouping is stopped if there is one cluster that will exceed the maximum vehicle capacity.
    f. If this happens, a new cluster is created as in the previous step.
2. The distribution route formation phase, the completion process in this phase using the Nearest Neighbor algorithm so that the route of each cluster is obtained. The following are the steps for establishing a distribution route.
    a. Determine one point as the starting point of the journey, namely from the company depot.
    b. Determine the agent that will be visited by the vehicle.
    c. Specifies the order of the temporary distribution routes.
    d. Selects the next point the vehicle will visit.
    e. Adds the selected point to the next route sequence.
    f. If all points have been passed, then the route is closed by adding an initiation point or starting point of the journey at the end of the route.

The CVRP problem in the distribution of the Solopos newspaper can be defined as a graph G = (V,E). The set V consists of a combination of the agent set A and the depot, V = {0,1,2,…,13}. Then the set C in the form of agents 1 to 12, C = {1,2, ... 12}, and depots are represented by 0 and 13. The road network used by the fleet is expressed as a set of directed edges E, which is the link between agents, E = {( i,j) | i,j V,i j}. So that all routes start and end at the depot. Furthermore, the set of K vehicles is a homogeneous collection of vehicles with a capacity of q. Each agent i for each i C has a demand at so that the length of the route is limited by the capacity of the vehicle. Each edge (i,j) E has distance cij, travel time tij, and also that cii = cjj = 0.

## 4. Results and Discussion

The data used in this study is hypothetical data that was carried out by forecasting from a literature study of the distribution data of the Solopos daily newspaper in November 2021 in the Colomadu, Kartasura, and Klaten area. The following figure 3 is a data processing flowchart used in the study.

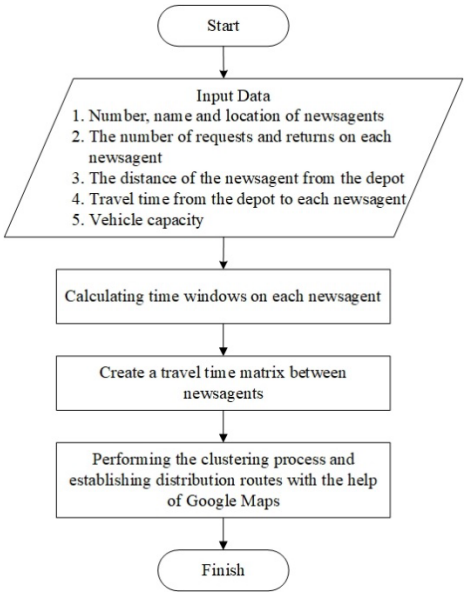


**Figure 3.** Data Processing Flowchart

The implementation of the distribution process for the Solopos daily newspaper covering the Colomadu, Kartasura, and Klaten area uses 1 fleet with a carrying capacity of 3000 copies. This fleet is used as a means of transportation for the distribution of the Solopos daily newspaper to 12 agents who have collaborated with PT Aksara Solopos. In addition, the number of requests or demands on each agent has a different level of demand. For the 12 agents who have collaborated (table 1), it is known that there is an increase in demand of around 10% from the previous months with a range of 193 to 1095 copies in November 2021. This results in a different number of returns and time windows. The daily distribution of Solopos is carried out every day starting at 03.00 in the morning and ending at 08.00 in the morning with a long service time for 50 copies of newspapers for 1 minute.

**Table 1.** The Newspaper Agents Data

| Newspaper Agent | Address | Distance from Depot | Demand | Return | Time Windows |
|---|---|---|---|---|---|
| A0 | Jl. Adi Sucipto No. 190 | 0 km | 0 | 0 | 0 |
| A1 | Jl. Adi Sumarmo | 6,3 km | 208 | 105 | 4,16 |
| A2 | Kios Pasar Malangjiwan | 4,4 km | 275 | 190 | 5,50 |
| A3 | Kios Pasar Kartasura | 9,4 km | 193 | 157 | 3,85 |
| A4 | Warung Nasgor | 8,8 km | 462 | 361 | 9,24 |

| | | | | | |
|---|---|---|---|---|---|
| | Sedahromo Kartasura | | | | |
| A5 | Pasar Kranggan Wirogunan Kartasura | 9,7 km | 297 | 200 | 5,94 |
| A6 | Kios Mayungan Trunuh Klaten | 38,2 km | 913 | 423 | 18,26 |
| A7 | Jalan Raya Delanggu | 20,3 km | 616 | 162 | 12,32 |
| A8 | Karangwuni Ceper Klaten | 28,3 km | 770 | 496 | 15,40 |
| A9 | Kios Pasar Srago Klaten | 35,1 km | 594 | 391 | 11,88 |
| A10 | Depan RSI Klaten | 35,0 km | 224 | 62 | 4,49 |
| A11 | Pasar Gentongan Klaten | 32,0 km | 1095 | 261 | 21,89 |
| A12 | Terminal Klaten | 35,8 km | 446 | 333 | 8,91 |

The map of the location of the depot and the agent is shown in Figure 4 and the travel time matrix for each agent from the location is shown in Table 2.

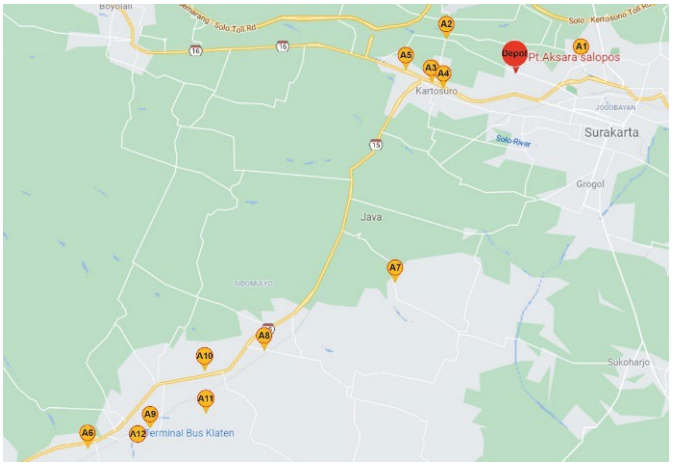


**Figure 4.** Depot and Agent Location Map

The travel time is obtained through google maps by entering the agent's address data that has been obtained from the company.

**Table 2.** Travel Time Matrix between Agents

| Depot | 0 | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | - | 11 | 15 | 18 | 16 | 20 | 64 | 36 | 46 | 57 | 55 | 52 | 59 |
| **A1** | 11 | - | 7 | 13 | 11 | 16 | 62 | 30 | 43 | 54 | 45 | 48 | 55 |
| **A2** | 15 | 7 | - | 8 | 9 | 10 | 56 | 59 | 35 | 49 | 39 | 43 | 49 |
| **A3** | 18 | 13 | 8 | - | 6 | 4 | 49 | 21 | 30 | 26 | 32 | 37 | 44 |
| **A4** | 16 | 11 | 9 | 6 | - | 5 | 51 | 22 | 31 | 44 | 34 | 37 | 45 |
| **A5** | 20 | 16 | 10 | 4 | 5 | - | 51 | 22 | 31 | 43 | 34 | 38 | 44 |
| **A6** | 64 | 62 | 56 | 49 | 51 | 51 | - | 35 | 25 | 16 | 19 | 22 | 10 |
| **A7** | 36 | 30 | 59 | 21 | 22 | 22 | 35 | - | 17 | 29 | 16 | 19 | 26 |
| **A8** | 46 | 43 | 35 | 30 | 31 | 31 | 25 | 17 | - | 16 | 7 | 11 | 18 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A9** | 57 | 54 | 49 | 26 | 44 | 43 | 16 | 29 | 16 | - | 14 | 11 | 2 |
| **A10** | 55 | 45 | 39 | 32 | 34 | 34 | 19 | 16 | 7 | 14 | - | 6 | 13 |
| **A11** | 52 | 48 | 43 | 37 | 37 | 38 | 22 | 19 | 11 | 11 | 6 | - | 11 |
| **A12** | 59 | 55 | 49 | 44 | 45 | 44 | 10 | 26 | 18 | 2 | 13 | 11 | - |

After calculating the travel time matrix between regional agents, then a clustering process is carried out which is determined based on the transport capacity of each fleet and three clusters are produced, namely cluster I which contains agents A2, A5, A3, A4, A6; cluster II containing agents A10, A9, A12, A11; and cluster III containing agents A8, A7, A1. Furthermore, the stage of forming the route of each cluster with the help of google maps is carried out as shown in Figure 5.

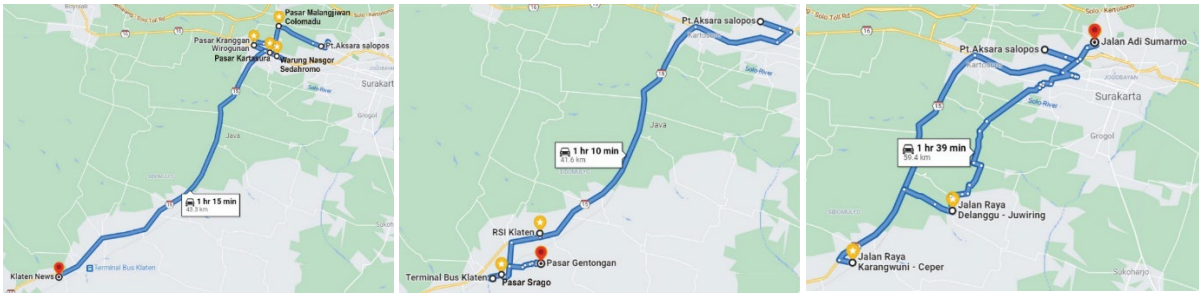


**Figure 5.** Distribution Route Map

Cluster determination is done by calculating the distance from the depot to each agent with a counterclockwise rotation, so that the three distribution routes of the Solopos daily newspaper are shown in table 3 below.

**Table 3.** Distribution Route

| **Route** | | **Total Demand** |
|---|---|---|
| **Route 1** | Depot-A2-A5-A3-A4-A6-Depot | 2140 |
| **Route 2** | Depot-A10-A9-A12-A11-Depot | 2358 |
| **Route 3** | Depot-A8-A7-A1-Depot | 1594 |

Based on the solution using the Sweep algorithm, the route with the total travel time and distance is shown in table 4 below.

**Table 4.** Distribution Route with the Total Travel Time and Distance

| | **Route 1** | **Route 2** | **Route 3** |
|---|---|---|---|
| | Depot-A2-A5-A3-A4-A6-Depot | Depot-A10-A9-A12-A11-Depot | Depot-A8-A7-A1-Depot |
| **Fleet Total Distance Travel (km)** | 78,9 | 73,8 | 63,3 |
| **Total Time Travel (Minute)** | 134 | 122 | 109 |

## 5. Conclusions

Based on the completion of the Capacited Vehicle Routing Problem (CVRP) with the Sweep Algorithm for Determining Optimal Routes for Newspaper Distribution at PT Aksara Solopos, three routes were obtained based on the grouping that had been done with a total travel time of the three routes for 6 hours 5 minutes in accordance

with the time Windows policy implemented by the company. . The first route is from the Depot – A2 – A5 – A3 – A4 – A6 – Depot; the second route is from the Depot – A10 – A9 – A12 – A11 – Depot; while the third route is from the Depot – A8 – A7 – A1 – Depot. In addition, in the distribution of newspapers with three routes, 3 fleets are used, with a standard capacity for each fleet to carry 3000 copies. Thus, each route can only use 1 fleet with a maximum number of 3000 copies of the Solopos daily newspaper.

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