Optimal distribution route to minimize transportation costs in soft drink industry

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Abstract. Minimum mileage and maximization of utilities will help the product distribution process to be optimal. Soft drink companies in the city of Medan have problems in distributing products to consumers who are not on time. This is related to the lack of regulation of product distribution channels by the company. Therefore this research was conducted to optimize product distribution routes in order to minimize distribution costs. With the Traveling Salesman Problem (TSP) method, it will combine several closest distribution routes and improve the route sequence. Then the development of sub-routes that are formed from the travel time and utility of transportation equipment used. Formation of sub-routes is still done manually while increasing the order of sub-routes is done by using the Software Quant System (QS) version 3.0. and produce minimum mileage on each sub-route. In planning product distribution, 6 proposed sub-routes are formed in one week and are served by 1 transportation car with a capacity of 220 crates. The proposed sub-route is 171 km shorter than the available sub-routes, thus shortening the travel time of 302 minutes to transport the product.

1. Introduction
Minimum mileage and maximization of utilities will help the product distribution process to be optimal. Many things affect the distribution of products from warehouses to consumers including traffic density, distance traveled and transportation capacity. Accessibility is a product distribution problem that is related to the services provided by the company. The problem of determining the distribution route is often referred to as the Vehicle Route Problem, which determines the number of routes that must be passed by a number of vehicles departing from one depot to several specified destinations and ending at the same depot [1].

Product distribution is the delivery of products from locations where products are produced to the consumers who will use them. The optimal distribution process will deliver the product to consumers on time. Given that this is important, many studies relating to the determination of distribution routes have also been carried out, including the Traveling Salesman Problem, which divides routes into sub-routes and seeks the shortest route to obtain product distribution optimization. Snacks that regulate distribution routes using the Periodic Vehicle Routing Problem (PVRP) method produce vehicle schedules and routes with a minimum total transportation cost. Determining the distribution route taking into account transportation equipment used by pickup and labor costs must also be considered because it affects the company's operational costs [2-5].
With an optimal distribution route, the company not only minimizes distribution costs but also increases customer satisfaction with timely delivery. Companies must have a potential distribution channel system so that companies can dominate the market to disseminate the company's production to consumers [6-8]. Other research has also been conducted in the selection of sugar suppliers to get suppliers that are timely because of consumer criticism in sending products to consumers and unstable prices. Research has also been conducted in the canned cigarette industry in the city of Medan which has resulted in a lack of vehicles in delivering products to consumers [9-10]. With this assumption needed, studies on optimal distribution routes are taken into account by considering the conveyor capacity in the time of efficient product distribution in the soft drink industry.

This research was conducted at a soft drink company located in the city of Medan located in the Indonesian province of North Sumatra, where the beverage is in demand by consumers. Demand from outlets or consumers has increased on average, especially at certain times such as religious holidays and new years. The novelty of this research is to predict the number of consumer requests by rearranging adjacent routes on request and considering the means of transportation used based on the number of requests per route. Data that must be owned is the number of requests, the location of outlets (consumers), and the capacity of transportation equipment to deliver products. Then do the data processing to get the number of vehicles or transportation equipment needed to deliver the product on time [11-12].

2. Method
The research method used is descriptive method because it presents the problem clearly and provides a solution. In this study, the problems faced by the company were presented in determining the optimal product distribution route by taking into account the transportation costs and the capacity of available transportation equipment so that distance can be obtained with a minimum cost.

2.1. Traveling salesman problem
Traveling Salesman Problem is a problem in making the easiest route from a single route that visits all customers and minimizes total travel time. This is called the salesman problem (Traveling Salesman Problem) which can be seen in figure 1.

![Figure 1. Traveling salesman.](image)

The right solution to the problem of vehicle routes can be found by using patterns of recognition capabilities with human thought. We know that the stop sequence is formed when the route does not cross each other [9].

2.2. Vehicle routing problem
Vehicle Routing Problem is related to the problem of how to approach customers using existing vehicles. Another term for this problem is Vehicle Scheduling Problem, Vehicle Dispatching Problem, or Delivery Problem. The Vehicle Routing Problem is a hard combinatorial optimization problem. This problem is closely related to the problem of Traveling Salesman Problem. The Vehicle Routing Problem
becomes a Traveling Salesman Problem when there is only one conveyance whose capacity is infinite [10], which can be seen in figure 2.

![Figure 2. Form of basic vehicle routing problem solutions.]

2.3. Routing and scheduling methods
The problem of finding a good solution to the problem of route routing and vehicle scheduling is more difficult with additional restrictions on the problem. Time windows, the large number of trucks with different capacities, the maximum total distribution time allowed in the route, the difference in speed in different zones, obstacles / obstacles in travel (rivers, turns, mountains), and rest periods for drivers are some of the necessary considerations in determining the design of routes. Among the many approaches suggested in dealing with complex problems, there are two methods, namely the simple method (The Sweep Method) and the more complex and accurate (The Savings Method).

3. Result and discussion
In this stage the research begins with primary and secondary data collection, namely measuring the time directly in the time of loading and unloading of the transport vehicle, service time at the outlet and collecting and studying company documents. which has been approved by the company in relation to product distribution.

This study focused on one conventional route salesman consisting of the majority of canteens (educational institutions and business institutions), food locations (food courts, restaurants such as fast food and fresh food, restaurants, food stalls), institutions (business entities) and modern outlets (supermarkets / supermarkets, mini markets) where the area is spread, deterministic demand, outlet location data and product demand data.

3.1. Determination of the shortest route
Determination of the shortest route is done through the available distribution routes, namely the distribution route from the Medan Sales Office surrounding all outlets and then returning to the Medan Sales Office.

Calculation of overall distance can be calculated by summing the entire distance from the Medan Sales Office around all outlets and returning to the Medan Sales Office with a total distance of 271.8 km.

3.2. Determination of cycle time (horizon planning)
Product demand data is based on request per week so it can be determined the cycle time or planning horizon is 6 days. Total volume demand during cycle times, namely:

\[
\text{Total volume demand} = \sum \text{total demand outlet}
\]
The total demand volume can be calculated as the sum of the total demand outlets (Biduk Vegetarian-Sutomo 1 + Raksana-Sedap Wangi RM + Wong Solo RM +...+ Spice Garden) which is 1313 crates.

3.3. Total distribution time
While the safety factor ($\phi$) is an allowance of 20%.

\[
Total\ Time = (Time\ to\ set\ up\ utility + Total\ Travel\ Time + Total\ Service\ time\ at\ the\ Outlet
+ Time\ loading\ and\ unloading) \times (1 +\ safety\ factor\ 0\ to\ 1)
\]

Calculation of total time is as follows:

- Time to set up utility = 15 minute
- Total Travel Time = 271.8 km/35 km/ hour = 7.77 hour = 465.96 minute
- Total Service time at the outlet = 83 x 18 minute = 1494 minute.
- Time loading and unloading = (1313 crates/7 crates per minute) + (1313 crates/8 crates per minute) = 351.7 minute
- Total Time = (15+465.96+1494+351.7) x (1+0.2) = 2792 minute

3.4. Minimum number of transport vehicles
The number of transport vehicles needed can be formulated:

\[
Minimum\ vehicle\ number = \frac{Total\ Time}{availability}
\]

The availability of transport vehicles is the amount of time available for transporting cars to operate. The availability of transport vehicles every day other than Friday is 480 minutes while on Fridays is 450 minutes. Then the calculation of the number of minimum transport cars becomes:

The minimum number of transport vehicles = 2792/480 minutes = 5.817 ≈ 6 transport vehicles.

3.5. Available time check
Reduction of mileage will certainly reduce the travel time of transported cars. The feasibility estimation and available time for each route can be seen in table 1 below:

| Sub Route | Day       | Available Time (minute) | Time of proposal distribution (minute) | Estimation Feasibility |
|-----------|-----------|-------------------------|----------------------------------------|------------------------|
|           |           |                         | Without allowance                       | With allowance         |
| I         | Monday    | 480                     | 368.946                                | 442.736                | Feasible               |
| II        | Tuesday   | 480                     | 369.557                                | 443.469                | Feasible               |
| III       | Wednesday | 480                     | 359.355                                | 431.225                | Feasible               |
| IV        | Thursday  | 480                     | 388.089                                | 465.706                | Feasible               |
| V         | Friday    | 450                     | 356.359                                | 427.631                | Feasible               |
| VI        | Saturday  | 480                     | 359.946                                | 431.936                | Feasible               |
|           |           | Total                   | 2850                                   | 2202.25                | 2642.703               |

The table above shows the estimated feasibility on each sub-route. Based on the calculation results, the distribution time of each sub-route is smaller than the available time, so it is called feasible. The planned / proposed sub-route formation consists of 6 sub-routes carried out by one salesman scheduled per week. Distribution starts from the Medan Sales Office then surrounds each outlet and then returns to the Medan Sales Office.
3.6. Number of outlets
Calculation of total time for distribution sub-routes is shown in table 2:

| Sub route | Numbers of outlet | Demand (crates) | Distance (km) | Traveling time (minute) | The number of transport vehicles (crates) | Capacity of transport vehicles |
|-----------|-------------------|-----------------|---------------|-------------------------|------------------------------------------|------------------------------|
| 1         | 1                 | 219             | 25.25         | 368.946                 | 1                                        | 220                          |
| 2         | 1                 | 220             | 25.45         | 369.557                 |                                          |                              |
| 3         | 1                 | 218             | 19.811        | 359.355                 |                                          |                              |
| 4         | 1                 | 220             | 25.76         | 388.089                 |                                          |                              |
| 5         | 1                 | 217             | 28.72         | 356.359                 |                                          |                              |
| 6         | 1                 | 219             | 30.5          | 359.946                 |                                          |                              |
| Total     | 83                | 1313            | 155.49        | 2202.25                 | 1                                        | 220                          |

4. Conclusion
Research conducted using the Traveling Salesman Method and version 3.0 Quant System (QS) software. In comparison, it was obtained using the Quant System version 3.0 obtained by reducing the distance traveled 170,799 per 171 km per week or 42.91% from the initial route 326.29 km per week, and travel time 301,737 ≈ 302 minutes per week. By using transportation with a capacity of 220 crates for each sub-route.

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