



# **Determining the Best Route for Multiple Orders Clients in Food Delivery Services with Simulated Annealing Algorithm**

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## **Abstract**

Food delivery services have been widely implemented by several companies such as Gojek Indonesia, Grab, Shopee Food and many more. Busyness and busy activity motivates someone to order online food delivery to meet their needs. For example, a worker who is tired of working all day orders food online for the dinner menu instead of cooking. Simulated annealing (SA) is an algorithm for performing general optimization. In this study, researchers built a system that determines the best delivery routes to deliver messages between customer meals using a simulated annealing algorithm. From the results of the study it was found that the application of the simulated annealing algorithm in finding the best route for multiple client food delivery in Binjai using data collected from drivers was quite good. Based on the results of trials conducted, Route [0-1-5-2-3-4] with a length of 6.29 km is the best route among others.

**Keywords:** Food Delivery Order, Multiple Client Order Online, Simulated Annealing Algorithm.

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## **1. Introduction**

Online shopping is no stranger to today's society. Busyness and busyness of activity motivates someone to place an online order to meet their needs. For example, a worker who is tired of working all day orders food online for the dinner menu instead of cooking [1]. This has inspired online ojek fleet entrepreneurs to open delivery services. To provide the best service for orders that have increased compared to the number of available fleets, delivery services can be provided to serve more than one customer [2]. The problem that arises from the process of sending a large number of orders is to determine the best route to minimize delivery costs [3]. The best route is chosen so that the travel time and costs used are low.

Simulated annealing (SA) is an algorithm for general optimization. Based on probability and statistical mechanics, this algorithm can be used to find an approach to the global optimum solution to a problem. The problem that requires this algorithmic approach is a combination optimization problem, where the search space for existing solutions is too wide, so it is almost impossible to obtain an exact solution to the problem. [4].

Simulated Annealing (SA) works by analogy with the annealing process. At the beginning of the process, an initial solution is selected, which represents the state of the material before the process begins. The free movement of atoms in matter is represented in the form of modifications to the initial solution/temporary solution [5]. At the beginning of the SA process, when the temperature parameter (T) is set high, the existing temporary solution is allowed to undergo modification freely. This freedom is relatively measured based on the value of a particular function that evaluates how optimal the temporary solution that has been obtained is. If the value of the modified evaluation function improves (in optimization problems where trying to find the minimum means the value is smaller) the modified solution will be used as the next solution. If the value of the modified evaluation function deteriorates, when the annealing temperature is still high [6].

This worse solution may still be acceptable, whereas when the annealing temperature is relatively low, this worse modified solution may not be acceptable. In subsequent stages when the temperature is gradually reduced, the possibility of accepting modification steps that do not improve the value of the evaluation function decreases. So the freedom to modify the solution is increasingly narrowed, until finally it is hoped that a solution that is close to the optimal solution can be obtained [7].

## 2. Research methodology

There are several problem solving methods that will be discussed in this research which will be described as below.

### 2.1. Optimization

Optimization is a means to express, in a mathematical model, the result of solving a problem in the best way [8]. This can be interpreted as running a business to maximize profits and efficiency while minimizing losses, costs or risks. The desire to solve problems in general optimization models can be used in almost all fields of application.

### 2.2. Simulated Annealing Algorithm

Simulated Annealing is an optimization method based on the cooling process used in metallurgy [9]. In general, when a substance goes through a cooling process, it is first heated to the melting point for liquefaction, then cooled slowly by controlling the cooling process until the substance solidifies again. The last properties of this substance are very dependent on the cooling schedule applied, if the cooling temperature is lowered quickly then the resulting substance will be easily damaged due to an imperfect structure, conversely if the cooling temperature is lowered slowly then the resulting structure is well organized and strong.

### 2.3. Multiple Client Orders

*Multiple client orders* are an optimization problem that has more than one ordering objective function, which allows conflicts between these objective functions [10]. The classification of popular techniques in Operations Research that focuses on overcoming several ordering objective function problems is as follows:

- A Priori Preference: decision making is carried out before searching for the ordering objective function. This technique takes an approach with several possibilities for achieving the decision maker's goals. The methods used include goal programming and global criteria.
- A Posteriori Preference: searching for the purpose of the order before making a decision. This technique is used if the decision maker does not have a preference for the problem at hand.
- Progressive Preference: integration between search and decision making. This technique is carried out in 3 stages, namely, looking for non-dominated solutions, modifying preferences based on non-dominated solutions, and modifying preferences again until there is no decision change.

## 3. Application of the Simulated Annealing Algorithm Method

Before applying the simulated annealing algorithm calculation, you must have a dataset that will be used as training data in testing in this study. the calculation is done manually with 6 location points, namely 1 starting location and 5 restaurant locations, the following is the route simulation table:

**Table 1:** Route Simulation

Index	Location name	Address	coordinates
0	Binjai Monument	Jl. Soekarno Hatta No.11, Tanah Tinggi, Kec. Binjai Tim., City of Binjai, North Sumatra 20731	3.610614494389467, 98.49476183699869
1	Hokben Binjai	Jl. Lintas Sumatra No. 14, Weigh Langkat, Kec. Binjai Tim., City of Binjai, North Sumatra 20735	3.6086802710277497, 98.4981863017823
2	Irian Restaurant	Jalan Irian No. 10/12, Binjai Township, Kec. Binjai City, Binjai City, North Sumatra 20711	3.6093195513549134, 98.49125301801816
3	Moro Tresno Grilled Chicken	Jatinegara, Kec. North Binjai, Binjai City, North Sumatra 20351	3.6171222532358, 98.49875872678912
4	Etek Jaya Restaurant	Jl. General Ahmad Yani, Kartini, Kec. Binjai City, Binjai City, North Sumatra 20742	3.60502792800737, 98.48748541942896
5	McDonald's Binjai	Jl. Soekarno Hatta No. 55A, Tanah Tinggi, Kec. Binjai Tim., City of Binjai, North Sumatra 20735	3.6090369982032544, 98.49948122435424

Solution for the scenario that the driver chooses 5 (five) visiting destinations including the initial location of existence, with an iterative process of 10 times. There are several operators used in the simulate annealing algorithm, including:

- Location nodes are stored in a list or L Array
- Generate 2 (two) random numbers 1 to NC, with  $N1 < N2$
- Front row = L(1) to L(N1-1)
- Middle row = L(N1) to L(N2)
- Back row = L(N2+1) to L(NC)
- Generate a random number r

- If  $r < 0.5$ , then

- NewFront = FrontRow
- NewMiddle = Middle row in reverse order from back to front
- NewBack = Backrow

- If  $r > 0.5$  then

- a. Temporary row = [Front to back]
- b. Suppose the temporary row has M elements, generate random numbers r with values between 1 to M
- c. NewFront = Temporary line (1:r)
- d. NewCenter = Center
- e. BackNew = Temporary(r+1:M)

Suppose the assumption of the temporary best route is

Lmin [0-1-2-3-4-5] with energy =  $450 + 2300 + 140 + 2400 + 1900 = 7.19$  KM

Parameter:

NC = 5 (visited points)

MI iteration = 2

MaxIterations = Miterations \* NC = 10

Iteration 1:

Random numbers N1 = 3, N2 = 4  
 Front row = [1, 2]  
 Middle row = [3, 4]  
 Back row = [5]  
 Random number  $r = 0.05$  (less than 0.5), then  
 New front row = [1, 2]  
 New middle row = [4, 3]  
 new back row = [5]  
 Obtained new path: [0-1-2-4-3-5]  
 New path energy = 9.55  
 $9.55 \text{ km} > 7.19 \text{ km}$ , then the new route is rejected

Iteration 2:

Random numbers N1 = 2, N2 = 4  
 Front row = [1]  
 Middle row = [2, 3, 4]  
 Back row = [5]  
 Random number  $r = 0.68$  (more than 0.5), so make a temporary row first  
 Temporary row = [1,5]  
 New front row = [1,5]  
 New middle row = [2, 3, 4]  
 new back row = []  
 New path obtained: [0-1-5-2-3-4]  
 New path energy = 6.29  
 $6.29 \text{ km} < 7.19 \text{ km}$ , then the new line is accepted

Iteration 3:

Random numbers N1 = 1, N2 = 3  
 Front row = []  
 Middle row = [1, 2, 3]  
 Back row = [4, 5]  
 Random number  $r = 0.58$  (more than 0.5), so first create a temporary row  
 Temporary row = [4,5]  
 new Front row = [4]  
 New middle row = [1,2,3]  
 new back row = [5]  
 Obtained new path: [0-4-1-2-3-5]  
 New path energy = 6.34  
 $6.34 \text{ km} < 7.19 \text{ km}$ , then the new line is accepted

Iteration 4:

Random numbers N1 = 1, N2 = 3  
 Front row = []  
 Middle row = [1, 2, 3]  
 Back row = [4, 5]  
 Random number  $r = 0.71$  (more than 0.5), so first create a temporary row  
 Temporary row = [4,5]  
 New front row = [4, 5]  
 New middle row = [1,2,3]  
 New backrow = []  
 Obtained new path: [0-4-5-1-2-3]  
 New path energy = 6.74  
 $6.74 \text{ km} < 7.19 \text{ km}$ , then the new line is accepted

Iteration 5:

Random numbers N1 = 4, N2 = 5  
 Front row = [1, 2, 3]  
 Middle row = [4, 5]  
 Back row = []  
 Random number r = 0.27 (less than 0.5), then  
 New front row = [1,2,3]  
 New middle row = [5, 4]  
 New backrow = []  
 New path obtained: [0-1-2-3-5-4]  
 New path energy = 6.89  
 6.89 km < 7.19 km, then the new line is accepted

The results of the trials carried out resulted in the best route for delivery of multiple client orders by applying the simulated annealing algorithm. The following table shows the best route results for the simulated annealing algorithm:

**Table 2:** Results of Testing the Best Route for the Simulated Annealing Algorithm

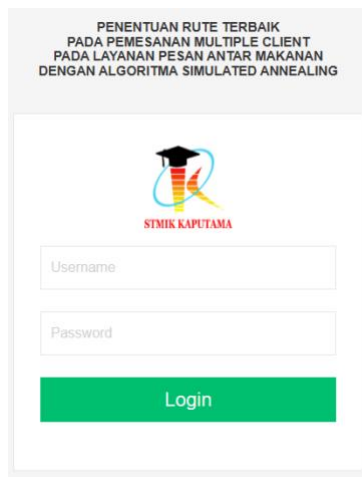
Iteration	N1	N2	Front	Middle	Behind	r	New Path	energy
1	3	4	1, 2	3, 4	5	0.05	0-1-2-4-3-5	9.55 km > 7.19 km Then the route solution is rejected
2	2	4	1	2, 3, 4	5	0.68	0-1-5-2-3-4	6.29 km < 7.19 km Then the route solution is accepted
3	1	3		1, 2, 3	4, 5	0.58	0-4-1-2-3-5	6.34 km < 7.19 km So the route solution is accepted
4	1	3		1, 2, 3	4, 5	0.71	0-4-5-1-2-3	6.74 km < 7.19 km So the solution is accepted, the route is accepted
5	4	5	1, 2, 3	4, 5		0.27	0-1-2-3-5-4	6.89 km < 7.19 km So the route solution is accepted
6	1	2		1, 2	3, 4, 5	0.67	0-3-1-2-4-5	9.6 kms > 7.19 km So the route solution is rejected
7	1	2		1, 2	3, 4, 5	0.4	0-2-1-3-4-5	9.5 kms > 7.19 km So the route solution is rejected
8	1	5		1, 2, 3, 4, 5		0.09	0-5-4-3-2-1	7.44 km > 7.19 km So the route solution is rejected
9	3	5	1, 2	3, 4, 5		0.15	0-1-2-5-4-3	9.05 km > 7.19 km Then the route solution is rejected
10	2	3	1	2, 3	4, 5	0.17	0-1-3-2-4-5	7.20 km > 7.19 km Then the route solution is rejected

From the test results above, it was found that Route [0-1-5-2-3-4] with a length of 6.29 km is the best route among the others.

**3.1. Discussion of Interface (Interface) and Display in the Program**

Testing the system and programs contained in the calculation program for determining the best route for multiple client orders for food delivery services using the simulated annealing algorithm. Next, determine the closest route based on several food ordering points in Binjai City. In the program there is also a login form, dashboard menu, about menu and algorithm menu.

1. Login Page



**Figure 1:** Login Pag

## 2. Dashboard view



Figure 2: Home view

## 3. About page



Figure 3 : About page

## 4. Algorithm Page

The algorithm page is a page that contains how to implement the performance of the simulated annealing algorithm for determining the best route for multiple client orders in food delivery services. The algorithm menu also contains added data and the application of the best route. And the results of the case data display are as shown below:

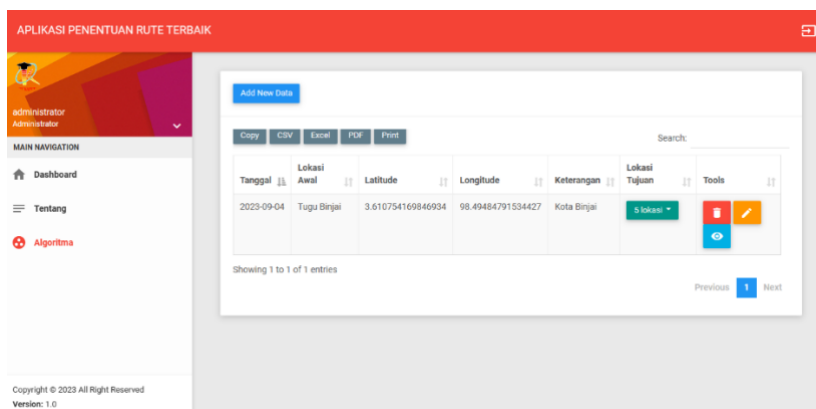


Figure 4 : Algorithm Page

The first step is to make a starting point, namely the point where the driver is located, by clicking the add new data button and a form will appear containing the place name, place address, latitude point and longitude point, as well as several buttons containing edit, delete and create routes. Like the following picture:

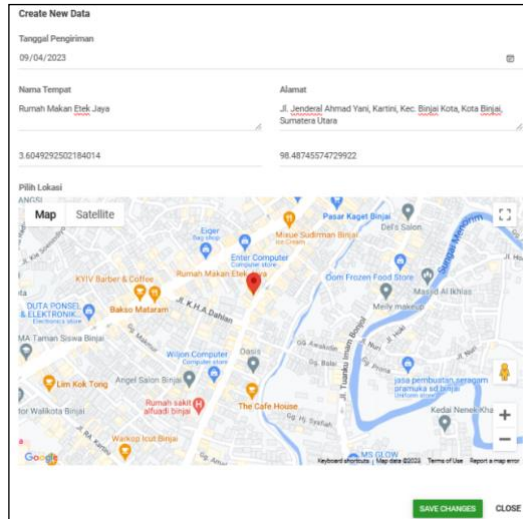


Figure 5 : Form Create New Data

After that, also fill in several destinations that will be determined for the next food order, after that a table will display several destinations that have been added. Like the picture below:

Lokasi Tujuan	Latitude	Longitude	Alamat	Jarak	Tools
Ayam Bakar Moro Tresno	3.6170501806546085	98.49875052946093	Jl. Jatinegara, Kec. Binjai Utara, Kota Binjai.	0.82317569792486	[Tools]
Hokben Binjai	3.6086180134001076	98.49818726556781	Jl. Lintas Sumatra No. 14, Timbang Langkat, Kec. Binjai Tim, Kota Binjai.	0.44015095695356	[Tools]
Pondok Surya	3.612681524734382	98.49210133331302	Jl. Ade Irma Suryani Gang Angrek No. 6, Pekan Binjai, Binjai Kota, Kota Binjai.	0.37258421547343	[Tools]
Rumah Makan Etek Jaya	3.604902481200162	98.48743697183612	Jl. Jenderal Ahmad Yani, Kartini, Kec. Binjai Kota, Kota Binjai.	1.048647188912	[Tools]
Rumah Makan Irian	3.609233698104387	98.49125643747333	Jalan Irian No.10/12, Pekan Binjai, Kec. Binjai Kota, Kota Binjai.	0.43291758483709	[Tools]

Figure 6 : View All Destination Locations

To apply the simulated annealing algorithm to determine the best route, click the eye button to produce the best route. Like the following picture:

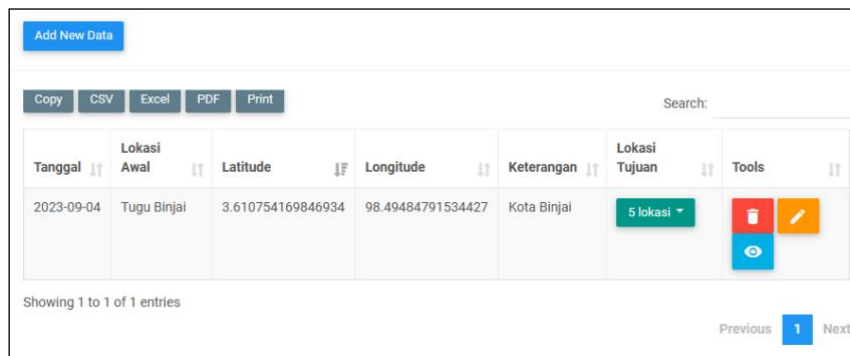


Figure 7 : Best Route View

Then click the create route button to generate the best route. Like the following picture:

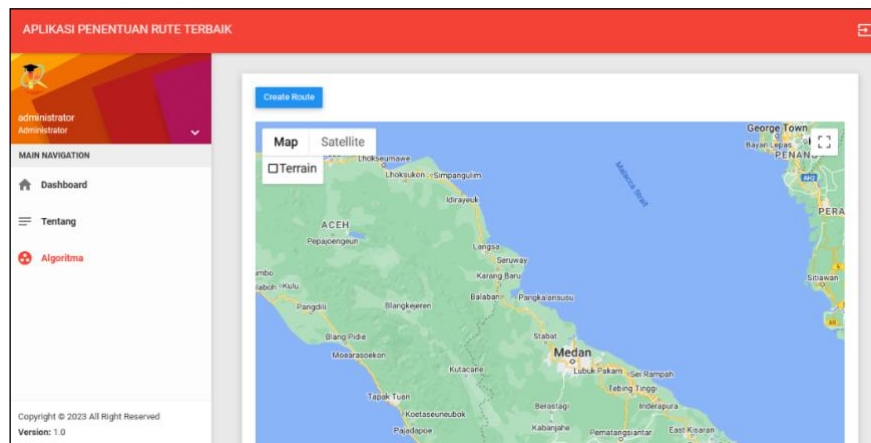


Figure 8 : Create Route

Next, it will produce the best route location based on simulated annealing algorithm calculations. Like the following picture:

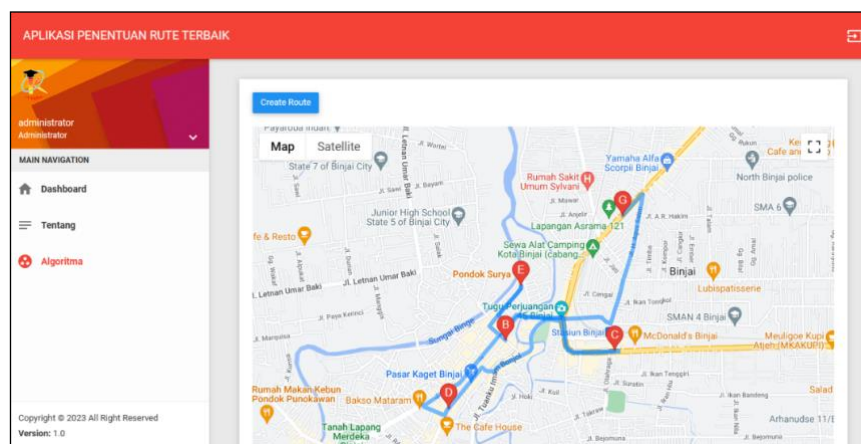


Figure 9 : Best Route Determination

## 4. Conclusion

Based on the results of making the application to determine the best route for multiple client orders for food delivery services using the simulated annealing algorithm, several conclusions are obtained as follows:

1. The best route determination system for multiple client orders in food delivery services with a simulated annealing algorithm makes it easy for drivers to find the best route in delivering multiple client orders.
2. In applying the simulated annealing algorithm in determining the best route it is very effective and efficient as a driver reference in delivering multiple client orders in food delivery services.
3. From the results of trials conducted, it was found that Route [0-1-5-2-3-4] with a length of 6.29 km is the best route among the others.

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