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PRODUCT DISTRIBUTION ROUTE OPTIMIZATION USING THE TRAVELING SALESMAN PROBLEM (TSP) METHOD AT PT. INBISCO NIAGATAMA SEMESTA (MAYORA GROUP) IN MAKASSAR

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ABSTRACT

In industry, the effective use of distribution channels is a key factor in reducing transportation costs. This research aims to optimize the product distribution route of PT Inbisco Niagatama Semesta (Mayora Group) using the Travelling Salesman Problem (TSP) method. Product distribution is an important element in the supply chain, and this research can help improve operational efficiency and reduce company costs. Companies face various challenges such as variations in distribution quantity, capacity constraints, tight delivery times, and fluctuations in demand. By analyzing distribution data, this study aims to find the optimal distribution route that minimizes travel distance and distribution costs. The results of this study show that the shortest route obtained from calculations using the traveling salesman problem branch and bound method of WinQsb software gets the results of the distribution delivery route that has been calculated with a total distance of 88.40 km with a predetermined delivery route and gets a total travel time of 132.6 minutes and fuel consumption at a cost of Rp. 60,112.

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INTRODUCTION

Companies engaged in the industrial sector must be able to streamline the use of distribution channels in saving transportation costs. Determining the optimal distribution route can help companies deal with transportation costs. In the business process, distribution is an important part that cannot be separated, especially in the process of distributing goods/products. [1].

An efficient way of working is a way that does not in the least reduce the results to be achieved such as: the easiest, fastest, cheapest, lightest, and shortest way. [2] Employee work efficiency is influenced by many factors that can be classified into three groups, the competence of the individual concerned, organizational support and management support." [3]

The concept of efficiency measurement according to Sherman and Zhu (2006) in [4] stated that the efficiency of a company consists of four types, namely: Technical efficiency (TE), Scale efficiency (SE), Price efficiency (PE), allocative efficiency (AE). optimization is the process of choosing the best alternative which in this case is the most optimal solution from several existing alternatives with several considerations. [5] Definition of optimalization according to Poerwadarminta (Ali, 2014: 124) in the journal [6] is the result achieved in accordance with the wishes, so optimization is the achievement of results as expected effectively and efficiently ". According to Winardi (Ali, 2014) in the journal [6] Optimization is a measure that leads to the achievement of a goal when viewed from the point of view of effort.

PT Inbisco Niagatama Semesta (Mayora Group) is a national private company established in 1983. PT Inbisco Niagatama Semesta is located at Jalan Kima Raya I No. 1A Blok D1. The company is part of Mayora Group, a distributor that specializes in distributing products from Mayora Group, namely Teh Pucuk Harum, Lee Mineral, kopiko, 7 dates milk and kopikap. Product distribution is an important part of the company's supply chain, and distribution route optimization can have a major impact on efficiency and operational costs. This research is important because it can help PT Inbisco Niagatama Semesta (Mayora Group) in improving product distribution efficiency. By minimizing the distance and time required, the company can reduce costs and improve service to customers.

In the industrial world, distribution efficiency is one of the main keys to optimizing transportation costs.

In the Indonesian dictionary, the definition of distribution is the distribution of delivery of goods to many people or to several places. [7]. Distribution is an activity that is closely related to the activity of moving goods or materials from related companies to the end customer. [8]. According to Juhandri (2018) in the journal [9] The definition of distribution is the movement of goods and services from suppliers to end consumers through distribution channels. Currently, distribution networks are considered an internal part of holistic supply chain activities and have a strategic role as a point of product and information distribution and as a means of creating added value. [10]

In the context of product distribution, PT Inbisco Niagatama Semesta (Mayora Group) faces a number of challenges, such as demand fluctuations, capacity constraints, and limited delivery times. In an effort to overcome these issues, the company relies on L300 vehicles with a capacity of 400-500 cartons of beverage products. However, product delivery is still not optimal because it only focuses on fulfilling demand without taking into account the distance and travel time factors. To solve this problem, this research proposes an approach using the Traveling Salesman Problem (TSP) method with nearest neighbor and branch and bound approaches.

With a focus on distribution route optimization, this research aims to determine the optimal distribution route and minimize distribution costs. Through a better understanding of distribution patterns and the use of the TSP method, it is expected that PT Inbisco Niagatama Semesta (Mayora Group) can improve its operational efficiency and reduce transportation costs.

As such, this research will make an important contribution to the distribution industry, particularly to companies such as PT. Inbisco Niagatama Semesta (Mayora Group), in their efforts to improve efficiency and customer service.

RESEARCH METHODS

The Traveling Salesman Problem is one of the combinatorial problems. Many problems can be represented in the form of TSP. This problem itself uses graph representation to model the problem represented, making it easier to solve. Among the problems that can be represented by TSP are transportation problems, efficiency of mail or goods delivery, design of pipeline installation, PCB (Printed Circuit Board) manufacturing process and others. The problem that arises is how to visit the nodes in the graph from the starting point to every other point with the minimum weight. This weight itself can represent various things, such as cost, distance, fuel, time, and others. [11]

Mathematically, TSP can be formulated in equation (1). While the constraint factors can be shown in equations (2) and (3).

$Z = \min\{\sum_{i=1}^{n}\sum_{j=1}^{n} C_{ij} X_{ij}\}$ (1)

$\sum_{i=1}^{n} xij = 1, \text{for } j = 1,2,3 \ldots, n-1$ (2)

$\sum_{j=1}^{n} xij = 1, \text{for } i = 1,2,3 \ldots, n-1$ (3)

If i and j are the start and destination nodes of a salesman's journey, respectively, then the following conditions can be stated:

1. $x_{ij} = 1$ if there is a salesman's journey from vertex *i* to vertex *j*.
2. $x_{ij} = 0$ if there is no salesman trip from vertex *i* to vertex *j*.
3. C_{ij} denotes the distance from vertex *i* to vertex *j*.

Equations (2) and (3) guarantee that each vertex is only visited once by a salesman. In this study, changes were made to the TSP formulation, namely the addition of a variable that considers the suitability of taste and time in the standard formulation. This is shown in Equation (4)

$Z = \min\{\sum_{i=1}^{n}\sum_{j=1}^{n} C_{ij} X_{ij}\} + suitability$ (4)

The suitability referred to in Equation (4) is the value of the suitability of time and taste. This appetite formulation is obtained by iteratively evaluating the GA results. [12]

A. With *Branch and bound*

Branch and bound (BB) is an algorithm used to determine the optimal solution to optimization problems, especially in discrete and optimization combinatorial. [13]. This method limits the optimal solution that will produce fractional numbers by creating upper and lower branches for each fractional-valued decision variable so that each restriction produces a new branch and forms a search tree (Septinauli, 2019). There are 2 basic concepts in the branch and bound algorithm, as follows:

1. Branching is the process of dividing a problem into sub-problems that usually lead to a solution.
2. Bounding is a process that functions to find or calculate upper bounds (in minimization problems) and lower bounds (in maximization problems) for optimal solutions to sub problems that lead to solutions, then LP-relaxation calculations are performed on the ILP. [14]

The steps in solving the problem using the Branch and Bound method are as follows:

1. Solve the Linear Program problem with the simplex method without integer constraints.
2. Check the optimal solution. If the expected base variable is integer, then the optimal solution has been reached. But if it is not integer, then proceed to step 3.
3. Choose the variable that has the largest fractional value (meaning the largest decimal number) of each variable to branch into sub-problems. Create two new constraints for this variable, with constraint and constraint.
4. Make the solution at the end of step 1 the upper bound and for the lower bound the solution whose decision variable has been rounded off.5. Menyelesaikan model program linier dengan batasan baru yang ditambahkan pada setiap sub-masalah [15]

B. With *Nearest Neighbour*

The nearest neighbor method is the simplest method to solve the Traveling Salesman Problem. Choose a node that represents a city or starting location. Next, select the destination node or city to be visited next, considering only choosing the city that has the closest distance to the previously visited city. Then, after all cities have been visited or all nodes have been connected, then close the travel route by returning to the origin city in general. The steps of this method are as follows:

1. Step 1: Initialization Define N = {1,2,3,4,...,n} as the number of cities or locations to be visited. Define an arbitrary city as the starting point of the trip (i 0), and V is the number of other cities that remain to be visited, and S is the current order of the route. In step 2, S = (i 0), as no other cities have been visited yet.
2. Step 2: choose the next city to visit If i 1 is the last city in the route sequence S. Then, find the next city (j *) that has the minimum distance to i 1 , where j * is a member of V . If there are many optimal choices then choose randomly.
3. Step 3: add to the next sequence of routes Add city j* to the last sequence of temporary routes and remove it from the list of unvisited cities.
4. Step 4: if all the cities to be visited have been included in the route or V=0, then there are no more cities left behind. Next, close the route by adding the initialization city or i 0 at the end of the route. In other words, the route is closed by returning to the origin city. Otherwise, go back to step 2 again.

The Nearest Neighbor method is a method whose principle is to always add the store closest to the last visited store, at the beginning of departing from the warehouse so that it looks for the store closest to the warehouse until returning to the warehouse.

RESULTS AND DISCUSSION

PT Inbisco Niagatama Semesta (Mayora Group) distributes beverage products including LM600, Teh pucuk harum. Kopikap, Kapal Api coffee, Susu 7 kurma, Toracafe cappuccino once a week to 38 stores in Makassar city.

A. Location Data and Total Distribution Demand

Location data and the amount of distribution demand refer to information that identifies the locations where goods or services are required, as well as the amount of demand for those goods or services at each of those locations. This is important in supply chain planning and management to ensure efficient distribution and meet customer needs in various locations.

Tabel 1. Location Data and Total Distribution Demand

Node	Store name	Location	Request
1	PT. Inbiso Niagatama Semesta (Mayora Group)	KIMA Daya	
2	RM. Tumbak Kayu Bangkoa	Jl. Lamaddukelleng Buntu	3
3	Warung Awe	Centre Point Of Indonesia	3
4	Rifat Cell	Jl. Slamet Riyadi	7
5	Toko Berkah	Jl. Supratman	4
6	Kios Rahman	Jl. Ujung Pandang	6
7	Kantor BCA	Jl. Muh Yamin	3
8	Plasa cell	Jl. Gunung Merapi	3
9	Veteran Bangunan	Veteran Selatan	3
10	Toko Koprs Sabhara	Jl. Arif Rate	6
11	Kios HJ. Sahari	Jl. Maipa	2
12	Toko Lia	Gontang	1
13	Toko Rian	Jl. Tanjung Alang	1
14	Toko Toding	Jl. Komplek IDI	5

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15	Toko Radiyah	Jl. Raya Antang	6
16	Toko Sufi	Jl. Raya Baruga	3
17	Toko Sarah	Jl. Amd Manggala	4
18	Toko Aira	Jl. Lasuloro	6
19	WR Cahaya Pangkep	Jl. Raya Borong	100
20	Toko Arief Cell	Jl. Inspeksi PAM	7
21	Toko Arief	Jl. Dr Leimena	7
22	Kios 789	Jl. Basalama	8
23	Kios Annisa	Jl. Sungai Saddang	8
24	Toko Micha Cell	Jl. Onta Lama	7
25	Toko Ikram	Jl. Pelanduk	13
26	Toko Sinar	Toddopuli Raya	28
27	Pallubasa Suzuki	Jl. Boulevard	106
28	Toko Rezky	Jl. Pelita Raya	8
29	Toko Putri	Jl. Cilallang	15
30	Toko Rifky	Jl. Racing Center	34
31	Al Yamin	Griya Ranggong Sakinah	22
32	Toko Comel	Jl. Ujung Bori	6
33	Toko Sakiyah Cell	Masjid Baiturrahman	13
34	Zahra Cell	Jl. Pengayoman	3
35	Toko Kembang Jawa	Jl. Hertasning	3
36	Toko Amanda	Jl. Waduk Tunggu	4
37	Toko Ida	Pampang	
38	Ibu Ira	Jl. Tidung Marilo	8
39	Zhanna	Jl. Raya Pendidikan	5
		Jl. Manunggal 22	11

B. Fuel Cost Data

- L300 fuel requirement per km is 0.1 liter/km
- The fuel used is diesel
- The price of fuel (diesel) per liter is IDR 6,800
- Fuel Cost = 0,1 liter/km x IDR 6800 = IDR 680,00
- Labor Costs Rp. 350.000,00

Data Processing

Determination of New Routes using the Traveling Salesman Problem Nearest Neighbor method

Determination of New Routes using the Traveling Salesman Problem Nearest Neighbor method in WinQsb software can be seen as follows:

03-20-2024	From Node	Connect To	Distance/Cost		From Node	Connect To	Distance/Cost
1	Node1	Node21	7.8	21	Node8	Node23	0.7
2	Node21	Node20	1.2	22	Node23	Node25	0.6
3	Node20	Node15	1.6	23	Node25	Node2	1.2
4	Node15	Node16	1.4	24	Node2	Node3	0.5
5	Node16	Node14	1.8	25	Node3	Node11	0.6
6	Node14	Node32	2.4	26	Node11	Node10	0.8
7	Node32	Node19	1	27	Node10	Node24	1.9
8	Node19	Node26	1.7	28	Node24	Node9	1.7
9	Node26	Node34	1	29	Node9	Node6	4.4
10	Node34	Node27	1.6	30	Node6	Node4	0.6
11	Node27	Node28	1.3	31	Node4	Node5	0.9
12	Node28	Node29	1.3	32	Node5	Node13	6.2
13	Node29	Node38	2.2	33	Node13	Node39	1.5
14	Node38	Node37	1.2	34	Node39	Node12	5.1
15	Node37	Node35	1.6	35	Node12	Node36	13
16	Node35	Node22	3.8	36	Node36	Node31	2.6
17	Node22	Node30	0.6	37	Node31	Node17	1.9
18	Node30	Node33	0.6	38	Node17	Node18	1
19	Node33	Node7	3.2	39	Node18	Node1	11
20	Node7	Node8	1.9				
	Total	Minimal	Traveling	Distance	or Cost	=	95.40
	(Result	from	Nearest	Neighbor	Heuristic)		

Picture 1. Route using WinQsb nearest neighbor method

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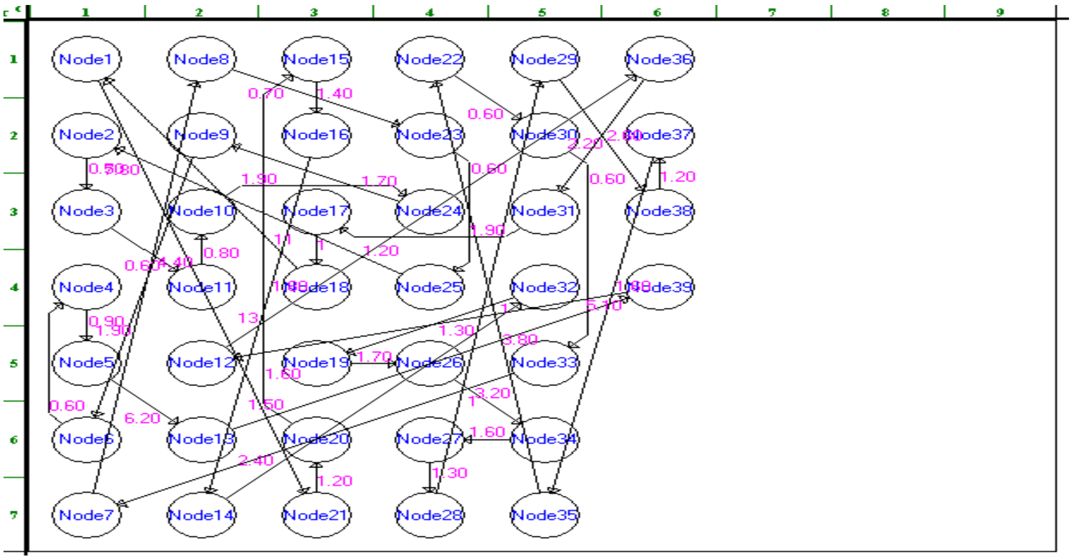
From picture 1, the distribution routes obtained for the Traveling Salesman method using the nearest neighbor are 7.8 + 1.2 + 1.6 + 1.4 + 1.8 + 2.4 + 1 + 1,7 + 1 + 1.6 + 1.3 +1.3 + 2.2 + 1.2 + 1.6 + 3.8 + 0.6 + 0.6 + 3.2 + 1.9 + 0.7 + 0.6 + 1.2 + 0.5 + 0.6 + 0.8 + 1.9 + 1.7 + 4.4 + 0.6 + 0.9 + 6.2 + 1.5 + 5.1 + 13 + 2.6 + 1.9 + 1 + 11 = 95,40 or with a time of 143 minutes and a fuel cost of IDR 64,872.



Picture 2. *Nearest Neighbor Method Distribution Route Graph*

Based on picture 2, the results of determining the route are as follows:
1 – 21 – 20 – 15 – 16 – 14 – 32 – 19 – 26 – 34 – 27 – 28 – 29 – 38 – 37 – 35 – 22 – 30 – 33 – 7 – 8 – 23 – 25 – 2 – 3 – 11 – 10 – 24 – 9 – 6 – 4 – 5 – 13 – 39 – 12 – 36 – 31 – 17 – 18 – 1.

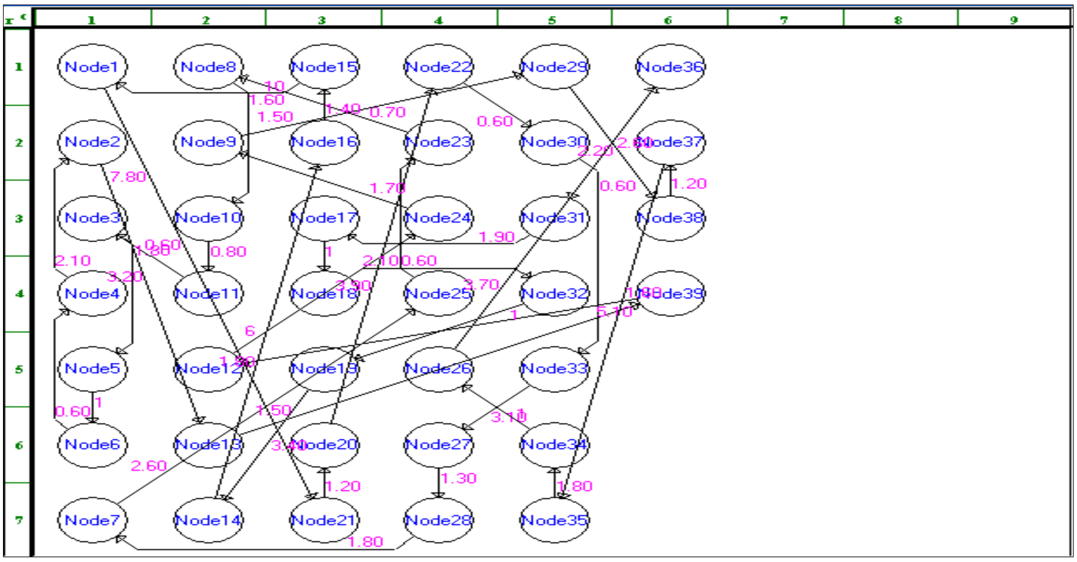
Determination of New Routes using the Traveling Salesman Problem Branch and Bound method

Determination of New Routes using the Traveling Salesman Problem Branch and Bound method in WinQsb software can be seen as follows:

05-19-2024	From Node	Connect To	Distance/Cost		From Node	Connect To	Distance/Cost
1	Node1	Node21	7.8	21	Node39	Node12	5.1
2	Node21	Node20	1.2	22	Node12	Node24	6
3	Node20	Node22	3.9	23	Node24	Node9	1.7
4	Node22	Node30	0.6	24	Node9	Node29	1.5
5	Node30	Node33	0.6	25	Node29	Node38	2.2
6	Node33	Node27	3.1	26	Node38	Node37	1.2
7	Node27	Node28	1.3	27	Node37	Node35	1.6
8	Node28	Node7	1.8	28	Node35	Node34	1.8
9	Node7	Node25	2.6	29	Node34	Node26	1
10	Node25	Node23	0.6	30	Node26	Node36	3.7
11	Node23	Node8	0.7	31	Node36	Node31	2.6
12	Node8	Node10	1.6	32	Node31	Node17	1.9
13	Node10	Node11	0.8	33	Node17	Node18	1
14	Node11	Node3	0.6	34	Node18	Node32	2.1
15	Node3	Node5	1.8	35	Node32	Node19	1
16	Node5	Node6	1	36	Node19	Node14	3.4
17	Node6	Node4	0.6	37	Node14	Node16	1.8
18	Node4	Node2	2.1	38	Node16	Node15	1.4
19	Node2	Node13	3.2	39	Node15	Node1	10
20	Node13	Node39	1.5				
	Total	Minimal	Traveling	Distance	or Cost	=	88.40
	(Result	from	Branch	and	Bound	Method)	

Picture 3. Route using WinQsb branch and bound method

From picture 3, the distribution routes obtained for the Traveling Salesman method using the branch and bound are 7.8 + 1.2 + 1.6 + 3.9 + 0.6 + 0.6 + 3.1 + 1.3 + 1.8 + 2.6 + 0.6 +0.7 + 1.6 + 0.8 + 0.6 + 1.8 + 1 + 0.6 + 2.1 + 3.2 + 1.5 + 5.1 + 6 + 1.7 + 1.5 + 2.2 + 1.2 + 1.6 + 1.8 + 1 + 3.7 + 2.6 + 1.9 + 1 + 2.1 + 1 + 3.4 + 1.8 + 1.4 + 10 = 88,40 or with a time of 132,6 minutes and a fuel cost of IDR Rp. 60.139



Picture 4. *Branch and bound Method Distribution Route Graph*

Based on picture 4, the results of determining the route are as follows:
1 – 21 – 20 – 22 – 30 – 33 – 27 – 28 – 7 – 25 – 23 – 8 – 10 – 11 – 3 – 5 – 6 – 4 – 2 – 13 – 39 – 12 – 24 – 9 – 29 – 38 – 37 – 35 – 34 – 26 – 36 – 31 – 17 – 18 – 32 – 19 – 14 – 16 – 15 – 1.

Comparison of Routes, Distance, Time, and Cost of Transportation Distribution of PT INS

	Route	Mileage	Time	Cost
Initial Route	1 - 21 – 20 – 14 – 16 – 32 – 15 – 33 – 18 – 36 – 19 – 30 – 22 – 17 – 26 – 31 – 23 – 28 – 25 – 37 – 34 – 27 – 29 – 4 – 5 – 7 – 6 – 8 – 35 – 38 – 2 – 10 – 11 – 3 – 9 – 13 – 24 -39 – 12 - 1	159,40	239	108.392
Optimum Route (*Nearest Neighbour*)	1 – 21 – 20 – 15 – 16 – 14 – 32 – 19 – 26 – 34 – 27 – 28 – 29 – 38 – 37 – 35 – 22 – 30 – 33 – 7 – 8 – 23 – 25 – 2 – 3 – 11 – 10 – 24 – 9 – 6 – 4 – 5 – 13 – 39 – 12 – 36 – 31 – 17 – 18 – 1	95,40	143	64.872
Optimum Route (*Branch and bound*)	1 – 21 – 20 – 22 – 30 – 33 – 27 – 28 – 7 – 25 –	88,40	133	60.112

23 – 8 – 10 – 11 – 3 –
5 – 6 – 4 – 2 – 13 – 39
– 12 – 24 – 9 – 29 – 38
– 37 – 35 – 34 – 26 –
36 – 31 – 17 – 18 – 32
– 19 – 14 – 16 – 15 – 1

- -

CONCLUSION

The results of data processing that have been calculated get the results of the calculation of distribution routes and more efficient distribution mileage. The total distance of PT Inbisco Niagatama Semesta's delivery distance is 159.4 km with a delivery travel time of 239 minutes and fuel consumption at a cost of Rp. 108,392 and the results of calculations using the WinQsb software branch and bound method researchers get the results of the distribution delivery route that has been calculated with a total mileage of 88.40 km with a predetermined delivery route and get a total travel time of 132.6 minutes and fuel consumption at a cost of Rp. 60,112.

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