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THE TIME OPTIMIZATION OF BOTTLENECK TRANSPORT PROBLEMS IN THE ISLAMIC HIGHER EDUCATION ENROLMENT USING MALLIA-DAS ALGORITHM

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Abstract

Bottleneck transportation problems have significant importance not only in military operations and disaster situations but also in higher education field, wherein in those cases time is a very important factor when supplying to the destination. In linear programming problems, there are the minimum and maximum problems, allocating products from source to destination which is known as the Transportation Problems. This bottleneck problem in the Islamic Higher Education Enrolment is formulated mathematically with transportation barriers that are commonly found in everyday life. In this research, an algorithm is shown to find the optimal solution by determining Z from the transportation table from the calculation of the initial feasible solution, then form a pseudo-cost matrix as a cell reference that must be minimized, rearrange the matrix and check on, if = 0 then the solution already optimal if not then repeat from step to form pseudo cost matrix. From the case of unbalanced data in the Islamic Higher Education Enrolment with a data size of 4x6, the optimal solution is 2775 units of time with 2 iterations, the optimal solution from the Mallia-Das algorithm, when compared to the NWC method, is 2885 and VAM is 2725, still the minimum optimal solution for the VAM method. Although it produces an optimal solution that is slightly larger than the VAM method, the Mallia-Das algorithm for the bottleneck case is superior because it pays attention to the bottlenecks.

Keywords: The Islamic Higher Education Enrolment, Operations research, Bottleneck Transportation Problem, Initial basic feasible solution, Minimization, Pseudo cost.

1. Introduction

Operations Research is one of the mathematical models to solve the problems of everyday life by converting them into the form of Linear Programming, Balanced Programming, Queuing Theory, and Inventory Theory [1,2,3,4,5,6]. In the industrial world, the activity of distributing goods from a plant to certain locations is called the Transportation Problem.

The application of transportation problems in the education field, such as in the Islamic Higher Education Enrolment. The activity of distributing new students from new student admissions paths to certain departments. In specific, the new student admissions path in UIN Sunan Gunung Djati Bandung consists of 5 paths,

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that is, 4 national paths and 1 local path. Total new students who apply were 18,799 in 2021. It increases from year to year [7].

The Transportation problem is a special linear programming problem that is arguably the most important. The Transportation Problem Model generally deals with the problem of distributing goods from several factories (sources) to several distributors (destinations). The application of the method to transportation problems can minimize the total transportation costs. [8,9,10].

In transportation, the type of goods that perish quickly, conditions when there is a war or a disaster occurs that requires assistance in as soon as possible for each different route. In this case, it aims to reduce the maximum time on a transportation route by looking for an alternative route with a shorter time but still able to meet demand. This transportation problem is called a bottleneck or congestion, more specifically the narrowing of the path. [11,12,13,14].

The major previous research on bottleneck transportation problems includes the problem of bottleneck transportation problems with time minimization using the Mallia-Das algorithm [15,16]. Another algorithm proposed to produce the optimal solution is the primal approach [17] and the Blocking Method. This proposed method provides the decision support that users need for handling time-oriented logistical problems [18, 19]. In addition, to get the optimal solution to the time minimization problem, the Zero-Point method can be used to get the optimal solution, which is the method they proposed in the time minimization case transportation problem [20].

2. Methods

In this research, the authors investigate further the bottleneck transportation problem with time minimization using the Mallia-Das algorithm (minimax) in the case of simulation data the UIN Sunan Gunung Djati Bandung enrolment and then compare the algorithm used with the North-West Corner transportation problem-solving method and the Vogel Approximation Method.

The bottleneck condition is in the equation of the form:

$$Z = max\{c_{ij}|x_{ij} > 0\} \tag{1}$$

where the value of Z is the largest time of distributing new students from the admission paths to certain department that has an allocation in the transport matrix cell that must be minimized. This Z value is considered to be able to inhibit distribution because the cell or route contains the largest distribution time among other cells that have allocations. Path narrowing or bottleneck occurs in cells (routes) that contain a value of Z or greater than Z.

The Mallia-Das (minimax) algorithm is intended to find an initial feasible solution and is expected to provide an optimal solution for the Bottleneck Transportation problem, which is a new algorithm to minimize the distribution time of the previous bottleneck transportation problem. Starting with the cost or time matrix C (where $x_{ij} = 0$ for each i-th source or j-th destination is dummy) and a feasible transport plan $= (xij)$ which can be obtained from various phase one method, such as NWC, VAM, and LCM.

The steps in solving the Bottleneck transportation problem with the Mallia-Das Algorithm (Minimax) are as follows [15]:

Step 1: Construct a transportation problem matrix if not given, where the rows are the sources and the columns are the supplies. If the matrix is unbalanced, then balance the matrix by adding a dummy.

Step 2: Furthermore, the initial transportation plan will be allocated using the North-West Corner method.

Step 3: Determine $Z = max\{c_{ij}|x_{ij} > 0\}$, choose the largest Z member from the allocated transportation time, and set the pseudo cost matrix $\hat{C} = (\hat{c}_{ij})$, with

$$\begin{cases} M, if\, c_{ij} > 0 \\ 1, if\, c_{ij} = 0 \\ 0, if\, c_{ij} < 0 \end{cases}$$

These set of pseudo cost matrix conditions are shown in Table 1.

Table 1. Pseudo Cost

	0	0	M	0
$\hat{C}_1 =$	0	1	0	0
	0	0	0	0

From Table 1, if the value in the table is greater than Z, then give the value M to the Pseudo Cost table. Furthermore, if the value in the table is equal to Z, it is given a value of 0, else if the value is less than Z, it is given a value of 1.

Step 4: Solve the transportation problem with the cost matrix $\hat{c}_{ij}$. In the cells that have pseudo cost = 1, then move the allocation to another cell. The result is a new transportation problem with $T = (x_{ij})$.

Define pseudo cost as follows:

$$\hat{Z} = \sum_i \sum_j \hat{C}_{ij} x_{ij} \qquad (2)$$

Step 5: Check whether $\hat{Z} = 0$

If so, then return to step 3. If not, then stop the algorithm, and the transportation plan is optimal.

The Mallia-Das Algorithm (Minimax) is represented in the flowchart in Figure 1.
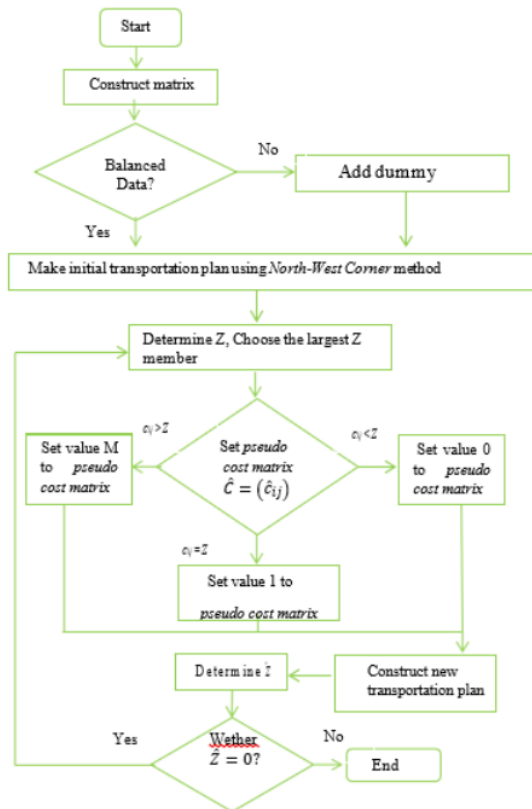
Figure 1. The Mallia-Das Algorithm Flowchart

3. Results and Discussion

3.1. Case Studies

Using simulation data, UIN Sunan Gunung Djati has 4 new student admission national paths and 6 most popular major . The demand from the six most popular major are 12, 20, 15, 25, 20 and 10 students. Then, the new student number available in the admission paths are 35, 22, 32, and 13 students. The delivery time of each student from the i-th admission path to the j-th most popular major is t_{ij} [14]. It is shown in Table 2.

Table 2. Initial Plan

T		Most Popular Major						Quantity
		1	2	3	4	5	6	
	1	25	30	20	40	45	0	35
Admission path	2	30	25	20	30	40	0	22
	3	40	20	40	35	45	0	32
	4	25	24	50	27	30	0	13
Demand		12	20	15	25	20	10	102

In Table 2, the 6th most popular major is a dummy. Then the North-West Corner method for the allocation of the initial feasible transportation plan. The results are presented in Table 3

Table 3. Transportation 1 Plan

T^1		Most Popular Major						Quantity
		1	2	3	4	5	6	
	1	25 (12)	30 (20)	20 (3)	40 (0)	45 (0)	0 (0)	35
Admission path	2	30 (0)	25 (0)	20 (12)	30 (10)	40 (0)	0 (0)	22
	3	40 (0)	20 (0)	40 (0)	35 (15)	45 (17)	0 (0)	32
	4	25 (0)	24 (0)	50 (0)	27 (0)	30 (3)	0 (10)	13
Demand		12	20	15	25	20	10	102

Furthermore, an optimal solution will be determined using the Mallia-Das algorithm.

3.2. Data Analysis

After applying the Mallia-Das algorithm to the case study in Table 3, the results are obtained as presented in Table 4.

Table 4. Optimal Transportation Plan

T^3		Most Popular Major						Quantity
		1	2	3	4	5	6	
Admission path	1	25 (12)	30 (20)	20 (3)	40 (0)	45 (0)	0 (0)	35
	2	30 (0)	25 (0)	20 (12)	30 (0)	40 (10)	0 (0)	22
	3	40 (0)	20 (0)	40 (0)	35 (25)	45 (0)	0 (7)	32
	4	25 (0)	24 (0)	50 (0)	27 (0)	30 (10)	0 (3)	13
Demand		12	20	15	25	20	10	102

Furthermore, compute the pseudo cost

$$\hat{Z} = \sum_i \sum_j \hat{C}_{ij} x_{ij}$$

$$\hat{Z}_2 = (40 \times 0) + (45 \times 0) + (40 \times 10) + (40 \times 0) + (40 \times 0) + (45 \times 0) + (50 \times 0) > 0$$

with pseudo cost $\hat{Z}_2 > 0$, then the iteration is stopped and the pseudo cost T^3 is optimal.

Furthermore, compute the optimal solution:

$$Z = (25 \times 12) + (30 \times 20) + (20 \times 3) + (20 \times 12) + (40 \times 10) + (35 \times 25) + (0 \times 7) + (30 \times 10) + (0 \times 3) = 2775$$

Thus, the optimal solution for this transportation plan is 2775 units of time, with a maximum time of 40 students of time and an allocation of 12 students from new student admission path 1 to most popular major 1, 20 students from new student admission path 1 to most popular major 2, 3 students from new student admission path 1 to most popular major 3, 12 students from new student admission path 2 to

most popular major 3, 10 students from new student admission path 2 to most popular major 5, 25 students from new student admission path 3 to most popular major 4, and 10 students.

The optimal solutions comparison using Mallia-Das algorithm, North West Corner transportation method, and Vogel Approximation Method is presented in Table 5.

Table 5. The Optimal Solutions Comparison

	Algoritma Mallia-Das	NWC	VAM
Optimal Solution	2775	2880	2725

It can be seen from Table 5 that the Mallia-Das Algorithm produces an optimal solution that is greater than the VAM method, meaning that the VAM method is better in terms of time because the optimal solution is more minimal. However, the Mallia-Das Algorithm is outstanding in overcoming the bottleneck problem because it is a concern to the paths that might hinder distribution [20, 21, 22].

3. Conclusions

This bottleneck transportation problem occurs due to obstacles caused by accidents, natural disasters, and accumulation of new students who are interested in a particular major in Islamic Higher Education enrolment. It is influenced by, among others, by the number of prospective students, the prospect of graduates, and the accreditation of the majors. Although the optimal solution obtained using the Mallia-Das algorithm is not as good as VAM method's but the Mallia-Das Algorithm is outstanding in overcoming the bottleneck problem. The research results show that by using the Mallia-Das algorithm, the allocation from new student admission paths to most popular major whose path is blocked and causes congestion can be overcome. For further research, it is possible to compare the Mallia-Das algorithm with the Maximum Range Method (MRM) and add case studies for the balanced transportation problem.

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