**Solution of The Shortest Route Problem on Trans Jogja Bus Routes with The Floyd Warshall Algorithm**

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**Abstract.** The Trans Jogja bus is one of the means of transportation in Yogyakarta. This study aims to 1) determine the problem solving of the shortest route on the Trans Jogja bus from Giwangan terminal and Jombor terminal to Condongcatur terminal using the Floyd Warshall algorithm, 2) determine the optimal level of the Trans bus route. Jogja from Giwangan terminal and Jombor terminal to Condongcatur terminal. This research data is secondary data in the form of a map from the website of the Yogyakarta Transportation Service and is carried out by literature study. There are several steps, namely 1) determining the connectedness matrix of a weighted directed graph, 2) calculating the distance for each iteration, 3) forming the final matrix with the shortest weighted connection W \*. The shortest distance from the Giwangan terminal to the Condongcatur terminal is through the Giwangan - Tegalturi 2 - Nitikan - PA Muhammadiyah - Kol. Sugiono 2 - MT Haryono - Tejokusuman - Ngabean Terminal - Hayam Wuruk - Kosudgama - Jl. Colombo (UNY) - Santren (Gejayan) - Condongcatur Terminal with the shortest distance traveled is 15.70 km with a travel time of 82 minutes with an optimization level of 54% with a very low category, while the shortest route from Jombor terminal to Condongcatur terminal is Jombor Terminal - RRU Monjali 1 - RRU Kentungan - Condongcatur Terminal with a distance of 4.6 km with a travel time of 18 minutes with an optimization rate of 88% with the optimum category.

1. **Preface**

Indonesia is a country with a population that is mostly transportation users. In 2017[1], Indonesia took second place on the INRIX 2017 Global Traffic Scorecard[5], which states that the average duration of traffic jams at peak hours in 2017 in Indonesia reached 51 hours. According to the INRIX 2017 Global Traffic Scorecard research, Yogyakarta is ranked as the 5th in Indonesia.

Yogyakarta is also one of the tourist cities that attracts tourists, so that the roads become jammed and ineffective in driving. The Yogyakarta Transportation Agency has developed an alternative way to reduce road congestion using the Trans Jogja Bus. The Trans Jogja bus is a transportation that began operating in 2008 by PT. Tugu Jogja which has 17 lanes and 267 bus stops that assess parts of the city of Yogyakarta[2].

Giwangan Terminal and Jombor Terminal are one of the inter-city or inter-island bus stops in Yogyakarta. Many people who come to Yogyakarta use buses and stop at the Giwangan or Jombor terminals. People who come do not necessarily know the city of Yogyakarta, some just want a vacation and some want to study. Many of the Trans Jogja buses from the Giwangan terminal that pass through the campuses head north, namely the Condongcatur terminal stop. Besides being near campus, Condongcatur terminal is also close to the center of places and lodging.

One way to reduce road congestion is by optimizing the distance. This distance optimization problem can use the Floyd Warshall algorithm. The Floyd Warshall algorithm is a dynamic program that solves problems by looking at the solutions obtained from the previous stage and there are more than one possible solution. Floyd Warshall's algorithm is a directed graph that has weights (V, E) where V is the vertex and E is the side of a graph. The advantage of the Floyd Warshall algorithm is that the Floyd Warshall algorithm can be used to find the shortest distance from each pair of edges[7].

Research conducted in 2013 by Fitriana Yuli, Nur Insani, and Retno Subekti discussed optimizing the Trans Jogja bus lane using the Floyd Warshall algorithm. The result of this research is that the 3A route is an optimum route while there are still many Trans Jogja bus routes that are not yet optimal and the optimum level of the route is 68% which is categorized as moderate. Therefore, this study will discuss the settlement of the shortest distance with the Floyd Warshall algorithm and its application to the Trans Jogja bus route from Giwangan terminal to Condongcatur terminal and Jombor terminal to Condongcatur terminal.

1. **Research Methods**

The data in this study are secondary data from the website of the Yogyakarta Special Region Transportation Service. Determination of the distance that the Trans Jogja bus will pass from the bus stop to the bus stop via google maps. The use of path search is done by entering input in the form of two different locations and google maps will provide output in the form of route routes and path lengths. The input used in collecting side weights is the two horizontal coordinates of the two vertices connected to one side, the output taken is the length of the path in meters. The path length value is used as the weight of the side of the graph[6]. This research was conducted by means of literature study.

Search the distance between Trans Jogja bus stops using google maps. To see the level of optimization of a Trans Jogja bus route is used[4] as follows:

**Table 1.** Criteria for Route Optimization Level

|  |  |
| --- | --- |
| Percentage of score obtained by | Category |
| 89% c 100% | Very Optimum |
| 79% c 89% | Optimum |
| 64% c 79% | Moderate |
| 54% c 64% | Low |
| c 54% | Very Low |

The percentage score is calculated by the following formula:

The total number of paths to be searched using the combination formula.

The bus travel speed assumes 35 km / hr and the stop time for each stop is about 5 minutes. Bus Travel time can be calculated using the following formula:

Information:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| C | : | Combination | t | : | travel time |
| n | : | Amount of data | s | : | distance |
| r | : | The amount of data that must be selected | v | : | Trans Jogja bus speed |

1. **Research Results and Discussion**

The Floyd Warshall algorithm is an application of dynamic programming. According to Jong Jek Siang (2011), the Floyd Warshall algorithm for finding the shortest path is an algorithm that is simple and easy to implement. The basic principle of the Floyd Warshall algorithm is that in the 1st iteration the shortest distance from all points to all points is calculated. Suppose that is a directional graph link matrix labeled starting, is the minimal connection matrix with equal to the shortest path from point to where *€* is the row in the matrix, *j* is the column in the matrix and *k* is the iteration 1 to *n* of the matrix.

Floyd Warshall’s algorithm uses a matrix as a representation of the graph. If a graph consists of n sides (edges), the matrix formed in the calculation is n x n. This matrix represents the weight of all the edges on the graph with the symbol dij. The weight from the starting node to the ending node has three possible values, namely:

1. *dij* = 0 if *€* = *j* (from vertex to vertex itself)

2. *dij* = edge weight if *€* ≠ *j* and vertex are connected to vertex

3. *dij* = ∞ if *€* ≠ *j* and vertex are not connected to vertex

The steps for finding the shortest distance to the Floyd Warshall algorithm are as follows[3]:

1. Determining the Floyd Warshall algorithm is to determine the n x n directed graph connectedness matrix, namely W =

2. For *k* = 1 to *n*

For *i* = 1 to *n*

For *j* = 1 to *n*

If then swap with

3. W \* is the final shortest weighted connectivity matrix from to , namely = W

In this study, the Trans Jogja bus lane modeling is a graph sourced from a Trans Jogja bus map where the Trans Jogja bus stop is symbolized by vertex (*v*) and the distance between the stops is symbolized by the edge €. Based on the Trans Jogja bus map, there are 30 bus stops and 34 edges on the Giwangan terminal route to the Condongcatur terminal and 30 bus stops and 37 edges on the Jombor terminal route to the Condongcatur terminal. The bus stops that are passed by the Trans Jogja bus from the Giwangan terminal to the Condongcatur terminal and from the Jombor terminal to the Condongcatur terminal are buses 2A, 2B, 3A, 3B, 5A, 5B and 11.

**Table 4.** List of Giwangan Terminal Bus Stop – Concat Terminal

|  |  |  |  |
| --- | --- | --- | --- |
| **Bus Stop** | **vertex** | **Bus Stop** | **Vertex** |
| Terminal Giwangan |  | MT Haryono |  |
| Tegalturi 2 |  | Tejokusuman |  |
| Tegal Gendu 1 |  | Terminal Ngabean |  |
| Dep. Kehutanan |  | KHA Dahlan 2 |  |
| Jogja Expo Center |  | Hayam Wuruk |  |
| Janti Utara |  | Sudirman 3 |  |
| Jl. Solo (ALFA) |  | Kosudgama |  |
| Jl. Maguwo |  | Cik Dirto 2 |  |
| Bandara Adisutjipto |  | Pertanian UGM |  |
| RRU PU PJN |  | RS Sarjito |  |
| Stiper 2 |  | Kentungan |  |
| UPN |  | Jl. Colombo (UNY) |  |
| Nitikan |  | UNY Gejayan |  |
| PA Muhammadiyah |  | Santren (Gejayan) |  |
|  |  |  |  |
| **Bus Stop** | **vertex** | **Bus Stop** | **Vertex** |
| Kol. Sugiono 2 |  | Terminal Condongcatur |  |

**Tabel 5.** List of Jombor Terminal Bus Stop – Concat Terminal

|  |  |  |  |
| --- | --- | --- | --- |
| **Bus Stop** | **Vertex** | **Bus Stop** | **Vertex** |
| Terminal Jombor |  | Ngeksigondo (Diklat PU) |  |
| RRU Monjali 2 |  | Gedong Kuning (Dep. Kehutanan) |  |
| Jl. Colombo (Kosudgama) |  | Kusumanegara (Gembira Loka) |  |
| AM Sangaji 2 |  | Kusuma Negara 4 |  |
| RRU Kentungan |  | Kenari 2 |  |
| Mangkubumi 1 |  | Yos Sudarso |  |
| Mangkubumi 2 |  | Sudirman 1 |  |
| Malioboro 1 |  | Cik Ditiro 2 |  |
| Ahmad Yani |  | Jl. Colombo (UNY) |  |
| Senopati 2 |  | UNY Gejayan |  |
| Katamso 2 |  | Jl. Solo (Debrito) |  |
| Katamso 1 |  | Santren (Gejayan) |  |
| Kol. Sugiono 1 |  | Jl. Solo (Ambarukmo) |  |
| PSKY |  | RRU UPN |  |
| RSI Hidayatullah |  | Terminal Condongcatur |  |

By using the google maps application, the distance between the Trans Jogja bus stops on the Giwangan terminal route to the Condongcatur terminal and the Jombor terminal to the Condongcatur terminal. The following is a graph of a Trans Jogja bus from Giwangan terminal to Condongcatur terminal and Jombor terminal to Condongcatur terminal.

|  |  |
| --- | --- |
|  |  |
| **Figure 2.** Bus Graph Trans Jogja Giwangan Terminal – Terminal Concat | **Figure 3.** Bus Graph Trans Jogja Jombor Terminal – Terminal Concat |

Using the graph above, the Floyd Warshall algorithm is calculated using the TORA software. Here is the result of the iteration *k* = 30.

**Table 7.** Iteration results of the thirty Giwangan terminals to the Condongcatur terminal

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vij | v1 | v2 | v3 | v4 | v5 | v6 | v7 | v8 | v9 | v10 | v11 | v12 | v13 | v14 | v15 |
| v1 | 0 | 1,4 | 1,5 | inf | inf | inf | inf | inf | inf | inf | inf | inf | 2,15 | 3,25 | 3,85 |
| v2 | inf | 0 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0,75 | 1,85 | 2,45 |
| v3 | inf | inf | 0 | 1,8 | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf | inf |
| v4 | inf | inf | inf | 0 | 2,4 | inf | inf | inf | inf | inf | inf | inf | Inf | inf | inf |
| v5 | inf | inf | inf | inf | 0 | 2,6 | inf | inf | inf | inf | inf | inf | Inf | inf | inf |
| v6 | inf | inf | inf | inf | inf | 0 | 0,9 | inf | inf | inf | inf | inf | Inf | inf | inf |
| v7 | inf | inf | inf | inf | inf | inf | 0 | 1,3 | inf | inf | inf | inf | Inf | inf | inf |
| v8 | inf | inf | inf | inf | inf | inf | inf | 0 | 1,2 | inf | inf | inf | Inf | inf | inf |
| v9 | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 2,6 | inf | inf | Inf | inf | inf |
| v10 | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 1,2 | inf | Inf | inf | inf |
| v11 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 1,8 | Inf | inf | inf |
| v12 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | Inf | inf | inf |
| v13 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 1,1 | 1,7 |
| v14 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 0,6 |
| v15 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 |
| v16 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v17 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v18 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v19 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v20 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v21 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v22 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v23 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v24 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v25 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v26 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v27 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v28 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v29 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v30 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |

Continution

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vij | v16 | v17 | v18 | v19 | v20 | v21 | v22 | v23 | v24 | v25 | v26 | v27 | v28 | v29 | v30 |
| v1 | 5,35 | 6,15 | 6,6 | 7,3 | 8,6 | 10 | 12,1 | 10,95 | 11,9 | 12,8 | 15,2 | 13 | 13,5 | 14,5 | 15,7 |
| v2 | 3,95 | 4,75 | 5,2 | 5,9 | 7,2 | 8,6 | 10,7 | 9,55 | 10,5 | 11,4 | 13,8 | 11,6 | 12,1 | 13,1 | 14,3 |
| v3 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v4 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v5 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v6 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v7 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v8 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v9 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v10 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| vij | v16 | v17 | v18 | v19 | v20 | v21 | v22 | v23 | v24 | v25 | v26 | v27 | v28 | v29 | v30 |
| v11 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v12 | inf | inf | inf | inf | Inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 1,6 |
| v13 | 3,2 | 4 | 4,45 | 5,15 | 6,45 | 7,85 | 9,95 | 8,8 | 9,75 | 10,65 | 13,05 | 10,85 | 11,35 | 12,35 | 13,55 |
| v14 | 2,1 | 2,9 | 3,35 | 4,05 | 5,35 | 6,75 | 8,85 | 7,7 | 8,65 | 9,55 | 11,95 | 9,75 | 10,25 | 11,25 | 12,45 |
| v15 | 1,5 | 2,3 | 2,75 | 3,45 | 4,75 | 6,15 | 8,25 | 7,1 | 8,05 | 8,95 | 11,35 | 9,15 | 9,65 | 10,65 | 11,85 |
| v16 | 0 | 0,8 | 1,25 | 1,95 | 3,25 | 4,65 | 6,75 | 5,6 | 6,55 | 7,45 | 9,85 | 7,65 | 8,15 | 9,15 | 10,35 |
| v17 | inf | 0 | 0,45 | 1,15 | 2,45 | 3,85 | 5,95 | 4,8 | 5,75 | 6,65 | 9,05 | 6,85 | 7,35 | 8,35 | 9,55 |
| v18 | inf | inf | 0 | 0,7 | 2 | 3,4 | 5,5 | 4,35 | 5,3 | 6,2 | 8,6 | 6,4 | 6,9 | 7,9 | 9,1 |
| v19 | inf | inf | inf | 0 | 2,2 | 3,6 | 5,7 | 4,55 | 5,5 | 6,4 | 8,8 | 6,6 | 7,1 | 8,1 | 9,3 |
| v20 | inf | inf | inf | inf | 0 | 1,4 | 3,5 | 2,35 | 3,3 | 4,2 | 6,6 | 4,4 | 4,9 | 5,9 | 7,1 |
| v21 | inf | inf | inf | inf | inf | 0 | inf | 0,95 | 1,9 | 2,8 | 5,2 | inf | inf | inf | 6,9 |
| v22 | inf | inf | inf | inf | inf | inf | 0 | Inf | Inf | inf | Inf | 0,9 | 1,4 | 2,4 | 3,6 |
| v23 | inf | inf | inf | inf | inf | inf | inf | 0 | 0,95 | 1,85 | 4,25 | inf | inf | inf | 5,95 |
| v24 | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 0,9 | 3,3 | inf | inf | inf | 5 |
| v25 | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 2,4 | inf | inf | inf | 4,1 |
| v26 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | inf | inf | inf | 1,7 |
| v27 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 0,5 | 1,5 | 2,7 |
| v28 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 1,0 | 2,2 |
| v29 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 1,2 |
| v30 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 |

**Table 8.** Iteration results of the thirty Jombor terminals to the Condongcatur terminal

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vij | v1 | v2 | v3 | v4 | v5 | v6 | v7 | v8 | v9 | v10 | v11 | v12 | v13 | v14 | v15 |
| v1 | 0 | 1 | 5,9 | 4,2 | 2,9 | 3,9 | 4,25 | 5,25 | 5,75 | 6,75 | 7,05 | 7,75 | 8,55 | 10,35 | 10,55 |
| v2 | inf | 0 | 21,65 | 3,2 | 1,9 | 2,9 | 3,25 | 4,25 | 4,75 | 5,75 | 6,05 | 6,75 | 7,55 | 9,35 | 9,55 |
| v3 | inf | inf | 0 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v4 | inf | inf | inf | 0 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| vij | v1 | v2 | v3 | v4 | v5 | v6 | v7 | v8 | v9 | v10 | v11 | v12 | v13 | v14 | v15 |
| v5 | inf | inf | 19,75 | inf | 0 | 1 | 1,35 | 2,35 | 2,85 | 3,85 | 4,15 | 4,85 | 5,65 | 7,45 | 7,65 |
| v6 | inf | inf | 18,75 | inf | inf | 0 | 0,35 | 1,35 | 1,85 | 2,85 | 3,15 | 3,85 | 4,65 | 6,75 | 6,65 |
| v7 | inf | inf | 18,4 | inf | inf | inf | 0 | 1 | 1,5 | 2,5 | 2,8 | 3,5 | 4,3 | 6,1 | 6,3 |
| v8 | inf | Inf | 17 | Inf | inf | inf | inf | 0 | 0,5 | 1,5 | 1,8 | 2,5 | 3,3 | 5,1 | 5,3 |
| v9 | inf | inf | 16,9 | inf | inf | inf | inf | inf | 0 | 1 | 1,3 | 2 | 2,8 | 4,6 | 4,8 |
| v10 | inf | inf | 15,9 | inf | inf | inf | inf | inf | inf | 0 | 0,3 | 1 | 1,8 | 3,6 | 3,8 |
| v11 | inf | inf | 15,6 | inf | inf | inf | inf | inf | inf | inf | 0 | 0,7 | 1,5 | 3,3 | 3,5 |
| v12 | inf | inf | 14,9 | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 0,8 | 2,6 | 2,8 |
| v13 | inf | inf | 14,1 | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 1,8 | 2 |
| v14 | inf | inf | 12,3 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 0,2 |
| v15 | inf | inf | 12,1 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 |
| v16 | inf | inf | 10,7 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v17 | inf | inf | 9,95 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v18 | inf | inf | 7,65 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v19 | inf | inf | 7,05 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v20 | inf | inf | 5,35 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | Inf | inf |
| v21 | inf | inf | 2,75 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v22 | inf | inf | 1,45 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v23 | inf | inf | 1 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v24 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v25 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v26 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v27 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v28 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v29 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v30 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |

Continution

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vij | v16 | v17 | v18 | v19 | v20 | v21 | v22 | v23 | v24 | v25 | v26 | v27 | v28 | v29 | v30 |
| v1 | 11,95 | 12,7 | 15 | 15,6 | 17,3 | 19,9 | 21,2 | 21,65 | 6,9 | 7,35 | 8,3 | 8,35 | 9,25 | 12,85 | 4,6 |
| v2 | 10,95 | 11,7 | 14 | 14,6 | 16,3 | 18,9 | 20,2 | 20,65 | 22,65 | 23,1 | 24,05 | 24,1 | 25 | 28,6 | 3,6 |
| v3 | inf | inf | inf | inf | inf | inf | inf | inf | 1 | 1,45 | 2,4 | 2,4 | 3,35 | 6,95 | 3,65 |
| v4 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf |
| v5 | 9,05 | 9,8 | 12,1 | 12,7 | 14,4 | 17 | 18,3 | 18,75 | 20,75 | 21,2 | 22,15 | 22,2 | 23,1 | 26,7 | 1,7 |
| v6 | 8,05 | 8,8 | 11,1 | 11,7 | 13,4 | 16 | 17,3 | 17,75 | 19,75 | 20,2 | 21,15 | 21,2 | 22,1 | 25,7 | 22,4 |
| v7 | 7,7 | 8,45 | 10,75 | 11,35 | 13,05 | 15,65 | 16,95 | 17,4 | 19,4 | 19,85 | 20,8 | 20,85 | 21,75 | 25,35 | 22,05 |
| v8 | 6,7 | 7,45 | 9,75 | 10,35 | 12,05 | 14,65 | 15,95 | 16,4 | 18,4 | 18,85 | 19,8 | 19,85 | 20,75 | 24,35 | 21,05 |
| v9 | 6,2 | 6,95 | 9,25 | 9,85 | 11,55 | 14,15 | 15,45 | 15,9 | 17,9 | 18,35 | 19,3 | 19,35 | 20,25 | 23,85 | 20,55 |
| v10 | 5,2 | 5,95 | 8,25 | 8,85 | 10,55 | 13,15 | 14,45 | 14,9 | 16,9 | 17,35 | 18,3 | 18,35 | 19,25 | 22,85 | 19,55 |
| v11 | 4,9 | 5,65 | 7,95 | 8,55 | 10,25 | 12,85 | 14,15 | 14,6 | 16,6 | 17,05 | 18 | 18,05 | 18,95 | 22,55 | 19,25 |
| v12 | 4,2 | 4,95 | 7,25 | 7,85 | 9,55 | 12,15 | 13,45 | 13,9 | 15,9 | 16,35 | 17,3 | 17,35 | 18,25 | 21,85 | 18,55 |
| v13 | 3,4 | 4,15 | 6,45 | 7,05 | 8,75 | 11,35 | 12,65 | 13,1 | 15,1 | 15,55 | 16,5 | 16,55 | 17,45 | 21,05 | 17,75 |
| v14 | 1,6 | 2,35 | 4,65 | 5,25 | 6,95 | 9,55 | 10,85 | 11,3 | 13,3 | 13,75 | 14,7 | 14,75 | 15,65 | 19,25 | 15,95 |
| v15 | 1,4 | 2,15 | 4,45 | 5,05 | 6,75 | 9,35 | 10,65 | 11,1 | 13,1 | 13,55 | 14,5 | 14,55 | 15,45 | 19,05 | 15,75 |
| v16 | 0 | 0,75 | 3,05 | 3,65 | 5,35 | 7,95 | 9,25 | 9,7 | 11,7 | 12,15 | 13,1 | 13,15 | 14,05 | 17,65 | 14,35 |
| v17 | inf | 0 | 2,3 | 2,9 | 4,6 | 7,2 | 8,5 | 8,95 | 10,95 | 11,4 | 12,35 | 12,4 | 13,3 | 16,9 | 13,6 |
| v18 | inf | inf | 0 | 0,6 | 2,3 | 4,9 | 6,2 | 6,65 | 8,65 | 9,1 | 10,05 | 10,1 | 11 | 14,6 | 11,3 |
| v19 | inf | inf | inf | 0 | 1,7 | 4,3 | 5,6 | 6,05 | 8,05 | 8,5 | 9,45 | 9,5 | 10,4 | 14 | 10,7 |
| v20 | inf | inf | inf | inf | 0 | 2,6 | 3,9 | 4,35 | 6,35 | 6,8 | 7,75 | 7,8 | 8,7 | 12,30 | 9 |
| v21 | inf | inf | inf | inf | inf | 0 | 1,3 | 1,75 | 3,75 | 4,2 | 5,15 | 5,2 | 6,1 | 9,7 | 6,4 |
| v22 | inf | inf | inf | inf | inf | inf | 0 | 0,45 | 2,45 | 2,9 | 3,85 | 3,9 | 4,8 | 8,4 | 5,1 |
| v23 | inf | inf | inf | inf | inf | inf | inf | 0 | 2 | 2,45 | 3,4 | 3,45 | 4,35 | 7,95 | 4,65 |
| v24 | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 0,45 | 1,4 | 1,45 | 2,35 | 5,95 | 2,65 |
| vij | v16 | v17 | v18 | v19 | v20 | v21 | v22 | v23 | v24 | v25 | v26 | v27 | v28 | v29 | v30 |
| v25 | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | inf | 1 | inf | inf | 2,2 |
| v26 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | inf | 0,95 | 4,55 | 6,15 |
| v27 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | inf | inf | 1,2 |
| v28 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 3,6 | 5,2 |
| v29 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 | 1,6 |
| v30 | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | inf | 0 |

The results of the iteration show the shortest distance from the Trans Jogja bus on the Giwangan terminal route to the Condongcatur terminal, namely Giwangan Terminal Giwangan () – Tegalturi 2 () – Nitikan () – PA Muhammadiyah () – Kol. Sugiono 2 () – MT Haryono () – Tejokusuman () – Terminal Ngabean () – Hayam Wuruk () – Kosudgama () – Jl. Colombo (UNY) () – UNY Gejayan () – Santren (Gejayan) () – Condongcatur Terminal () with the shortest distance traveled is 15,70 km and the travel time is around 82 minutes, while the shortest distance is the Trans Jogja bus from Jombor terminal to Condongcatur terminal, namely Jombor Terminal () – RRU Monjali 1 () – RRU Kentungan () – Condongcatur Terminal () with a distance of 4,6 km and the travel time is around 18 minutes. Based on these results, when compared to the Trans Jogja bus route on the Giwangan terminal line to the Condongcatur terminal at this time, this route is not optimal, while the Trans Jogja bus route from the Jombor terminal to the Condongcatur terminal has been said to be optimal.

In this study, it is assumed that the trips that cannot be taken directly by two unconnected bus stops are said to be non-optimum. By using the combination formula and the percentage of route optimality, it is obtained that the Giwangan terminal route to the Condongcatur terminal has an optimization of 54%, so it can be concluded that the Trans Jogja bus route from Giwangan terminal to Condongcatur terminal currently has a very low level of optimization. Meanwhile, the Trans Jogja bus route from Jombor terminal to Condongcatur terminal has an optimization of 88%, so it can be concluded that the Trans Jogja bus route from Jombor terminal to Condongcatur terminal is currently in the optimum category.

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| **Figure 4.** Pie Diagram of Route Optimization for Giwangan Terminal – Concat Terminal | **Figure 5.** Pie Diagram of Route Optimization for Jombor Terminal – Concat Terminal |

1. **Conclusions and Recommendations**

Based on the results and analysis in this study, the conclusions obtained from this study are as follows:

1. The shortest distance from Giwangan terminal to Condongcatur terminal is through the Giwangan – Tegalturi 2 – Nitikan – PA Muhammadiyah – Kol. Sugiono 2 – MT Haryono – Tejokusuman – Ngabean Terminal – Hayam Wuruk – Kosudgama – Jl. Colombo (UNY) – Santren (Gejayan) – Condongcatur Terminal with the shortest distance traveled is 15,70 km with a travel time of 82 minutes, while the Trans Jogja bus route from Jombor terminal to Condongcatur terminal has been said to be optimal with the Jombor Terminal route – RRU Monjali 1 – RRU Kentungan – Condongcatur Terminal with a distance of 4,6 km and a travel time of 18 minutes.

2. At the current Giwangan terminal route to Condongcatur terminal the optimization is in the very low category, namely 54% of the optimum route. Meanwhile, the Trans Jogja bus route from Jombor terminal to Condongcatur terminal is currently in the optimum category, which is 88% of the optimum route.

The suggestions in this research are:

1. Future research can use other algorithms such as Djikstra, Bellman-Ford and A\* search or other software such as java, matlab or others.

2. Further research should not only find the shortest distance but also find the fastest time and the most cost effective time of the Trans Jogja bus.

3. It is expected to be able to research all the routes used by the Trans Jogja buses at this time.

4. It is hoped that the DIY Transportation Agency can add the Trans Jogja bus lane.

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