Developing Prototype for Telecommunications Network Information System of PT. Telkom to Determine Optimal Route in Phone Interference Handling Based on Floyd - Warshall Algorithm

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Key words: optimal route, network analysis, Floyd-Warshall algorithm, telephone network, geographical information system

Geoinformation, Spatial Planning

SUMMARY

Nowdays, many providers are emerging in Indonesia so that they lead high competition among telecommunication operators to win over the public. As a state owned company that has authorities on the development of telecommunications sector, especially for cables telephone, PT. TELKOM also realize that, so they strive for a better service to the customers.

This research aims to create a spatial database and interactive telephone network information system model of PT. Telkom by using Quickbird imagery derived from Google Earth, Global Position System (GPS) and Geographical Information Systems (GIS) to determine the optimal route telephone network for error handling based on Floyd-Warshall algorithm. Determination of the optimal route is based on the variable impedance of the travel distance and travel time derived from the length of road divided by the average speed of vehicles per road segment. Subsequent tissue analysis results are integrated with GPS navigation technology to help a network technician search for location of interference and network technicians to assist the movement towards the location of the phone to crash in the field.

The result of the research is Telkom Bantul Optimal Route Information System (SIROTOL) desktop based and stand alone application. This information system is made by combining a visual programming language called Microsoft Visual Basic with ESRI Map Objects 2.2, geographic information system applications developer software. SIROTOL optimal route program can be acquired by ‘Spatial Programming with Floyd-Warshall Algorithm’, so it can be applied to determine the optimal route accurately on Telkom Bantul’s error handling or at least close to field conditions. It can be proved by field validation results which resulted in accurate optimal route test value based on travel distance of 97.06% and travel time of 96.14%.

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1. INTRODUCTION

Indonesian national policy in the telecommunications sector has outlined substantially as set out in the 1988 Broad Guidelines *of* State Policy (GBHN) that telecommunications development continued to increase the range and quality of services by expanding networks and telecommunications connections as well as improve efficiency. In line with that, public telecommunications facilities has developed, spread, and reach out to the wider community. The telecommunications company has a fundamental duty to provide public telecommunications services in the country. The role of telecommunications services is essentially enhances the efficiency and productivity of the industrial sector, trade, and economy in general, so that the common priorities to be implemented is the range expansion and increasing the services (Umar, 1995).

PT. Telkom as the a business entity in charge of the construction and development of the telecommunications sector, particularly the telephone wires, trying to improve telecommunications services to their customers. Improving the quality of telecommunication services is currently focused on the addition new features and service improvement on interrupt or error handling (phone interference handling) that occurred in the telecommunication network. Improvements in the speed and precision on the interference handling is an effort to improve the telecommunications service currently. Interference handling is conducted by PT. Telkom based on the customer reports who are experiencing interference on the telephone network.

Delays in phone interference handling is often caused by non-technical factors, the network technicians were sent sometimes have difficulty in finding the location or address of the customer who reports. The network technician who has been sent sometimes have difficulty in finding a location or address disturbed customers. This is can be avoided if a network technician know the spatial information about the telephone cable network and the road network. PT. Telkom could solved the problem by preparing a database of spatial information system of the customer's address and phone network components along with the analysis of the optimal route determination to solve the problem delays phone interference handling. Advances in technology remote sensing, geographic information systems (GIS) and Global Positioning System (GPS) will facilitate the preparation of a database and information system for determining the optimal route in efforts to increase telecommunications services, especially in terms of speed and accuracy of handling phone interference.

PT. Telkom have an information system that is commonly called SISKA (Customers

Information System) and COC (Customers Operation Center). Both of these information systems were used to manage variety of existing data with high security and accuracy, from network data, customer data, Service Level Guaranty for Customer (segmentation of service), and customers subscription data. However, it was not enough to maximize customer service. For example, information regarding the customer's address or components of the telephone network, sometimes addressing consist of various kinds, such as addressing based on the administrative location, street names, or landmarks, where the customer's home or components of the telephone network. Sometimes there is still a confusing location while search on the system, so it requires an addressing system that is unique and has a high accuracy. That means an address of an information that a unique, single, and only imposed on those locations.

This kind of information can only be found if addressing is based on the geographical position. Spatially addressing system is done based on the plotting coordinates using a Global Positioning System (GPS). Satellite use for positioning will facilitate the users of information systems to obtain the information they wants, basically the basic concept of GPS positioning is resection with distance, ie with distance measurement simultaneously to multiple GPS satellites known coordinates (Abidin, 2002). GPS technology is also used to simplify the search of phone interference handling location and to assist the movement of network technicians to the location. The development of geographic information systems which grew rapidly and particularly in network analyst. Analysis carried out for example to localize the trouble happened through the analysis of query and determining the optimal route through the network analyst. Network analyst of this research are used to solve effectiveness of the network problems, in particular to resolve the problems of the optimal route in the handling of interference phone.

Good modeling is approaching reality, reliable, and the results obtained high accuracy and correctly. There are many algorithms that can be used to solve the optimal route search, both conventional methods and heuristic methods. However, determining the optimal route in this study requires algorithms that are able to provide the exact and accurate results. Thus, the utilization of Floyd-Warshall algorithm is the right choice to resolve the issue of the optimal route in aiding the handling of interference telephone network in this study.

2. DETERMINATION OF OPTIMAL ROUTE

2.1 Determination of Impedance Value

Determination of the optimal route related to sum of impedance values of every road that is impassable. Optimal route is a route that has the smallest impedance value. Impedance value commonly used is the mileage and travel times are derived from mathematical calculations between road length divided by the speed of the vehicle speed per unit time. Length of the road can be obtained easily from the interpretation of high-resolution remote sensing imagery such as Quickbird imagery. However, data on vehicle speed per unit time at each road can’t be obtained through image interpretation, so that direct measurements in the field is required. The travel time is derived from road length (mileage) divided by the speed of the vehicle speed per unit time. Determination of the optimal route is based on the sum of impedance values of every road that passed between the starting point to the destination point.

$$\mathbf{V} = \frac{S}{t} \quad \text{...} (1)$$

$$\mathbf{t} = \frac{S}{V} \quad \text{...} (2)$$

Where :
V = average speed (km/ h)
S = the distance travelled by the object (length segments – km)
t = the duration of the interval travel time along the road segment (h)

The database network in this study was based on results of Quickbird image interpretation which captured from Google Earth. GPS navigation is used to determine GCP (ground control point) on geometric correction for Quickbird imagery sourced from Google Earth. GPS navigation is also used as a tool for plotting and tracking Telkom network to test the model's accuracy for optimal route. Use of Quickbird imagery is to get road network data more accurate (in accordance with actual conditions in the field). The length of road derived from road network data from the Quickbird image interpretation which captured from Google Earth, while data regarding vehicle speed per unit time at each road segment is obtained from direct measurements in the field with velocity method point (spot speed). Based on calculated distance (mileage) and impedance factor, the most efficient path can be determined, more than just the shortest path. Nodes can be coded as a point of stopping, which shows the traffic control lights and interchange. Based on the difficulty of turning left or turning right at an intersection, and even could also marked as obstacles that slow the velocity of the vehicle to go somewhere. As well mileage, all variable are taken from road condition, intersection, etc. (Arham, 2002).

2.2 Algorithm For Determination of Optimal Route

Determination of the optimal route from one point / point to point / elsewhere is a problem which is faced in everyday life. Along with running time, the problem of determining the optimal route has been solved by various algorithms. Some popular algorithms that can solve the problem of finding the optimal route is the Dijkstra algorithm and Floyd-Warshall algorithm. Dijkstra's algorithm is a variant of the greedy algorithm, which is one form of popular algorithms in solving problems related to optimization problems.

In accordance with the meaning which literally means greedy, but not in a negative context, greedy algorithm is only thinking of the best solution which will be taken at each step without thinking of the consequences ahead. In principle, take what you can get at the moment, and the decisions taken at each step can’t be changed back. The point of this greedy algorithm seeks to make a selection of local optimum value at every step and hope that this leads to a local optimum value to the global optimum value (Novandi, 2007). Floyd-Warshall algorithm is one of the optimal route search algorithm which is a variant of the dynamic programming, the algorithm considers that a solution will be obtained a decision interrelated, so that the solution formed from the solution coming from the previous stage. That is, the Floyd-Warshall algorithm compares all possible trajectories in a graph / line for each side of all nodes.

Things that differentiate finding optimal solutions using the dynamic programming with the greedy algorithm is that the decisions taken at each stage of the greedy algorithm is only based on limited information so that the optimum value obtained at that time. On the greedy algorithm, we do not think about the consequences that would happen if we choose a decision at any stage. In some cases, the greedy algorithm fails to provide the best solution because of its weakness earlier. This is where the role of dynamic programming try to provide solutions which have a thought for the consequences arising from the decision-making on a stage. Dynamic programming can reduce the enumeration decisions which isn't lead to a solution. That principle held by dynamic programming is the principle of optimality, that is if the optimal total solution then the solution to a stage (for example stage-i) is also optimal (Novandi, 2007).

SIROTOL testing program is in addition aimed to test the function of all controls contained in SIROTOL program, also aimed to compare the results of the optimal route program with the actual situation in the field, where field testing done with several different routes to get to error location. Determination of the optimal route in the program done based on the road network and telephone cable network. Determination of the optimal route based on the road network is done by two methods, the optimal route by considering the closest distance and optimal route taking into account the fastest time. While determining the route based telephone cable network is a method of determining the route to search telephone cable network (tracing).

The selected study area is a service area of automatic telephone exchange (STO) Bantul in the form local copper network access with ration indirectly. Bantul district is located between 07º 44 '04' - 08º 00 '27 "South latitude and 110º 12' 34" - 110º 31 '08 "East Longitude. Bantul Regency has an area of 506.85 km2 is divided administratively into 17 districts, 75 villages and 933 hamlets. Indirect supply network is a local cable network where customers air supplied from the Distribution Point (DP) nearby connected prior to the Feeder Point (RK) before being connected to the *Main Distribution Frame (*RPU) as in Figure 1 and Figure 2. The use of indirect supply network is also used in cities and towns and are used to distribute local customers scattered and far away. The telephone network in Bantul almost distributed in every region, both in the urban areas, the city of Bantul, as well as in other sub-districts is still a rural area, so that variations in the location of the customer and the type of the existing road network makes it possible to obtain results more complex analysis.

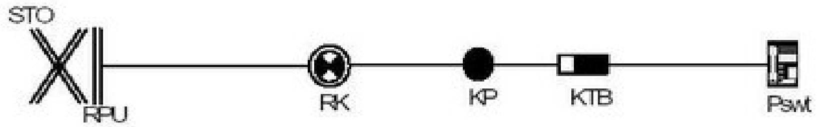


Figure 1. Basic Configuration of Local Copper Network Access

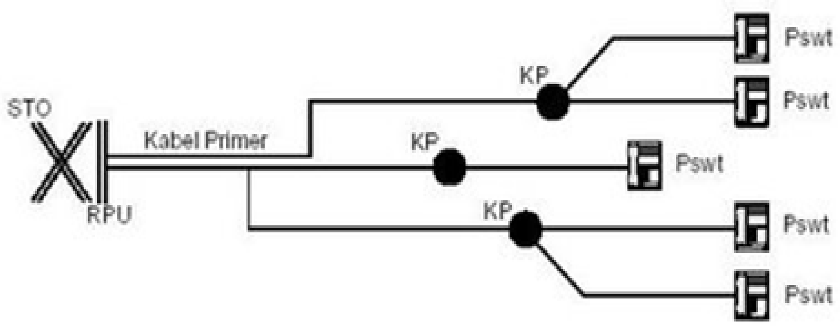


Figure 2. Indirect Supply Network Configuration.
(Source:http://pogotel.blogspot/2008/07/jaringan-lokal-akses-tembaga-jarlokar.html)

Where :
STO : automatic telephone exchange (*Sentral Telepon Otomat)*
RPU / MDF : Main Distribution Frame *(Rangka Pembagi Utama)*
KP / DP : Distribution Point (*Kotak Pembagi*)
KTB / TB : Terminal Block (*Kotak Terminal Batas*)
Pswt : telephone
Kabel Primer : The primary cable

2.3 The preparation of Road Network Database

Network database can basically be made from shapefile type of line, either pre-existing or feature class type of line which contained in the geodatabase. Network database has two characteristics as follow :

a. Between the arc must be connected, because if it is not connected then the road will be considered broken.
b. Field name that contains information about the condition of the road network must also follow the standard naming rules. Standard field name is used to declare the unit cost of the network database can be seen in Table 1. Besides field names are listed in Table 1,

Table 1. The Field Standard Name of Network Database

Unit cost	Field Standard Name FT = TF From-To = To-From	Field Standard Name FT ≠ TF From-To ≠ To-From
Seconds	SECONDS	FT_SECONDS and TF_SECONDS
Minutes	MINUTES	FT_MINUTES and TF_MINUTES or FT_DRIVETIME and TF_DRIVETIME or FT_IMPEDANCE and TF_IMPEDANCE or FT_TRAVELTIME and TF_TRAVELTIME
Hours	HOURS	FT_HOURS and TF_HOURS
Milimeters	MILIMETERS	FT_MILIMETERS and TF_MILIMETERS
Centimeters	CENTIMETERS	FT_ CENTIMETERS and TF_ CENTIMETERS
Meters	METERS	FT_METERS and TF_METERS
Kilometers	KILOMETERS	FT_ KILOMETERS and TF_ KILOMETERS
Inches	INCHES	FT_ INCHES and TF_ INCHES

Yards	YARDS	FT_ YARDS and TF_ YARDS
Feet	FEET	FT_FEET and TF_FEET
Miles	MILES	FT_ MILES and TF_ MILES
Nautical miles	NAUTICALMILES	FT_ NAUTICALMILES and TF_ NAUTICALMILES
Non-time/ non-distance units, such as monetary unit	COST or UNITS	FT_COST and TF_COST
		FT_UNITS and TF_UNITS

Source: Raharja, 2010

There are other field namely ONEWAY or ONE_WAY to declare that a line can be passed in two directions, one direction, or closed to pass. The information regarding road conditions should be included in the preparation of the network database (see Table 2)

Table 2. Field Information Network Database

Field	Type	Field Size	Contents
TF_MINUTES	Short Integer	Default	According table of travel time
FT_MINUTES	Short Integer	Default	
ONEWAY	Text	10	According to the route : FT = dari From ke To junction TF = dari To ke From junction B = two-way street N = the road can 't be bypassed
Jalan	Text	25	Address / road names
Length	Long Integer	Default	Length of road

Source: Raharja, 2010

2.4 Determination of Optimal Route Based on Floyd-Warshall Algorithm

The default starting point in this study is automatic telephone exchange or *sentral telepon otomat* (STO) Bantul, a place for complaints phone interference for service area STO Bantul and also from other network component or even from other customers, while the point of aim is a component phone network (Feeder Point and Distribusion Point) and customers who reported phone interference.

Floyd-Warshall algorithm is an algorithm for finding the optimal route with the smallest impedance value of all the paths that connect a pair of points and do it all at once to all the other pair of points, so it would be advantageous in finding the optimal solution for the shortest path. There are two main algorithms in determining the optimal route with the Floyd-Warshall algorithm, that minimum load matrix algorithm and minimum load path matrix algorithm. Minimum load matrix algorithm is an algorithm used to calculate the smallest impedance value obtained in a movement from point of origin to point of destination. The minimum load path matrix algorithm is an algorithm used to determine the route to be taken from the origin to the destination point which has the smallest impedance value as that produced in the matrix algorithm minimum load. Examples of determining the optimal route from the starting point to the destination point by Floyd-Warshall algorithm see Appendix 1.

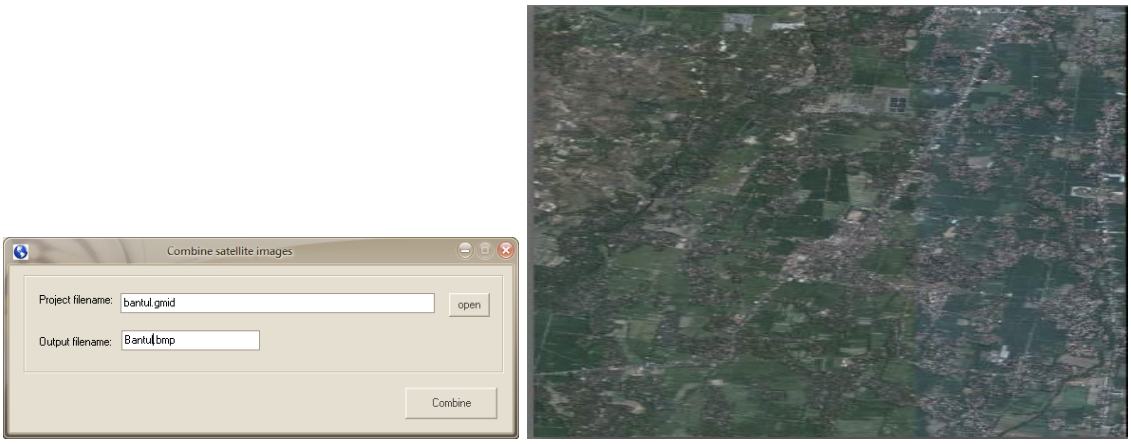
3. PREPARING THE IMAGE

Remote sensing imagery used in this study is the Quickbird imagery sourced from Google Earth. Quickbird image acquisition is done through the process of capturing. This process begins with determining the boundary preferred area then do capturing process. The scope of this study area is in the latitude and longitude coordinates, whether it boundary the the top and bottom of latitude, and boundary coordinates the leftmost and rightmost of longitude from the coverage preferred area. The digitization process in this research is conducted to obtain data on the road network from Quickbird image. Results of subsequent digitization is used as input in the preparation of the road network in the network database analyst.

This study only uses magnification of 18 (a maximum magnification of Google Satellite Maps Downloader 6:46, could reach 22), the quality of the resulting image has been considered good enough for object recognition in the the appearance of the road network. Moreover, determination of the amount of magnification also affect the length of the capturing process and memory size of the resulting image file. The amount of memory image file produced is also considered in this study because that image will be used as the background display in the information system, where the file sizes will affect the process of loading data and execution of a system, so that the files used in the construction of this information system be pursued in minimum size.

Quickbird image capturing results from Google Earth has quality under the original, either spatial resolution or radiometric resolution of the image. Quickbird original has high spatial resolution up to 0.6 m and a radiometric resolution with 11 bit digital coding in the Google Earth application has experience the process of resampling, resulting in geometry and size of the new pixel value. Based on data analysis known that this resampling process has caused shortening size of the pixel image from its original size 0.60 meters to 0.59 meters. This will certainly have an impact on the reduction of detail of presented information and the geometric quality of the image. Radiometric quality of the images reflected in the ability of the sensor to record the spectral response of the object to be reflected or emitted. The ability of the sensor associated with the coding capability (digital coding) that is expressed in bits. Quickbird image of the original has a 11-bit coding systems that change the intensity of the reflected or emitted into 2^{11} = 2048 levels of brightness. Unlike the Quickbird image capturing results of Google Earth has 8-bit coding system, wherein the signal with the same intensity range of the image to be converted into 2^8 = 256 levels of brightness.

This resulted in the image ability to visualize the appearance in which the image with a higher bit coding is able to present the appearance with the number of color levels more, so that an object appearance will be more obvious or more easily distinguished by the other. This happens because the satellite images on Google Earth in general has deteriorated, especially in spatial resolution and radiometric resolution. Decline in quality is also caused by the treatment in the process of capturing. Nevertheless, it can be said Quickbird image quality good enough to be used as a relatively good spatial resolution, there is no cloud cover, and the data to be extracted is the road network data is relatively easy to recognize.



(a) (b)

Figure 3.a). The process of merging the image (combine satellite images); b). Quickbird image capturing results with Google Satellite Maps

3.1 Geometric Correction

Geometric correction in this study using six reference point as Ground Control Point (GCP). Topography of this study area is relatively flat, so even just using few GCP, the results of geometric correction is good and the coordinates of the image can be in accordance with the actual coordinates on the ground (Figure 4). The six reference point that spread in this study area are known from GPS plotting coordinates on the field. Site selection is based on road intersection to easy identification, both on image and on field.

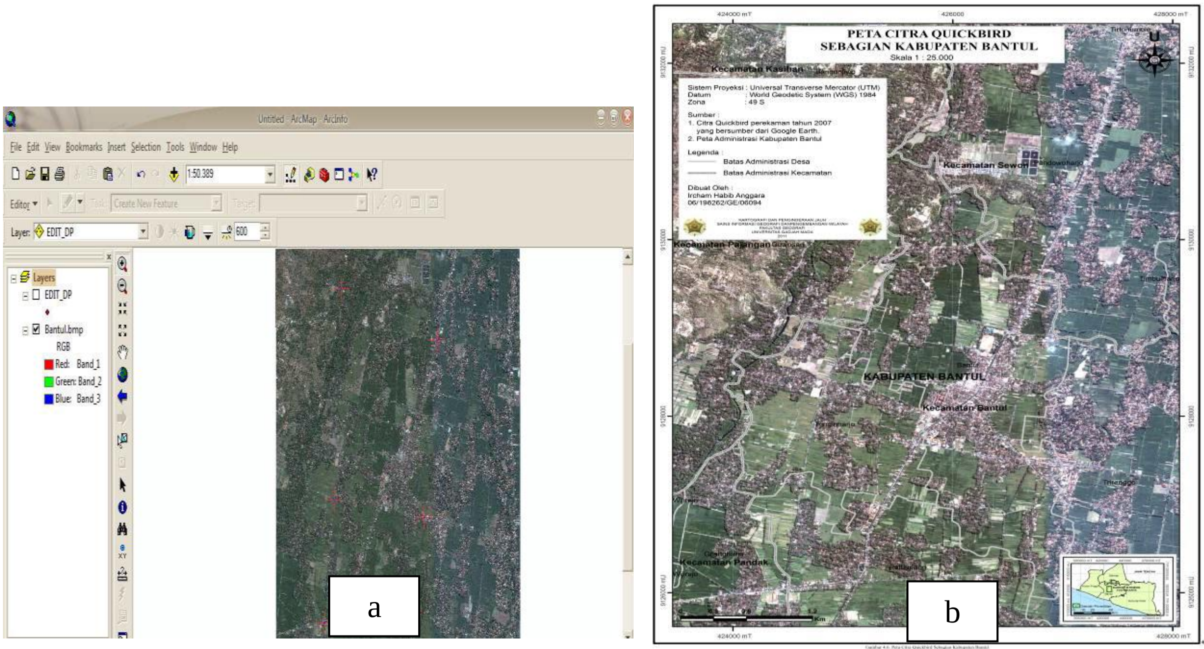


Figure 4 (a) Geometric correction with ground control point using ArcGIS (b) Bantul Map Scale 1: 25,000 using UTM projection system, Datum WGS 1984, 49S, using the image of Quickbird from Google Earth and Maps Administration of Bantul

3.2 Interpretation of Road Network

Road network data is digital data entry in the analysis for the determination of the optimal handling phone interference. The road network data was obtained through the image interpretation of road network from Quickbird with on-screen digitizing method. The difficulties that often faced is the interpretation of the road network that went into the village, covered by the residential building, and sometimes covered by high density of vegetation. However, this can be resolved by using Topographic Map of Indonesia (RBI), namely Map RBI Bantul and Yogyakarta sheet's with scale 1: 25,000, as well a map of the road network which is sourced from the Department of Public Works Bantul as a guide in the process of interpretation network road. Map of the road network which is sourced from the Bantul Department of Public Work, and also used as input data to fulfill attribute name of road in this study.

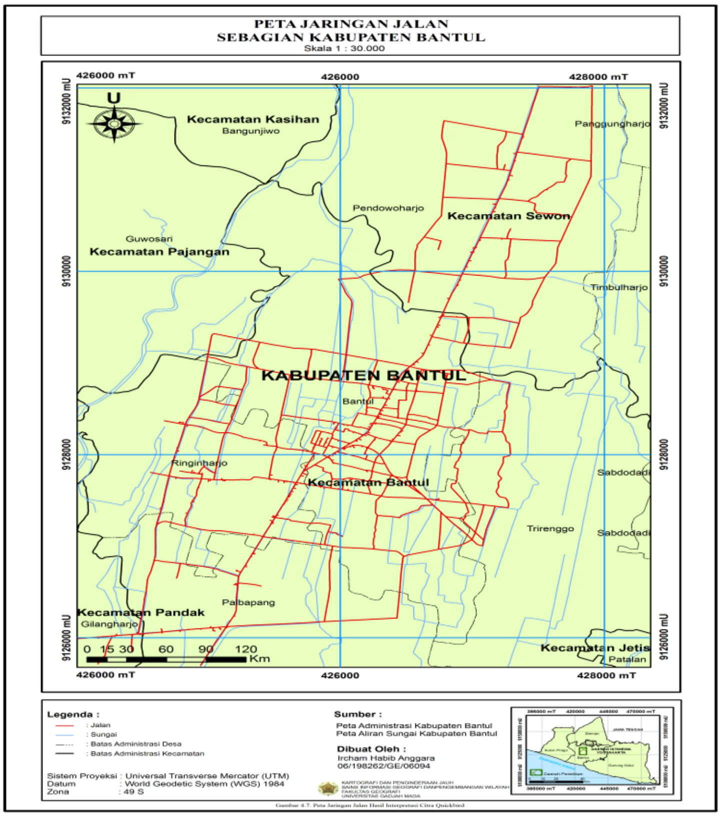


Figure 5. Map of Regional Administration Research in Bantul sourced from the administrative map of Bantul and watershed map of Bantul

3.3 Field Data Collection

Field work is an activity to gather information that can not be tapped from remote sensing imagery. Field data collected in this study contains information on the current direction of movement of vehicles on the road, average speed of vehicles on the roads, and the coordinates of the phone network components PT. Telkom, which includes the coordinates of the customer, Distribution Point, Feeder Point, and STO. Information about the current direction of vehicles movement and vehicle speed data average on roads are used to construct the road network database. Information about the current direction of vehicles movement on the road obtained through field checks to determine the condition of a road, whether the road is a one way or a two-way.

Selection of the sample in the check direction of movement of vehicles on the roads is done by using purposive sampling method, the sample selection is only aimed at the road network is not yet known and preferred direction of movement of vehicles on the road section that passed by cable network telephone PT. Telkom. Data on average vehicle speed for each road segment is obtained by direct measurements in the field. Measurement speed of the vehicle is done by using a speed survey point (spot speed), the method of measuring the speed of moving vehicles where the observer to observe the speed of vehicles which have been classified, which in this study in the form of two-wheeled vehicles (motorcycles), the road is restricted as far as 100 meter, and observers began to take the time when the vehicle began to cross the mark I to mark II. Observations were carried out three times in a row on any road.

a vehicle speed measurement in this study did not take the peak time, but adapted to the working hours of employees of PT. Telkom, who handling phone interference is served from 08.00am to 16.00pm. Measurement speed of the vehicle is using spot speed survey, the method of measuring by observing the speed of vehicles that have been classified on two-wheeled vehicles (motorcycles), roads is limited to maximum 100 meters, and observers began take the time when the vehicle began to cross the mark I to mark II. These observations were performed three times in a row for each road. Field activities intended to perform plotting the coordinates of the phone network components PT. Telkom and build road network database. Data collected includes the coordinates of the customer, Distribution Point (DP), Feeder point (RK), and automatic telephone exchange (STO) through plotting the coordinates with the GPS. This coordinate data is the data compilers spatial database PT. Telkom and also aimed to check the telephone cable network PT Telkom.

3.4 Preparation of Spatial Data Bases PT. Telkom

Spatial database PT. Telkom that built in this research include telephone customer databases and databases of telephone cable network. Telephone customer database PT. Telkom is a collection of spatial information about the customer position/coordinate with telephone history information, such as customer name, customer address, telephone number, and information components of the telephone network. This database is the result between the spatial data customer in the form of coordinates which is obtained from plotting with GPS in the field and tabular data (attributes) about telephone history information from Customer Information System (SISKA) PT. Telkom.

Table 3. Customers Spatial Database of PT. Telkom

Field	**Type**	**Description**
FID	Object ID	Sequences ID objects
Shape	Geometry	data types according to the type of shapefile, ie point.
ID	String	ID objects
X	Double	X coordinate (mT)
Y	Double	Y coordinate (mU)
Nama	String	Customer name
Alamat Ins	String	Telephone installation address
Telepon	String	Customer phone number
RK	String	Description of RK
DP	String	Description of DP
Primer	String	Description of primer cables
Urat Primer	Double	Primer cables number
Sekunder	String	Description of secondary cables
Urat Sekunder	Double	secondary cables number
T	Short Integer	ID point objects

Table 4. Telephone Cable Networks Database Format of PT. Telkom

Field	**Type**	**Description**
FID	Object ID	Sequences ID objects
Shape	Geometry	data types according to the type of shapefile, ie *polyline.*
Id	Long Integer	ID objects
Nama	String	Cable name
Panjang	Double	Cable length in meters
F	Short Integer	Initial node cable ID (according to the direction of digitization)
T	Short Integer	Final node cable ID (according to the direction of digitization)

The stages of the road network database includes road network data preparation, defining the rules for each road network segment, and network analysis for the resolving network problems. Preparation of the road network data that will be used as input data in road network database process is done by applying topology rule to check if the road network map from interpretation Quickbird image results are already qualified in the development of network database or not eligible.

Map of the road network is ready when the map of the road network is free from problems of over-shoot and under-shoot. Over shoot occurs when there are two lines that are not connected but intersect, while undershoot occurs when there are two lines that are not connected. Map of the road network which has been prepared further defined according to the rules that apply to each segment of the network (roads). Defining these rules include determining the direction of the flow of vehicles on each road and the determination of the "costs" that must be paid for through a road section, which in this study used the impedance value is mileage and travel time.

Defining a rule initiated by the addition of new fields in the attribute data of the road network to represent impedance values that must be spent to cross the road. The first field is a field that contains information about the length of roads and the second is the field that contains information about the travel time where there are two different conditions that affect the naming of this field, are: 1) if both directions (back and forth) in one segment of the line has impedance values the same (FT = TF), and 2) if both directions have different impedance values (FT ≠ TF). The road network in this study had a different impedance values in both directions, then there are two fields that are added, the field FT_MINUTES and TF_MINUTES. MINUTES suffix used for travel time unit used is minutes away, while the FT and TF prefix indicates the value of the load on the road section on each segment differentiated according to the direction of digitization.

Tabel 5. Road Network Database Format

Field Name	**Type**	**Description**
FID	Object ID	Sequences ID objects
Shape	Geometry	Data types according to the type of shapefile
Id	Long Integer	ID objects
Nama	String	Road name
Panjang	Double	Road length in meters
ft_V	Double	The average vehicle speed from initial node to final node
tf_V	Double	The average vehicle speed from final node to initial node
FT_MINUTES	Double	The travel time from initial node to final node (according to the direction of digitization)
TF_MINUTES	Double	The travel time from final node to initial node (according to the direction of digitization)
F	Short Integer	initial node ID (according to the direction of digitization)
T	Short Integer	final node ID (according to the direction of digitization)

4. DEVELOPING OPTIMAL ROUTE INFORMATION SYSTEM PT. TELKOM BANTUL BASED ON FLOYD - WARSHALL ALGORITHM

Optimal route information system for handling phone interference PT. Telkom is based on GIS-desktop which is operated through the computer without connecting to the internet (stand-alone application). This is due to the use of GIS Component, where geographic information system products such as ESRI Map Objects inserted into Visual Basic programming language. The program consists of three main parts (program code in appendix 2), namely the part of the map, a menu bar and tool bar. Part of the map is the main content of the information system that includes data raster and vector data. Raster data consists of Quickbird imagery that function as the background of this information system, whereas the vector data consists of a map of the road network, map of telephone cable network, map of telephone network components, and map of administrative boundary. Section menu bar itself is divided into three submenus, namely: location determination, sequence locations, and route determination. Location determination menu is the first menu in determining the optimal route when handling phone interference happen. In this menu the user must specify the starting point departure of technician which is from STO Bantul office or network components other phone, as well as customer data telephone and location to be addressed (destination point) or phone network components that susceptible to interference (DP and RK).

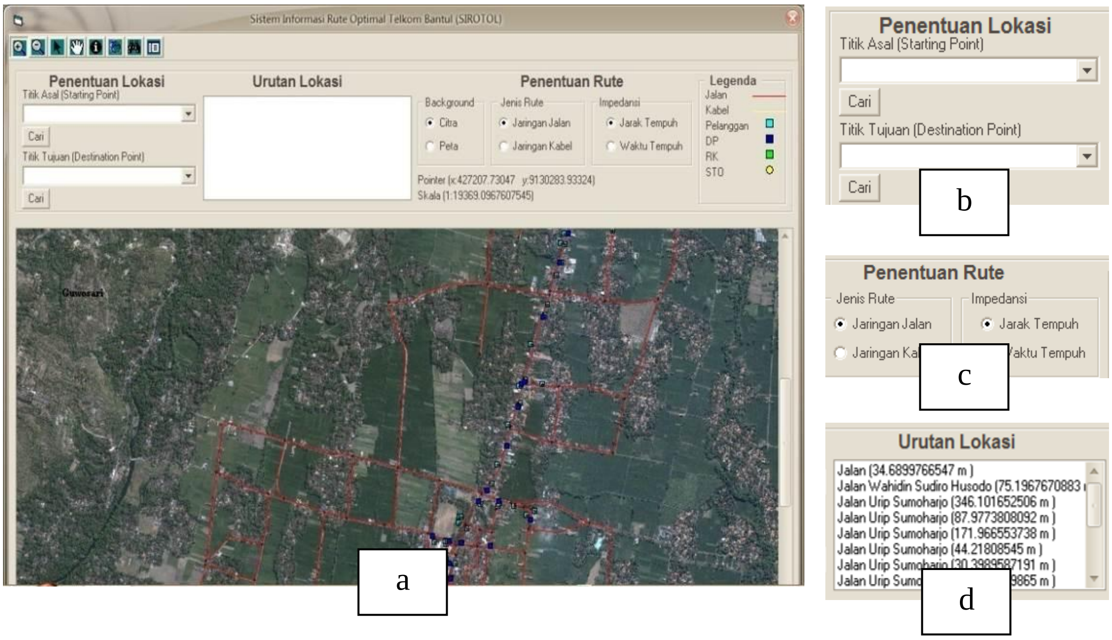


Figure 6. Optimal Route Information System Telkom Bantul (a) display program (b) location determination menu (c) route determination menu (d) sequence locations menu

5. Optimal Route Information System Testing

Testing program is presented in three different cases for the know the benefits of this information system. The first case is the determination of the optimal route of Bantul STO office in Jalan Wahidin Sudiro Husodo, to address the impaired telephone customers, which in this case is PT Cahaya Mulia Persada. Method of determining the optimal route here is done in two ways: first, obtained the optimal route based on the shortest mileage, wherein the impedance value in determining the routes obtained from the attribute data path length (meters); second, the optimal route is obtained based on the fastest travel time, where the value of the impedance in determining the routes obtained from the data attributes and TF_MINUTES FT_MINUTES.

Table 6. Testing Results from STO Bantul to PT Cahaya Mulia Persada

SIROTOL RESULT			**FIELD SURVEY**		
Impedance	Result		Sample	Impedance	
	Optimal Route	Impedance		Length	time
Length	R5_a	1,761 km	S5_a	1,678 km	3’ 56,20”
time	R5_b	3’ 23”	S5_b	1,848 km	3’ 36,34”
			S5_c	2,476 km	4’ 08,10”

Optimal route R5_a with impedance value of 1,761 km is the optimal route test results SIROTOL program with an impedance in the mileage, whereas the optimal route R5_b with impedance values 3' 23" (3 minutes 23 seconds) is the optimal route to the impedance in travel time. Based on both the optimal route, further testing result is known that R5_a in the field reached by distance 1,678 km for 3 '56.20 "(route S5_a), whereas R5_b reached by distance 1,848 km during 3'36,34" (route S5_b). The test results indicate that the route R5_a an optimal route with the closest distance and route R5_b an optimal route with the fastest travel time (Table 6). It appears that the difference in the test results with the results of field testing SIROTOL not large, only 83 m to the closest distance and 13.34 seconds for the fastest travel time. While S5_c route is the route taken to prove that routes other than R5_a and R5_b not an optimal considering the mileage and travel time value is bigger than the optimal route generated SIROTOL program.

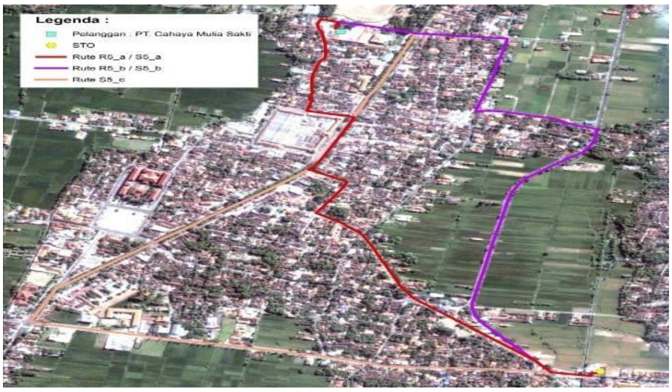


Figure 7. Testing for Optimal Route 1st case

Results of the determination of the optimal route based on Floyd-Warshall algorithm above is presented in two forms, namely the optimal route map images (*.jpg) and the description of the name of the road that passed along with the value of the impedance (*.txt), which can be seen in Figure 8. Results determination of the optimal route for phone interference handling can be saved and printed as a guidance for network technician to go to the error location.

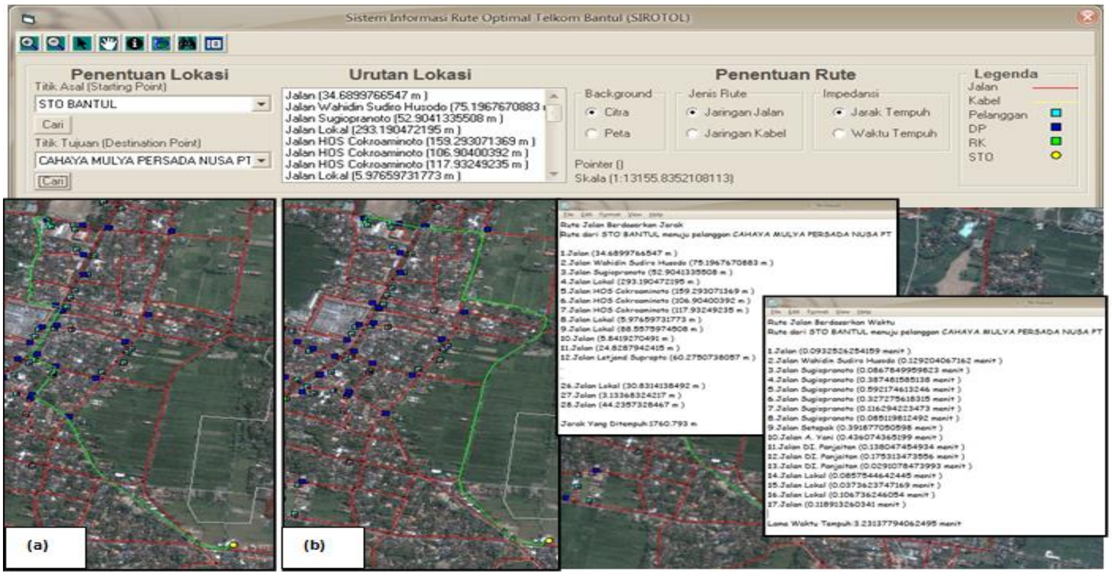


Figure 8. Results of the determination 1st case based on : (A) Distance and (B) Travel Time.

The second case is similar to the first case, but in this case the optimal route SIROTOL program show that the optimal route based on the impedance value of mileage and travel time have the same route. Testing of the second case is intended to find the optimal route from STO Bantul to the Office of the Election Commission (KPUD) Bantul in Wakhid Hashim street. The results of this second case, the optimal route taken through routes R3_a with distance 2,224 km for 3 '30 " (Table 7). These SIROTOL optimal program outcomes showed the same results with the results of testing in the field, where the route S3_a taken at a distance of 2,194 km for 3 '24.96 "is the route with the distance of the closest and fastest travel time (Figure 9 and Figure 10).

Table 7. Testing Results from STO Bantul to the Election Commission (KPUD) Bantul

SIROTOL RESULT			FIELD SURVEY		
Impedance	Result		sample	Impedance	
	Optimal Route	Impedance		length	time
Length	R3_a	2,224 km	S3_a	2,194 km	3’ 24,96”
Time	R3_a	3 ‘ 30”	S3_b	2,718 km	4’ 21,63”
			S3_c	2,341 km	4’ 14,28”

Figure 9. Testing for Optimal Route 2nd case

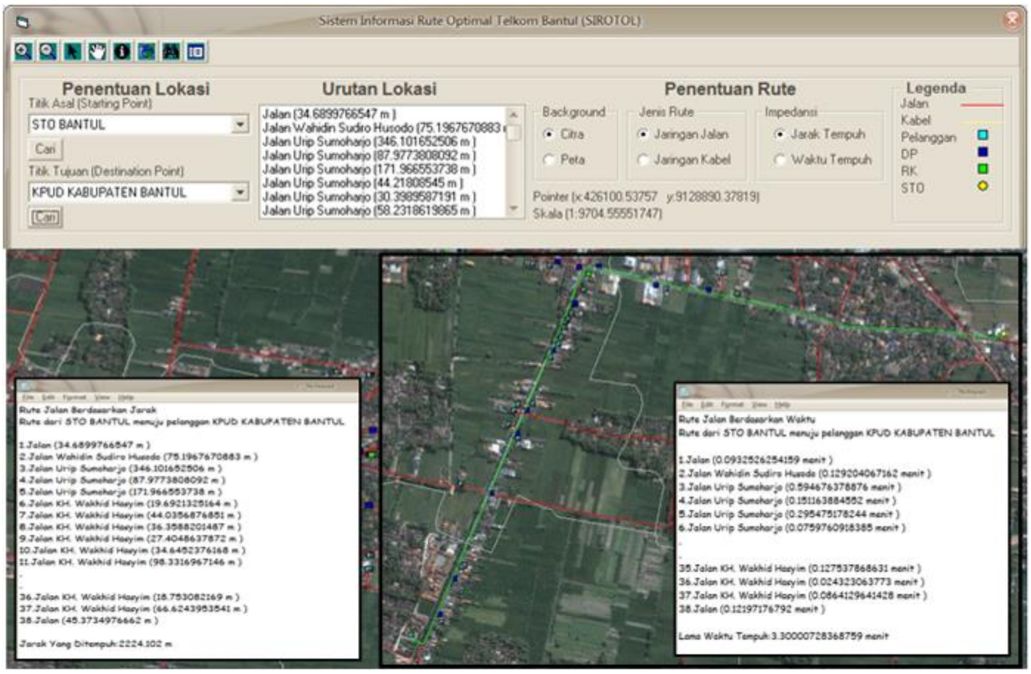


Figure 10. Results of the determination of the optimal route based on travel time (minutes)

The first and second case is a case in determining the optimal route when viewed from the perspective of the road network, which is to determine the optimal impedance route mileage and travel time. While in the third case this determination handling the phone interference from the perspective of telephone cable network. Determining the route based on the cable network devoted to simplify network technicians in understanding the structure of the network installation of telephone cables along the spatial distribution of the components of the telephone network. Method of determining the route is expected to help in localizing the disorder network technician telephone and accelerate the detection of error. This can be achieved because the information generated in addition to containing information about the type of cable networks as well as cable length, also contains information about the component cable network path.

Determining the route in the third case is aimed to find out the telephone cable installation from the Office STO Bantul towards Bappeda Bantul in Komplek Parasamya, Bantul. Results of the determination of the telephone cable network in the form of information about the type of cable networks, which in this third case, the cable network that is passed is the primary cable 4, secondary cable 4, and channels leading penanggal Bappeda Bantul. Network components information are also presented, which in the case of telephone cable network that led to Bappeda Bantul through the house wiring RB and distribution point RB 53 (Figure 11).

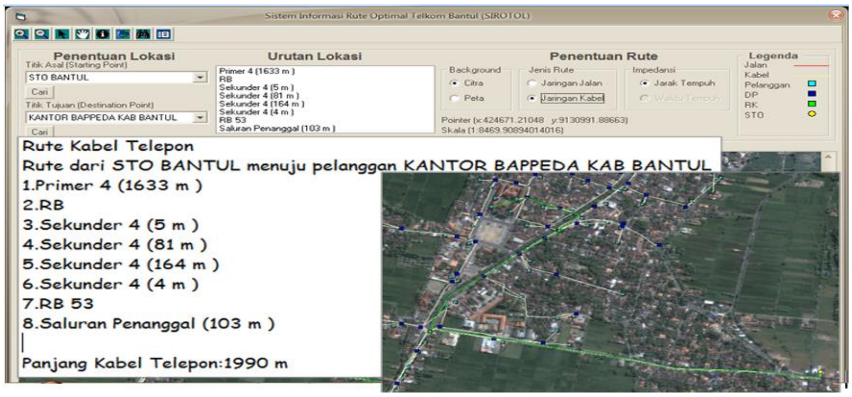


Figure 11. Results of the determination of the telephone cable network.

Analytical ability and level of usefulness of this program in providing optimal route information is done by comparing the analysis results with the results of the field survey program. The less difference between the results of the analysis with the results of the field program, the level of confidence in the data and analysis results higher. Field testing is done by tracing some of the results of the program is the optimal route using two-wheeled vehicles (motorcycles) during office hours or when the phone service interference lasted, between 08.00am - 16.00pm. The parameters tested include mileage and travel time when an optimal route taken by the vehicle speed range between 45 km/h to 60 km/h. Based on the results of testing known that the accuracy test the optimal route based on mileage of 97.06% and an accuracy test value based on the optimal route travel time of 96.14% (Table 8). Value test accuracy of 95% indicates that the information system has been successfully completed and the optimal route problems can be utilized in the handling of phone interference PT. Telkom, especially in the search for fault location and optimal route to get to the fault location, either nearby or travel route takes the quickest route.

Table 8. the results of the optimal route program from STO Bantul to customer

Customers	**Optimal Route Program**		**Field survey**		**Difference/ deviation**		**Akurasi (%)**	
	length (km)	time	length (km)	time	length (km)	Waktu (sec)	length	time
Bappeda Kab. Bantul	1.325	2’ 59”	1.25	2’ 42”	0.075	17	94.34	90.50
Perusahaan Kayu Jati Agung	2.01	3’ 15”	1.944	3’ 13”	0.066	2	96.72	98.97
KPUD Kab Bantul	2.224	3’ 3”	2.194	3’ 25”	0.03	5	98.65	97.62
Suminah Jamhari	4.071	5' 59"	3.994	6' 06"	0.077	7	98.11	98.05
Drs. Pardiyono	3.785	5' 16"	3.756	5' 22"	0.029	6	99.23	98.10
PT Cahaya Mulia Persada	1.761	3’ 23”	1.678	3’ 36”	0.083	13	95.29	93.60
Accuracy (%)							**97.06**	**96.14**

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BIOGRAPHICAL NOTES

Ircham Habib Anggara, born in Bantul, 25 October 1987, graduated bachelor in geography science from Gadjah Mada University (2011), work as surveyor for thematic geospatial information (Geospatial Information Agency), active in remote sensing analysis, programming, and land cover specialist.

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Suprajaka, born in Bantul, 29 September 1964, graduated bachelor in Geomorphology from Gadjah Mada University (1989), graduated master degree in urban and rural planning from Gadjah Mada University (1999), graduated Doctoral Degree in Geography from Gadjah Mada University (2012), works in thematic geospatial information (Geospatial Information Agency) since 1991, and now as a head of Center For Standardization and Institutional of Geospatial Information. Research interests are applied remote sensing and GIS for natural resource analysis, spatial fragmentation analysis, spatial stocktaking analysis. He is also on the editorial boards for Geomantic Journal (Geospatial Information Agency Journal).

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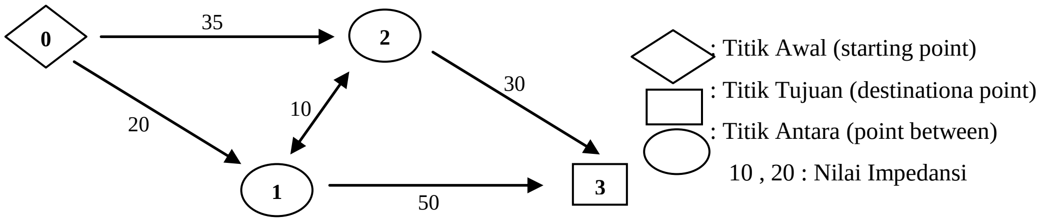
APPENDIX 1



Step Completion :

1. Determination of impedance value on matrix minimum load with the matrix minimum load algorithm:
   a. Declaration of 2-dimensional matrix as a graph [maximum] [maximum]

	0	**1**	**2**	**3**
0	1000	1000	1000	1000
1	1000	1000	1000	1000
2	1000	1000	1000	1000
3	1000	1000	1000	1000

   b. Initiation matrix, for i, j = 0,1,2, ..., n
   - If i = j then the graph [i] [j] = 0
   - If i ≠ j then the graph [i] [j] = immense value, eg = 1000

	0	**1**	**2**	**3**
0	0	1000	1000	1000
1	1000	0	1000	1000
2	1000	1000	0	1000
3	1000	1000	1000	0

   c. Inserting load each segment i, j that are known, graphs [i] [j] = impedance value that is known

	0	**1**	**2**	**3**
0	0	20	35	1000
1	1000	0	10	50
2	1000	10	0	30
3	1000	1000	1000	0

   d. matrix test, for k = n, ..., 2,1,0 graph [i] [j] for i, j = n, ..., 2,1,0

	0	**1**	**2**	**3**
0	0	20	**30**	**60**
1	1000	0	10	**40**
2	1000	10	0	30
3	1000	1000	1000	0

minimum impedance values

If the graph [i] [k] + graf [k] [j] <graf [i] [j] then the graph [i] [j] = graf [i] [k] + graf [k] [j]

2. Determination of Optimal Route with matrix minimum path load algorithm

a. Declaration matrix path as a path [maximum] [maximum]

	0	**1**	**2**	**3**
0	1000	1000	1000	1000
1	1000	1000	1000	1000
2	1000	1000	1000	1000
3	1000	1000	1000	1000

b. Initiation matrix, for i, j = 0,1,2, ..., n then the path [i] [j] = i

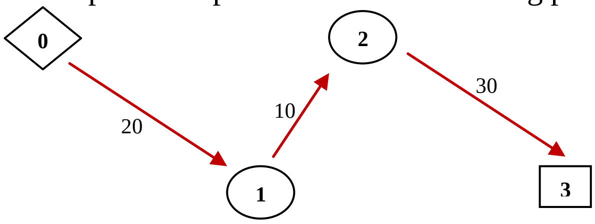
	0	**1**	**2**	**3**
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3

c. matrix test, for k = n, ..., 2,1,0 on the load graph matrix [i] [j] for i, j = n, ..., 2,1,0

	0	**1**	**2**	**3**
0	0	0	**1**	**2**
1	1	1	1	**2**
2	2	2	2	2
3	3	3	3	3

If the graph [i] [k] + graf [k] [j] < graf [i] [j] ***so the path [i] [j] = path [k] [j]***

3. Description of optimal route from starting point (0) to point objective (3):



Optimal route: **0 → 1 → 2 →3**

Impedance Minimum values : 60

APPENDIX 2

```
Private Sub proses()  'kode program penentuan rute optimal jaringan jalan
  Dim j As Integer
  Dim i As Integer
  Dim n As Integer

  Dim recs As MapObjects2.Recordset
  Set recs = Map1.Layers("Jalan").SearchExpression("")
  If Not recs.EOF Then
    Do While Not recs.EOF
      Dim awal As String
      awal = recs.Fields("F")
      Dim akhir As String
      akhir = recs.Fields("T")

      Dim indek1 As Integer
      Dim indek2 As Integer

      For j = 0 To 657 - 1
        If titikJalan(j) = awal Then
          indek1 = j
        End If
        If titikJalan(j) = akhir Then
          indek2 = j
        End If
      Next
      jarakJalan(indek1, indek2) = CSng(recs.Fields("FT_Panjang"))
      jarakJalan(indek2, indek1) = CSng(recs.Fields("TF_Panjang"))
      menitJalan(indek1, indek2) = CSng(recs.Fields("FT_MINUTES"))
      menitJalan(indek2, indek1) = CSng(recs.Fields("TF_MINUTES"))

        recs.MoveNext
    Loop
  End If
  MsgBox "1"
  n = 657

 For i = 0 To n
    For j = 0 To n
       If i <> j Then
        If jarakJalan(i, j) = 0 Then
          jarakJalan(i, j) = 99999
        End If
        If menitJalan(i, j) = 0 Then
          menitJalan(i, j) = 99999
        End If
      End If
    Next
  Next
  MsgBox "2"
  For i = 0 To n
    For j = 0 To n
```

```
        If j <> i Then
         For k = 0 To n
           If k <> i Then
             If (jarakJalan(j, i) + jarakJalan(i, k)) < jarakJalan(j, k) Then
               jarakJalan(j, k) = (jarakJalan(j, i) + jarakJalan(i, k))
               jalurJarakJalan(j, k) = j & "," & i & "-" & i & "," & k
             End If
             If (menitJalan(j, i) + menitJalan(i, k)) < menitJalan(j, k) Then
               menitJalan(j, k) = (menitJalan(j, i) + menitJalan(i, k))
               jalurMenitJalan(j, k) = j & "," & i & "-" & i & "," & k
             End If
           End If
         Next
       End If
     Next
   Next
   MsgBox "3"
   Call conn.Execute("delete from data_jarak")
   Call conn.Execute("delete from data_menit")
   For i = 0 To n
     For j = 0 To n
       Call conn.Execute("insert into data_jarak(indek1,indek2,jarak,jalur)_
         values(" & i & "," & j & "," & jarakJalan(i, j) & ",'" _
        & jalurJarakJalan(i, j) & "')")
       Call conn.Execute("insert into data_menit(indek1,indek2,menit,jalur)_
         values(" & i & "," & j & "," & menitJalan(i, j) & ",'" _
        & jalurMenitJalan(i, j) & "')")
     Next
   Next
End Sub

Private Sub proses2()‘kode program penentuan rute optimal jaringan kabel
   Dim j As Integer
   Dim i As Integer
   Dim n As Integer

   Dim recs As MapObjects2.Recordset

   Set recs = Map1.Layers("Kabel").SearchExpression("")
   If Not recs.EOF Then
     Do While Not recs.EOF
       Dim awal As String
       awal = recs.Fields("F")
       Dim akhir As String
       akhir = recs.Fields("T")
       Dim indek1 As Integer
       Dim indek2 As Integer

       For j = 0 To 334 - 1
         If titikKabel(j) = awal Then
           indek1 = j
```

```
                End If
              If titikKabel(j) = akhir Then
                indek2 = j
              End If
            Next
            jarakKabel(indek1, indek2) = CSng(recs.Fields("Length"))
            jarakKabel(indek2, indek1) = CSng(recs.Fields("Length"))

            recs.MoveNext
        Loop
    End If
    MsgBox "1"
    n = 334

    For i = 0 To n
        For j = 0 To n
            If i <> j Then
                If jarakKabel(i, j) = 0 Then
                    jarakKabel(i, j) = 99999
                End If
            End If
        Next
Next
    MsgBox "2"
    For i = 0 To n
        For j = 0 To n
            If j <> i Then
                For k = 0 To n
                    If k <> i Then
                        If (jarakKabel(j, i) + jarakKabel(i, k)) < jarakKabel(j, k) Then
                            jarakKabel(j, k) = (jarakKabel(j, i) + jarakKabel(i, k))
                            jalurJarakKabel(j, k) = j & "," & i & "-" & i & "," & k
                        End If
                    End If
                Next
            End If
        Next
    Next
    MsgBox "3"
    Call conn.Execute("delete from data_jarak_kabel")
    For i = 0 To n
        For j = 0 To n
            Call conn.Execute("insert into data_jarak_kabel_
              (indek1,indek2,jarak,jalur) values(" & i & "," & j & "," & jarakKabel_
              (i, j) & ",'" & jalurJarakKabel(i, j) & "')")
        Next
    Next
End Sub
```