CERTIFICATION OF APPROVAL

Route Optimization System

by

Ainulmardhiyah Binti Ibrahim

A project dissertation submitted to the
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Universiti Teknologi PETRONAS
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Approved by,

_____

(Mr. Justin Dinesh Devaraj)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
December 2005

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

AINULMARDHIYAH BINTI IBRAHIM

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

ABSTRACT

Congestion has been the main factor for the traveler to plan their destination. The traveler needs to consider the time and even cancel their planning to one place because of this factor. With the advancement of the technology that can guides in decision making, it can solve one of the traveler problem. Route optimization system is a stand-alone system that can give the traveler the shortest route upon user request. This system can be an important resource for the traveler to reach their destination within their planning schedule. This project will highlight the usage of GIS in implementing the system. The objective of this project is focusing on the integration of Geographical Information System (GIS) and Artificial Intelligence (AI). The main purpose is to concentrate in displaying the map along with the database, searching and enable user to retrieve the shortest path. This is due to enhance the capability of the user to choose another route. The method used in this project is Rapid Application Development (RAD) methodology which consists of four stages; requirement planning, user design, construction and cutover. This research also details the study on current system that has already implemented in Europe, which with the same objective is to find the shortest path. While in Malaysia, the car manufacturer is doing this system which motivates me to do this route optimization system as well. The result from the research will be the proposed framework for route optimization system, the discussion on the GIS and AI as well as the prototype of this system. This study proved that Route Optimization System has great potential to be commercially implemented to get the shortest path as today's community is eager of getting free from congestion on the road.

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TABLE OF CONTENTS

CERTIFICATION OF APPROVAL.....

CERTIFICATION OF ORIGINALITY.....

ABSTRACT..... i

ACKNOWLEDGEMENT.....

CHAPTER 1: INTRODUCTION..... 1

1.1 Background of Study..... 2

1.2 Problem Statement..... 3

1.2.1. Problem Identification..... 3

1.2.2. Significance of the Project..... 4

1.3 Objectives and Scope of Study..... 5

1.3.1. Objectives..... 6

1.3.2. Scope of Study..... 6

1.3.2.1 The Relevancy of the Project 6

1.3.2.2 Feasibility of the Project within the Scope and Time Frame..... 7

CHAPTER 2: LITERATURE REVIEW AND THEORY..... 8

2.1. Introduction to Geographical Information Systems (GIS) 8

2.2. Introduction to Route Optimization System (ROS)... 8

2.3. Integration of GIS and AI in Route Optimization 11
2.4. The existing systems implemented and its objectives..... 12

2.5. The future enhancement done on Route Optimization System..... 15

CHAPTER 3: METHODOLOGY / PROJECT WORK..... 17
3.1. Procedure Identification..... 17
3.1.1. Requirements Planning Phase (Analysis)..... 18
3.1.2. User Design Phase (Design)..... 18
3.1.3. Construction (Detailed Design and Code Generation)..... 21
3.1.4. Cutover (Installation and Handover)..... 22
3.2. Tools..... 23
3.2.1. Software Requirement..... 23
3.2.2. Hardware Requirement..... 24

CHAPTER 4: RESULTS AND DISCUSSION..... 25
4.1. Findings..... 25
4.1.1. Displaying the Map..... 25
4.1.2. Visible the Node or Line of the Road on the Map..... 28
4.1.3. Database of the Road..... 30
4.2. Discussion..... 33
4.2.1. Integration of GIS and AI in

Route Optimization System 33
4.2.2. GIS Search Query..... 34

CHAPTER 5: CONCLUSION AND RECOMMENDATION..... 35
5.1 Relevancy to the Objectives..... 35
5.2 Suggested Future Work for Expansion and Continuation..... 35
5.2.1 Conversion to Web-Based and Wireless Route Optimization System 36
5.2.2 Use High-End Database Management Systems (DBMS)..... 36
5.2.3 Integration with Global Positioning System (GPS)..... 37

REFERENCES..... 38

APPENDICES..... 40

LIST OF FIGURES

Figure 3.1	Rapid Application Development Process
Figure 3.2	Proposed Workflow for Route Optimization System
Figure 3.3	Database Structure of Kuala Lumpur area in Design View
Figure 4.1	Interface That Enable User to Choose .shp File as Reference Map
Figure 4.2	Kuala Lumpur Area View
Figure 4.3	Selected Origin and Destination of the Road
Figure 4.4	Shortest Path is Highlighted in Yellow
Figure 4.5	Database Interface View
Figure 4.6	Database in the Combo Box Connected to the Map

LIST OF TABLES

Table 3.1	File Structure
Table 3.2	Software Requirement
Table 3.3	Minimum Hardware Requirement

ABBREVIATIONS AND NOMENCLATURES

ACO	Ant Colony Optimization
AI	Artificial Intelligence
AODV	Ad-Hoc On-Demand Distance Vector Routing
ATIS	Advanced Traveler Information System
CSCW	Computer Supported Collaborative Work
DBMS	Database Management Systems
DSS	Decision Making System
GA	Genetic Algorithm
GIS	Geographical Information Systems
GPS	Global Positioning System
HCI	Human Computer Interaction
IT	Information Technology
ITS	Information Transportation Services
LORA_CBF	Location Routing Algorithm with Cluster-Based Flooding
MMS	Multimedia Messaging Service
PDA	Personal Digital Assistant
RAD	Rapid Application Development
ROS	Route Optimization System
SMOGA	Simulation-based Multi-Objective Genetic Algorithm
VBA	Visual Basic for Application

CHAPTER 1

INTRODUCTION

The importance of people needs to get to their destination in the shortest time is critical nowadays. Most of the population in Malaysia owns a car that makes the road become more crowded at peak hours. The only limitation for the car manufacturer to provide a routing optimization system is because of frequently road upgraded in Malaysia. However, the system that is going to be implemented by the car manufacturer in Malaysia will help in minimizing the congestion and also the time travel for the user. This vehicle routing system especially has already been implemented in Europe mainly for the business company that wanted to minimize their traveling cost and time to reach to their destination. As for an introduction, this routing optimization system will be useful for the used in a small area in Malaysia. As in the Geographical Information System (GIS), the collaboration with Decision Support System (DSS) and Artificial Intelligence (AI) can help in making the routing optimization system works. The GIS that was born in late 1960s has been actively called out to serve increasingly critical enterprise-wide roles. Realizing the needs of exploiting these technologies has brought to the establishment of Route Optimization System (ROS).

Mainly, the establishment of ROS is based on the needs of people who want to reach to their destination within their planning time with the help of providing the shortest route. Besides, the existence of ROS is based on the consideration of minimizing time, cost, and mileage and petrol usage. ROS is stimulated by the need for information retrieved from geographically data, result given is the shortest path, performance in retrieving the information is not delayed, and it will help the improvements in congestion hitch. Thus, this system is highly motivated to be implemented with the usage of GIS, DSS and AI. This has brought to the foundation of Routing Optimization System that mainly focuses on integration of GIS and AI.

Routing in which data, such as time delay, extracted from incoming messages, during specified periods and over different routes, are used to determine the optimum routing for transmitting data back to the sources (Whitey Thayer, 2000). Thus, when discussing on Route Optimization System, it is actually defines the usage of the emergence of Information Technology (IT) accessing the geographical data on a map through the integration of GIS with AI. ROS is characterized by its ability to provide the shortest path which will minimize the time and mileage to reach the destination. Shortest path is working based on AI methods, where it calculates and shows the shortest route should a user take to get to their destination. Plotting the nodes on the roads, displaying the map and enabling the database of the road names are using the GIS methods with the help on Java Programming.

1.1 Background of Study

This is a group project done by me and my partner, Abdul Hayy B Zulkifli. The project on developing the Route Optimization System is mainly to cater several purposes and objectives. As on my part, this project will be concentrating on the GIS part which is on displaying the map along with the database on the road names and provide the shortest route line of the road with another color to differentiate the road. Those are my responsibilities in order to make this project success. Kuala Lumpur is the area of study where the research been done to test the route optimization method. Car manufacturer in Malaysia such as Mercedes is currently implementing this system which motivates me to continue doing the research and implement it as well in a standalone basis. The research on GIS is narrowed down on how to displaying the map using Java programming language along with enabling the road names on the map. Besides, research on integrate with AI also has been done where Java programming language can supports the Djikstra algorithm. The algorithm is widely used in finding the shortest path. The prototype will demonstrate the integration of GIS and AI that will help user to retrieve the shortest route to the desired destination from the current location. It also will provide briefly direction on which road should a user take and the total distance to get to their destination.

1.2 Problem Statement

1.2.1 Problem Identification

Several problems and circumstances are encountered with respect to this project that shows the need to have the routing optimization solution for the user to reach the desired destination:

i. Congestion, nature disaster and accidents

Recently, in newspaper and news in television or radio, there will be a report on the road condition especially the information on the main roads. This daily road-distraction is the limitation for the traveler to reach their destination on time. With that, the establishment of this system will reduce the congestion as the traveler will take another route for their convenience journey to the desired location.

ii. Minimize the time travel

As many roads usually will face the congestion problem especially during the peak hours, there are possibilities for the traveler to spend more time on the road which it can avoid if the system is implemented. The traveler can choose another route and plan their journey to minimize the time travel to the desired destination. Although the route could be lengthier, it may be reach the destination much faster.

iii. Needs to wait for the information on the radio

Currently, the only portable information provided to the traveler can received is from a road condition report on the radio. The traveler needs to wait for the road condition report which mostly will be on air every one hour. This is time consuming for the traveler that needs to reach the destination in a short time

because of urgent work or business needs to be done. However, with the system that is going to be implemented, it can be enhance whether to make it wireless or provide a touch screen in the traveler car to make it more convenience to be used.

iv. Need to bring paper maps for direction

Some of the traveler still keeps the paper map in their car in order to know the roads direction that need to be taken in order to reach their destination. They need to bring paper map to find the particular location. In addition, certain road names and information in the maps is not updated and this might cause difficulties for the traveler in finding the places.

v. Utilize the capabilities of the GIS and AI application

The integration of GIS and AI can help in making the system more useful for a traveler on the road. This will not only minimize the time travel for the traveler but also to minimize the congestion problem on the road. Thus, it is beneficial to utilize the capabilities of the GIS and AI application into the technology device by providing the route optimization system that gives the shortest route as well as the road condition information.

1.2.2 Significance of the Project

The significance and importance of this route optimization system can be articulated in various ways as follows:

a) It is as a starting point of implementing Route Optimization System (ROS) through the establishment of the prototype for this project. This will lead to the advancement of this prototype into a more complete system, where the user can use the system successfully and conveniently.

b) It will motivate and promote other car manufacturer or researcher to do enhance research on the road condition and build such a system so that people in Malaysia too can use the routing optimization system.

c) With the road condition information such as the location of accident happen, it will alert the user and aware them on the obstacles along the path that they choose.

d) It will prove that GIS and AI can be successfully integrated to produce a marketable routing optimization system and has potential in the future to become new trend system application in the car manufactured.

e) It provides a foundation for research-based studies on the elements and aspects incorporated in designing and developing the route optimization system.

f) It suits the needs of traveler in finding the location based on the shortest route in faster and efficient ways using the integration of GIS and AI application with help in DSS area.

1.3 Objectives and Scope of Study

1.3.1. Objectives

This study will be based on the needs of road users within Kuala Lumpur area only. This study will benefit and provide new alternative to traveler in which they will be able to reach their destination in a minimize time. In addition, the system developed from this study will serve as the prototype of Routing Optimization System.

The objectives of this study:

a. To be able in viewing and displaying the map along with different color of road names choose by the user.

b. To provide easy and understandable Graphic User Interface (GUI) for the user to use it.

c. To provide a basis of new research and enhancement studies on the importance of routing optimization in Malaysia

d. To capable in integrating GIS and AI application.

1.3.2. Scope of Study

1.3.2.1 The Relevancy of the Project

This study aims to establish a prototype of Routing Optimization System to cater the needs of traveler or the road user. The rationale of this project is actually to highlight the capabilities of GIS to work with AI application in order to retrieve the spatial data and provide the shortest path. This project deals with a large volume of spatial data, which is the vital element in GIS. As the car manufacturer in Malaysia is also developing this project, hence it motivates me to implement the system as well but as a stand-alone basis. Analysis is performed on Kuala Lumpur spatial data through simple spatial data search. Users make the request by choosing two nodes, which are the current location and the destination location on the system. The prototype will do the calculation based on the distance on each node and other related roads. The result will be generated and displayed with a different color for the shortest route provided to the user. This project promotes a new dimension of transportation services application and will benefit the travelers. It helps the tourists that are not very familiar with the Kuala Lumpur area, to find the

shortest route to the desired destination. Hence, it could provide a basis of new research and enhancement studies on the importance of routing optimization in Malaysia.

1.3.2.2 Feasibility of the Project within the Scope and Time Frame

This project and study are feasible to be conducted within the scope defined and the time frame given. The project is able to prove that Route Optimization System capable to integrate Geographical Information Systems (GIS) with Artificial Intelligence (AI) application technology. This project is feasible to come out with a prototype that able to display the Kuala Lumpur road map and enable the user to zoom the map as well as enquiry the possible shortest route. Thus, it will help the traveler to reach the desired destination on time.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Introduction to Geographical Information Systems (GIS)

Geographical Information System (GIS) is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. It also defines GIS as including the procedures, operating personnel, and spatial data that go into the system (U.S. Geological Survey, 2005). GIS technology can be used for scientific investigations, resource management, and development planning. Geography helps people in making better decisions in many disciplines in human life. Geographic data can be gathered and organized to support the generation of information products to help organizations run better. A GIS can be used to emphasize the spatial relationships among the objects being mapped. While a computer-aided mapping system may represent a road simply as a line, a GIS may also recognize that road as the boundary between rural and urban development between two census statistical areas.

The GIS is an emerging technology that has evolved every rapidly in the last decade. GIS systems have been used by a variety of institutions such as governmental organizations and universities and also by companies and multinational corporations. The reason behind this evolution is that GIS is a technology that provides means of merging diverse information supports the development of effective solutions for complex problems [5].

2.2 Introduction to Route Optimization System (ROS)

Route Optimization System (ROS) is the ability to find the geographical information of the road on the shortest path of a current location (origin) to the desired location (destination) (Radia Perlman, David M. Piscitello and A. Lyman Chapin, 1993). It uses at least two nodes which is mainly one node from the origin and the other node is where the

traveler wants to go, its destination. As for a beginner in this project, ROS will be implemented as a standalone basis, whereby in the future it can be enhance to make it as a web-based or using wireless. The road information can be an absolute factor in term of volume of traffic, type of road, road width, and number of junction and turns a transportation need to set off [1]. The traveler can access the routing optimization system to retrieve the shortest path in a minimal time as a device is plugged in their vehicle, which in this paper the author is focusing to the ambulance [1].

ROS is classified by its functionality and utilization of shortest route information. Firstly, the map or the spatial data given is in a digital format so that it can be easily for the user to view it. As for determine the route optimization, an intelligence aspect is needed for the system to calculate the shortest path among the nodes of the roads that are connected to the destination. It becomes a vehicle guide service for the traveler when it is the crucial time for them to reach the destination in the shortest time. Hence, it is called navigation service when it supports finding of the way to specified destinations. The other type of a system is finding the shortest route but not focusing on the shortest travel time. This has been done as one of the research said that a shorter route does not always give the less time to reach to the destination because of the narrow in width or higher volume of traffic [1]. However, the main concepts of routing is in which data, such as time delay, extracted from incoming messages, during specified periods and over different routes, are used to determine the optimum routing for transmitting data back to the sources (Whitey Thayer, 2000).

Road safety is a major problem with today's vehicular traffic. Almost every year the statistic provided by the Police Traffic Department is increasing, which reveal that a large number of people lose their lives in traffic accidents. Injuries also associated with the traffic events [5]. As in 1999, "there were about 9000 injuries were reported daily happen in European Union" (European Transport Safety Council, 1999). The ROS services focused on traffic safety such as collision warning, collision avoidance and automatic control. The introduced system is mainly "to lead the reduction of at least 20% of collision" (Intelligent Transportation System America, 2001). Most of the research being

done is focusing on designing and developing the efficient systems for urban or rural traffic management and road administration. Whereas, there were very small number of the system is analyzing the potential benefits of utilizing GIS systems for improving the traffic safety from an in-vehicle perspective.

The driver's lack of situation awareness is one of the main causes for today's accidents. There is a study been done that address the loss of situation awareness using knowledge-based and performance-based approaches have proved the decision-making is strongly affected by the components of situation and the decision-maker's previous knowledge about it (Albers M, 1999). Based on the research done by the author, the requirements for successful realization of such GIS system address not only the system itself but also its application within the vehicular domain. There are several important aspects that need to take into consideration in implementing in-vehicle GIS systems:

a. **Processing and storage aspects** related to the utilization of data contained by the GIS system. The available computational power and memory requirements may impose certain limitations on system functionality. Since the system should operate in vehicles with different characteristics, specific hardware and software architectures may also be needed.
b. **GIS system interconnectivity with other in-vehicle systems.** This includes the hardware and software compatibility, data formats and operation modes. Since the system should operate in vehicles equipped with different devices, specific implementations for information processing modules may be needed.
c. **In-vehicle GIS data sharing.** The GIS system contains and may provide various data that can be useful for other in-vehicle systems. These data can be primarily data or processed data resulting from geographical analysis. Standards method for the utilization of the data may need to be developed.
d. **Information updating.** Since certain of the data change over time, it is important that the information resident in vehicles is updated. The updating procedures can be static by the use of CDs or may be dynamic by the use of vehicular communication. The second approach is more convenient and efficient by

introduces a series of problems such as information availability, communication capability and cost.

e. **Information filtering and presentation.** The contents and formats of the information that is presented need to contribute to the improvement of the driver's situation awareness. Therefore, aspects such as comprehensibility, driver reactions and cognitive overload have to be considered.
f. **Development and deployment of GIS-based collaborative applications.** The data provided by or included within the GIS system may be used for developing collaborative applications where the traffic participants act together to complete tasks.
g. **GIS system reliability.** The safety systems installed in vehicles, which implement the awareness, avoidance and warning functions, will use the data provided by the GIS system when determining the risk of a traffic situation. Therefore, the accuracy of these data needs to be high.
h. **Cost issues** related to the development and deployment of the GIS system.

2.3 Integration of GIS and AI in Routing Optimization

Discussing on the integration of Routing Optimization using GIS and AI, it brings the author to study in details on the implementation of the system which is based on GIS and AI using Java programming language. Vehicle has been the most important transportation for the community to move from one place to another. Reducing the traffic demands helps to reduce traffic jams, thereby alleviating the air pollution [2]. Routing optimization using GIS and AI application allows people to access and retrieve spatial information on the shortest path to their destination from a current location. Worldwide, the transportation problems faced by various nations have increased manifold, necessity search for methods or alternatives that ensure efficient, feasible and faster means of transport. This is all true if it based on our country Malaysia, where during the peak hours in weekdays, the congestion is really bad especially in urban areas. However, to

implement the ROS, it has its own characteristics that need to take into consideration as well as the road names need to be updated.

2.4 The existing system implemented and its objectives

Although in Malaysia the car manufacturer still in their development phase in implementing this system, it has already been used widely in Europe and Japan country. The system that already been implemented is called Advanced Traveler Information System (ATIS) or Intelligent Transportation Services (ITS) [4] [5].

The shortest path is defined as minimizing the distance, time, cost or combination of criteria under deterministic environment. The uncertainties arise from many resources such as the traffic demand and link capacity during the peak and non-peak hours, the variation of seasons and weather conditions, the unpredictable intersection delays, the mixed traffic flow by different vehicle types. Research done by Michael Rice in his paper on "Computational Intelligence Algorithms for Optimized Vehicle Routing Applications in Geographic Information Systems" says that travelers rather pay a toll road to avoid the congestion and to achieve greater reliability in travel time. The distance-based model is to solve the multi-objective optimization problem with the help of Pareto analysis. The Genetic Algorithm (GA) is an intelligent stochastic scorch method for optimization complex problem. However, it is difficult to maintain the feasibility of a chromosome under GA's crossover and mutation operation. The numerical experiment is to ensure the availability of the system [10].

D. Thirumalaivasan and Prof. V. Guruswamy in their paper on "Optimal Route Analysis using GIS" stated that even in India has divided the roads into North, West and Southwest, it still unable to accommodate the current traffic loads, where the main concern is on the ambulance and fire services that are needed regardless the time. This study is to find the solution on optimal route between two given points; either it is the shortest path or the minimal travel time to be selected.

Research has been done that the use of public transport too in planning to reach the destination is one of the option taken by the road user. Using the connectivity matrices of three nodes, it computes the travel time as it is to maintain the efficiency of the time arrival. The invented connectivity matrices can capture the route constraint on how to travel from origin to destination. Its objective is to provide the shortest path or just to arrive to the destination which reluctant of saving time and cost [2].

The Routing Optimization System will provide the information needed by the traveler once they are on the road. The information provided is based on the integration between GIS and AI where with these two elements it will utilize the emergence of computer, communication and information technology. The system will coordinate the transportation systems in a safe and efficient ways to monitor the traffic conditions, control traffic flow and hence provide the information on road traffic to enable the awareness for the traveler. The traveler will be well-informed to choose their path, saves travel time and helps in avoiding the congestion. It uses GIS based advanced traveler information system to assist individual and fleet drivers of changing traffic conditions using wireless technology and spatial databases. ATIS uses ArcView GIS environment to develop route planning, which provide shortest distance, quickest route, vehicle traffic restrictions and driver's travel preferences [4].

However, according to Anthony Chen in his paper on "A Simulation-based Multi-Objective Genetic Algorithm (SMOGA) for Transportation Network Design Problem" stated that the travel demand forecast is affected by the:

i. Economic growth
ii. Land use pattern
iii. Socioeconomic characteristics

Those factors however, cannot be measured and the issues raised are profit and welfare maximization problem. The information on multiple objective optimizations would facilitate and enhance the decision making concept regardless knowing the travel demand

uncertainty. Based on the system algorithm, it is for transportation planning and management problem, whereby the leaders (system) will guide the traveler [3]. While in network clustering based the routing algorithm in a location-based is focused on the flooding for vehicle to vehicle communication. Ad hoc networks have addressed the difficulties related to unicast routing. The algorithms are proactive and reactive, which depends on the route discovery mechanism. The proactive algorithm do not introduce a delay before sending data while reactive nodes discovered routes on demand and maintain only active routes. The Ad-Hoc On-Demand Distance Vector Routing (AODV) and Location Routing Algorithm with Cluster-Based Flooding (LORA_CBF) are compared by simulation. It uses the traffic model of OPNET to evaluate average route discovery time, end-to-end delay, routing load, routing overhead, overhead and delivery ratio [6].

Routing Optimization System is using the path algorithm to determine the link that can be traversed directly from the nodes in the fastest way. This research is done with one objective which is to optimize the system. Therefore, the issue whether the user will beneficially use the system is arised. The system is on dynamic traffic that uses topological vector GIS to create two tables, which are supply and demand of travelers at nodes and information on cost and capacity functions for the arcs. This would minimize the time travel to the destination. The first issue is advantage in designing object oriented interface and logical network structures. Second, the result of path finding is not solely algorithm result because of it depends on building and maintaining labels. The network assignments application is mainly on route guidance and network planning [7].

The GIS application can be implemented not only using Java programming language as to find the shortest path. There are several systems that using GA as the algorithm to calculate the shortest path in their system. However, in implementing GIS and GA, it needs the help of an agent, Ant Colony Optimization (ACO). Vehicle routing involves finding efficient routes for vehicle in order to minimize route length, service cost, travel time and number of vehicles. The ACO is a multi agent that behaves like an ant, where the ant will choose the shortest path to their destination if there is a choice of route [9].

2.5 The future enhancement done on Route Optimization System

Based on the author research, these route optimization systems that have already been implemented can enhance their system. As most of the objectives of implementing the system are all the same which are to provide the:

i. Shortest path
ii. Minimizing the travel time
iii. Minimizing the cost
iv. To find the optimize route in their system.

From only as a web-based or stand-alone system, this ROS can be implemented in wireless aspects too. There is an intelligent transportation planning based on computer supported collaborative work (CSCW) that would satisfy the needs for collecting, issuing, interchanging and sharing the georeferenced information and provide the collaborative working environment with Java GIS and J2EE technology. Using the rapid application development methodology in developing this GIS based applications can minimize the costs and time. The GIS java applet is the front end in the browser to show the graphical map. The transportation planning principles are:

a. Information sharing
b. Human computer interaction based on WEB-GIS
c. Transportation planning projects broadcasting
d. Transportation planning department, traffic department, relevant government department and public cooperation.

The system provides a visual of GIS and CSCW environment that fulfill the needs of transportation planning, it can be viewed via internet that can access anywhere in the

world and can speed up the transportation planning decision making as it involves many different departments and public people [8].

With the motivation from the existence system, it is not possible for this ROS being implemented in this project as well. Hence, no matter of using any algorithm to find the shortest path, the important information is behind the interface, with databases of road names along with the distance, timely updates of current information, and appropriate retrieving response information. These are the challenges of ROS in assembling, updating, and distributing mass of information in a convenient way to suit traveler's needs in minimizing the travel time.

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 Procedure Identification

The methodology being used to develop the prototype is Rapid Application Development (RAD). RAD methodology is emphasizing the extensive user involvement in a rapid construction of working process of a system to accelerate the system development process. RAD helps in decreasing time needed to implement information systems radically through speedy development and shorter schedules.

RAD methodology consists of four (4) phases:

i. Requirement Planning Phase (Analysis)
ii. User Design Phase (Design)
iii. Construction (Detailed design and code generation)
iv. Cutover (Installation and Handover)

This project will go through all phases in order to come out with the prototype of Route Optimization System. The following diagram depicts the relationships between stages in the RAD process.

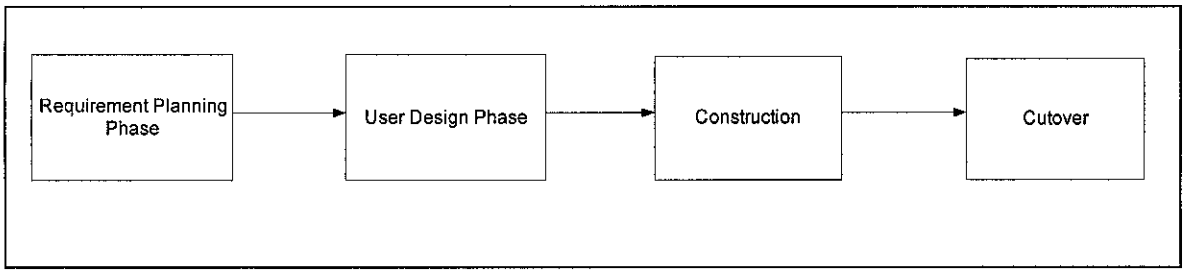

Figure 3.1: Rapid Application Development Process

While in each phases, there are sub-tasks being done in order to complete the phases to implement the system.

3.1.1 Requirements Planning Phase (Analysis)

The first phase in RAD is also known as Concept Definition Stage. In this first phase, the author identified the objectives of implementing route optimization system as well as the requirement specification needed including hardware and software specification for the prototype of the system. Study on the existing system that is implemented in Europe has been done to have better understanding and as the motivation to implement the stand-alone system. The forecast problem and limitation of the system has been identified and analyzed as well. During this phase, there are lots of findings, research, white papers, articles, journals and relevant web site forum that covering the Route Optimization, using Java application, GIS, AI and related area. Those findings were used for the author to study their methods in implementing the routing optimization system and producing desired result of the proposed system. The studies focused on characteristics of particular ROS products available in the Europe market to provide initial functional and non-functional requirements for Routing Optimization System.

The proposed system enables the traveler to communicate via query for the suitable route for their destination. Kuala Lumpur area is given as prototype to implement this project. Therefore, two layers are used in order to give the information on the road condition in that area. Besides, the study on deciding which software tools and application will help in developing and implementing the proposed project.

3.1.2. User Design Phase (Design)

The second phase in RAD is also known as Functional Design Stage where the designing and refining involved. The scope, objectives, data models and reports previously done during analysis stage were reviewed and revised. Based on the findings of research and studies during analysis phase, the system's workflow and ideas in developing the project

is identified. Hence, the initial design of the prototype is done. The objective of this proposed project is to enable the traveler to browse a digital map so that they can choose the best, wise and shortest route to their destination. The files obtained are in following format:

File Format	File Name
.shp	Shape File
.dbf	Database File
.shx	Index File

Table 3.1: File Structure

Below is the identified workflow of the Route Optimization System:

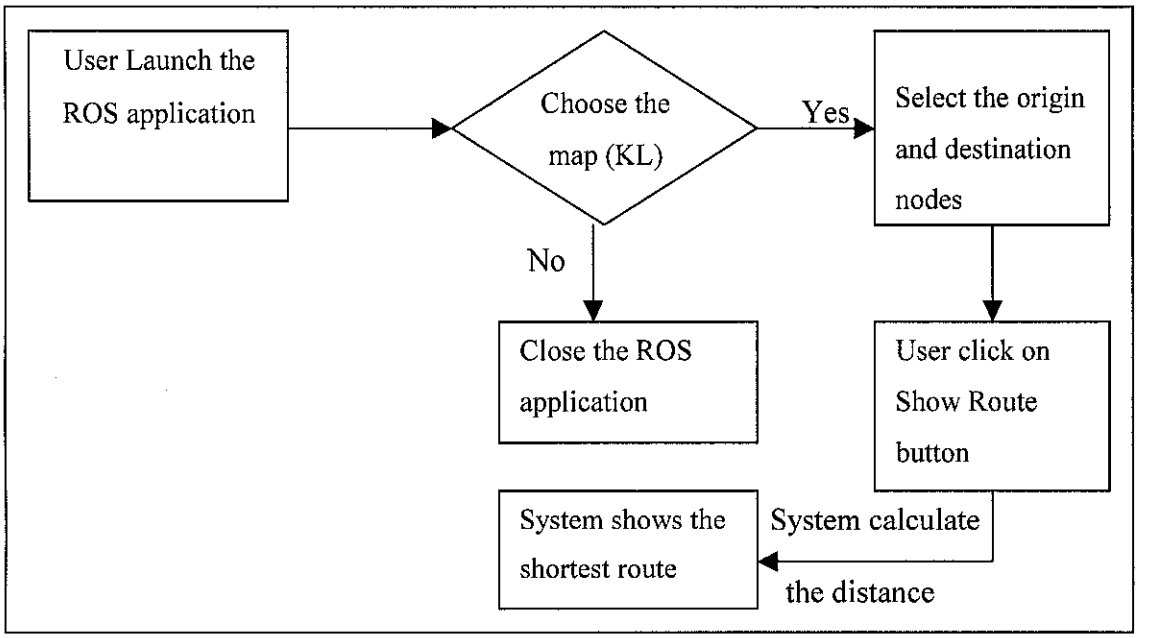

Figure 3.2: Proposed Workflow for Route Optimization System

As for an introduction of this ROS, the system is developed in a stand-alone basis. The information on the database, such as the road names and distance are static. This ROS is mainly to reach the objective to provide the traveler the shortest path for their journey. Firstly, user needs to launch the ROS application and using the *File-Open* menus; user

can choose the digital map that will show the road, but in this case, Kuala Lumpur area is the study area. Once the user chooses the map, the system will display the map for a better view. In this interface, it provides the user to choose their origin and destination nodes to search for the shortest path. Once the user clicks on the *Show Route* button, the system will calculate the distance and provide the shortest path.

The software that is used to edit the shape files data in this phase is ArcView GIS 3.2. This software is used to sort the layer in the shape file format so that the traveler can have a better view via digital map. Besides, using this software tools it enable the map to show the road names in label format so that it helps the author to study the Kuala Lumpur area. For this route optimization system, the design constructed mainly focus on user friendly, where the traveler can understand the digital map as well as the interface provided.
Initial interface has been drafted and designed. This is to give the author more focus on the basic processes common to all components in the system's prototype. The components tend to be data-intensive, so that the designs for the basic components concentrate on user interfaces for searching and applying the shortest route function. It is also for concentrating on user interfaces design in handling the retrieval information on the shortest route for the desired road.

Database scheme and tables was designed in this phase. The database for Kuala Lumpur spatial data was already generated during the creation of the layers. For the system database, it only uses one table, which consists of the distance and road names. In this table, the attributes stored are for the system to calculate the distance hence provide the shortest route based on the user requested. Below is the structure of the database in a .dbf file that is viewed using Microsoft Access 2003.

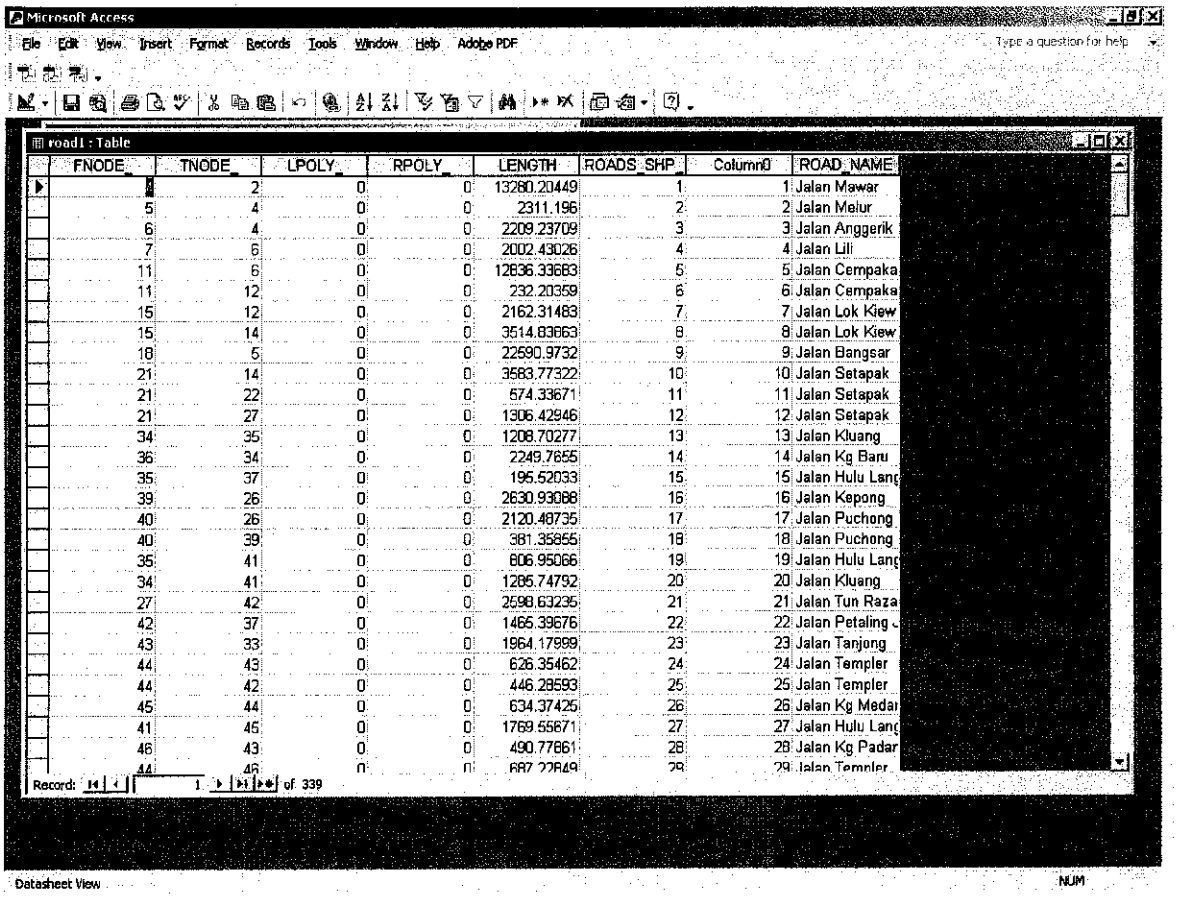

Figure 3.3: Database Structure of Kuala Lumpur area in Design View

3.1.3. Construction (Detailed Design and Code Generation)

This third phase in RAD is also known as Development Stage. During the development, detailed design is done using suitable design tool and the design is translated into code via code generator. Adjustments and necessary modifications will be made. The system's prototype will be implemented in a series of 'design-and-build' steps. With the sequence of this step, it enables the changes during planning designed and review the resulting software implementation. The changes will be done during design as the codes will be regenerated and optimized. This stage also includes in preparing for the cutover to production. However, before the cutover and hand over, selected users will be needed to validate and test the system comprising the screens layout and also the functions of the prototype itself. Usability will be done on every subsystem to ensure that the system's prototype is easy to use. Testing will be done on the following features and

functionalities to ensure they are operational: analysis on finding shortest path, capturing or exporting the shortest path image, basic functionalities of ArcView GIS 3.2 in Forte for Java software tools using Java environment, algorithm that works when query is made.

The prototype and code generation is done via Forte for Java software tools as the programming language used is also Java. Using this software tools, the code generation is done to have the connection between the package involved such as graphics package, road names package and the algorithm to calculate the shortest route package. The calculation of distance is using Djikstra algorithm.

3.1.4. Cutover (Installation and Handover)

The final phase in RAD is Cutover or Deployment Stage, where it involves various activities towards the implementation of fully functional prototype into real environment. This may include implementing bridges between the existing data, converting data, training users. The user acceptance is the end point of the implementing stage. This route optimization system is able to being widely-used once the user satisfied during the user acceptance testing on the system. The system is the modified version as the result from feedback during testing. In this phase, once the system is already fully tested and satisfied by the end-user the final documentation is prepared to guide them in using the system. The system is expected to function correctly and is user friendly so that the traveler can easily browse the map along with the useful information provided.

Applying RAD as the chosen methodology has provided the author with various advantages. RAD tools are easy to learn and promote good design of a user-friendly interface. Furthermore, RAD allows for quick testing and debugging of a system as it provides early visibility through prototyping. In addition, RAD also offers greater flexibility in which redesign process is done almost at will.

3.2. Tools

The Route Optimization system is combination of GIS and AI application. With that, there are few types of software that need to be used in order to implement this project. Here are the listings of software and hardware that is used in this project.

3.2.1. Software

No.	Software	Description
1	ESRI® ArcView GIS 3.2	For analyzing, mapping, managing, editing, sharing, and publishing geographic information
3	Forte For Java	For designing the prototype and as the scripting programming language
4	Microsoft® Access 2003	For database management

Table 3.2: Software Requirement

3.2.2 Hardware

No	Device	Requirement
1	Operating System	Microsoft Windows XP
2	Processor	Intel Pentium 4 2.40 GHz
3	Memory	712 MB of memory
4	Disk Space	40GB of free space
5	Monitor	15" or 17" best viewed in 1024 x 768
6	Other Peripherals	Keyboard, Mouse

Table 3.3: Minimum Hardware Requirements

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Findings

Results and several findings related to the research works are presented in this section. As the product for this project will be the prototype of Route Optimization System, the findings and results will cover on displaying the map, searching the roads based on the current location to the desired location, visible the nodes or lines of the road on the map, the integration of GIS and AI, getting the shortest path as user requested, and prototype of Route Optimization System as well as the future enhancement of this system.

4.1.1 Displaying the map

During the implementation of the system prototype, Java is used as programming language to display the map. Below are the figures shows that the user can choose the map to suit their destination in an area.

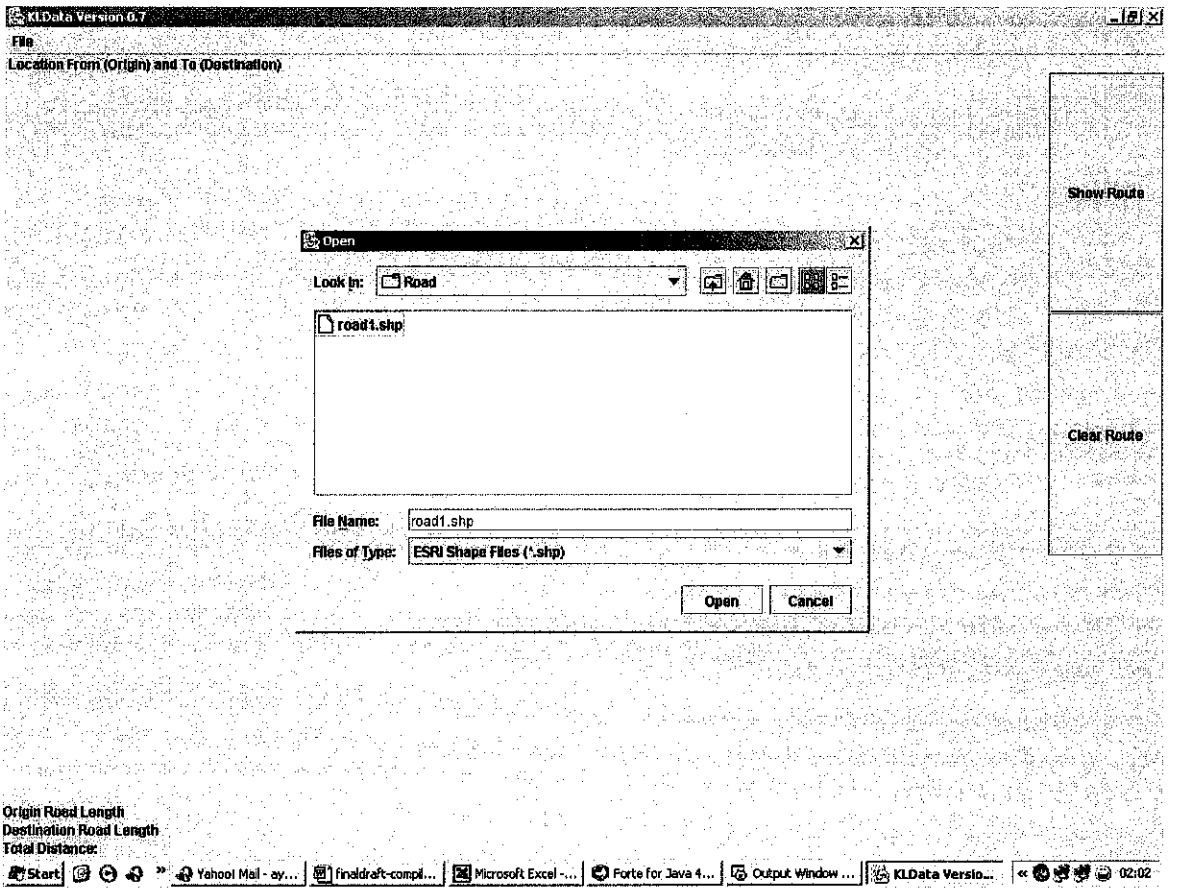

Figure 4.1: Interface That Enable User to Choose .shp File as Reference Map

As for the testing development phase, the author is using Kuala Lumpur area as the study area on this system. However, the used of *JFileChooser* gives an advantage for the user to choose a map, which is in .shp file. This means the system can cater any area of the roads as long as it is in .shp file. Below is the sample of coding of *JFileChooser* for the user to choose the shapefile data.

```
                class ShapeFileFilter extends javax.swing.filechooser.FileFilter
{
  public boolean accept(File f)
  {
    if (f.isDirectory()) return true;
    int index = f.getName().length() - 4;
    if (index > 0)
      return (f.getName().substring(index).equalsIgnoreCase(".shp"));
    else
      return false;
  }
  public String getDescription()
  {
    return "ESRI Shape Files (*.shp)";
```

```
    }
  }
void getInputFilename()
  {
    JFileChooser fileChooser = new JFileChooser();
    fileChooser.setFileFilter( new ShapeFileFilter() );
    int result = fileChooser.showOpenDialog( this );

    if( result == JFileChooser.APPROVE_OPTION )
      open( fileChooser.getSelectedFile() );
  }
```

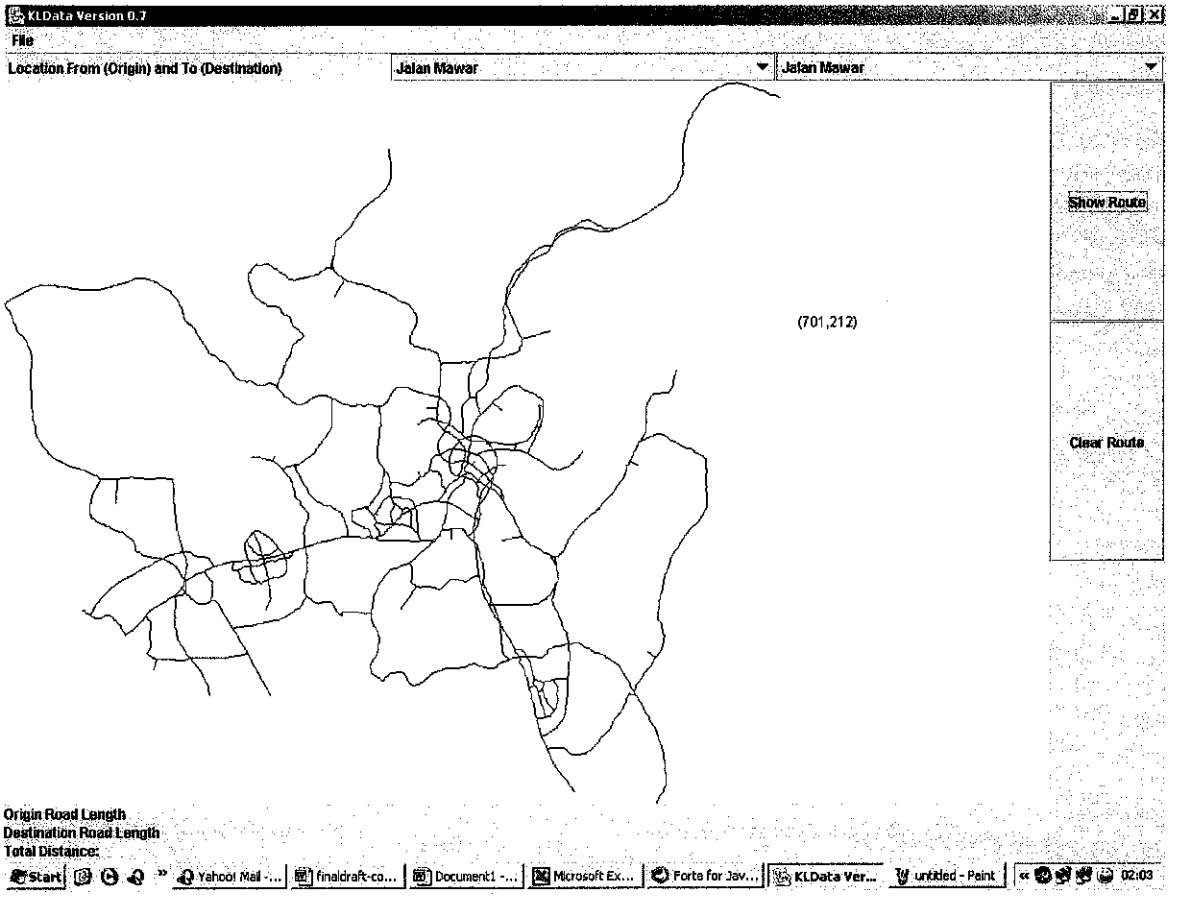

Figure 4.2: Kuala Lumpur Area View

Above is the interface once the user clicks on the *Open* button in the Figure 4.1. It will display the road layer of the Kuala Lumpur area. From here, the user can choose the origin and destination location to retrieve the shortest path to reach the desired location. Below is the sample code that is been using in Java application to display the map.

```
private void open(File file) {
```

```
    try {
      String path = file.getPath();

      map = new Map(path);
     getContentPane().add(map,java.awt.BorderLayout.WEST);
      setSize (map.getPreferredSize());
    } catch (Throwable t) {
      JOptionPane.showMessageDialog(this, "An error occurred while loading the file",
        "Map viewer", JOptionPane.ERROR_MESSAGE);
      t.printStackTrace();
    }
  }
```

4.1.2 Visible the node or line of the road on the map

The system is mainly implemented to find the shortest path for the user to reach their destination. However, this system can inform user which road that they choose. In order to make it happen, once the user choose the road names in the combo box provided, the road will automatically change into another color. As for this system, the origin road is in green and the destination road is in red. With this function, user will be more alert on which road they are choose. In addition, the user interface designed also provides the *Show Route* button. The function of this button is to calculate the distance along the path connected to the desired location and find the best and shortest path to the destination. The node or line of the road on the map will change to another color once the shortest path is obtained. As for this ROS, the shortest route will highlight in yellow.

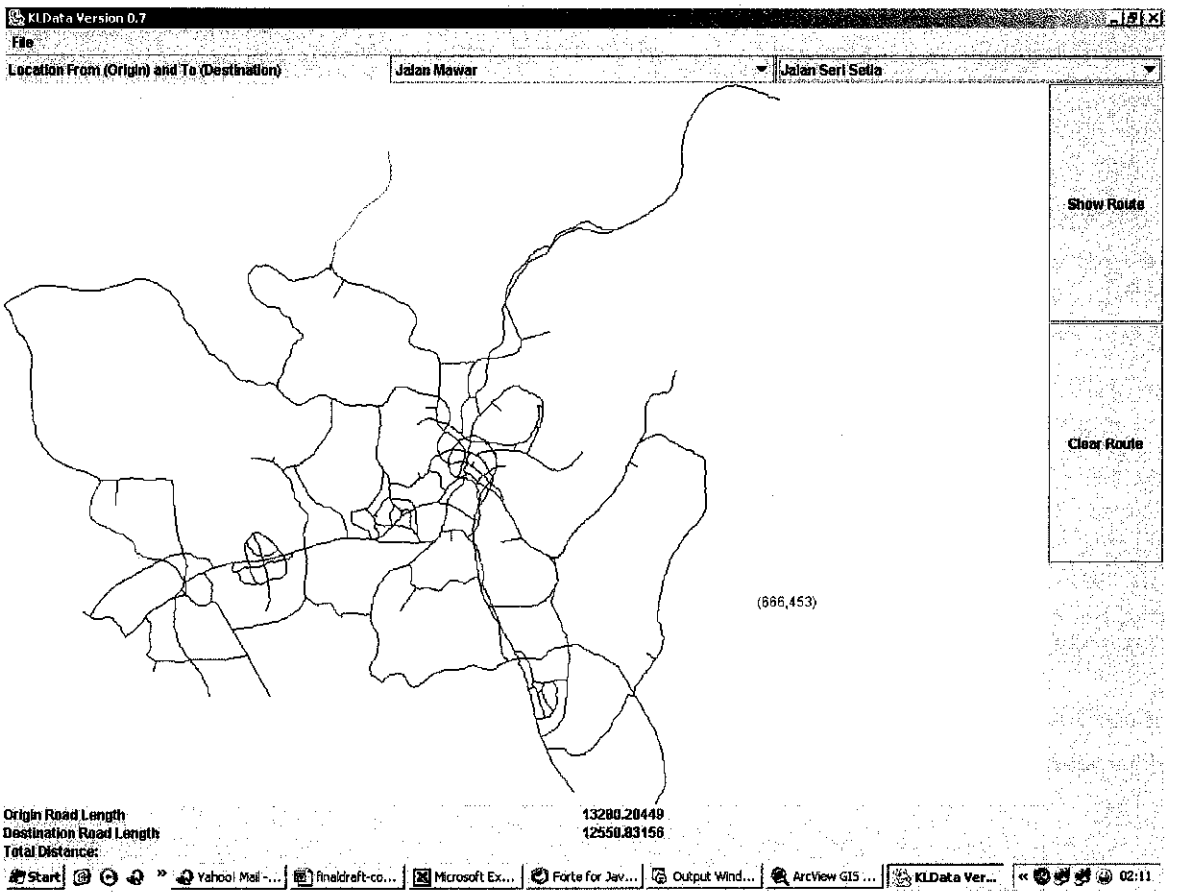

Figure 4.3: Selected Origin and Destination of the Road

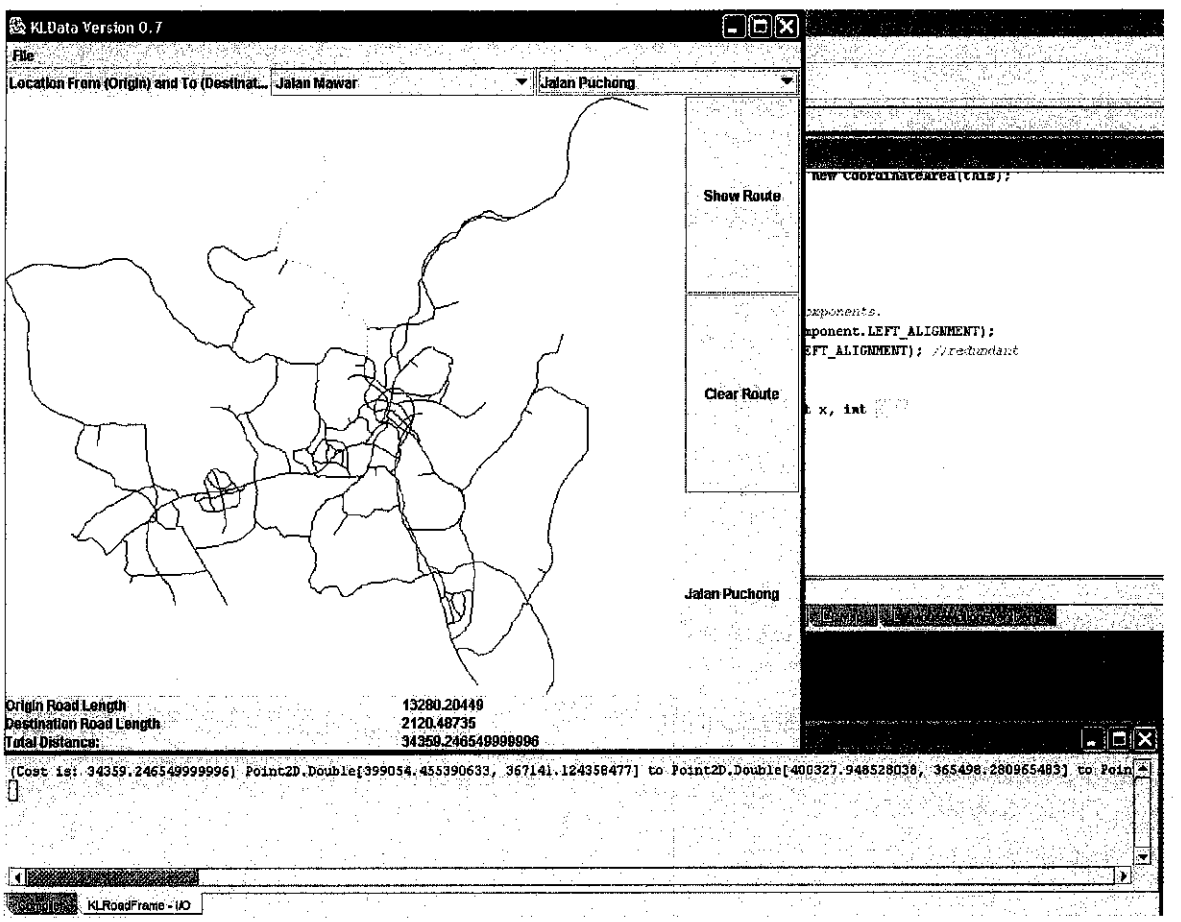

Figure 4.4: Shortest Path is Highlighted in Yellow

The figure above shows that the shortest path of the desired location is put into another color. This is to emphasize that it is the path that the user should take. Hence, the interface also provides the length of origin and destination, as well as the total length after the shortest path is calculated.

The *Clear Route* button is to make the road (polyline) in the map return into black line.

4.1.3 Database of the road

The database which consists of the road names and distance is connected and link to the Kuala Lumpur road data. Here is the interface that proves the database is successfully available and parallel to match the map data. As for the testing phase, the system will prompt the user and asking about the road names that is available. If the road name is in

the database, it will give the result along with the location of the record such as '*That is a valid address, in record 26'*.

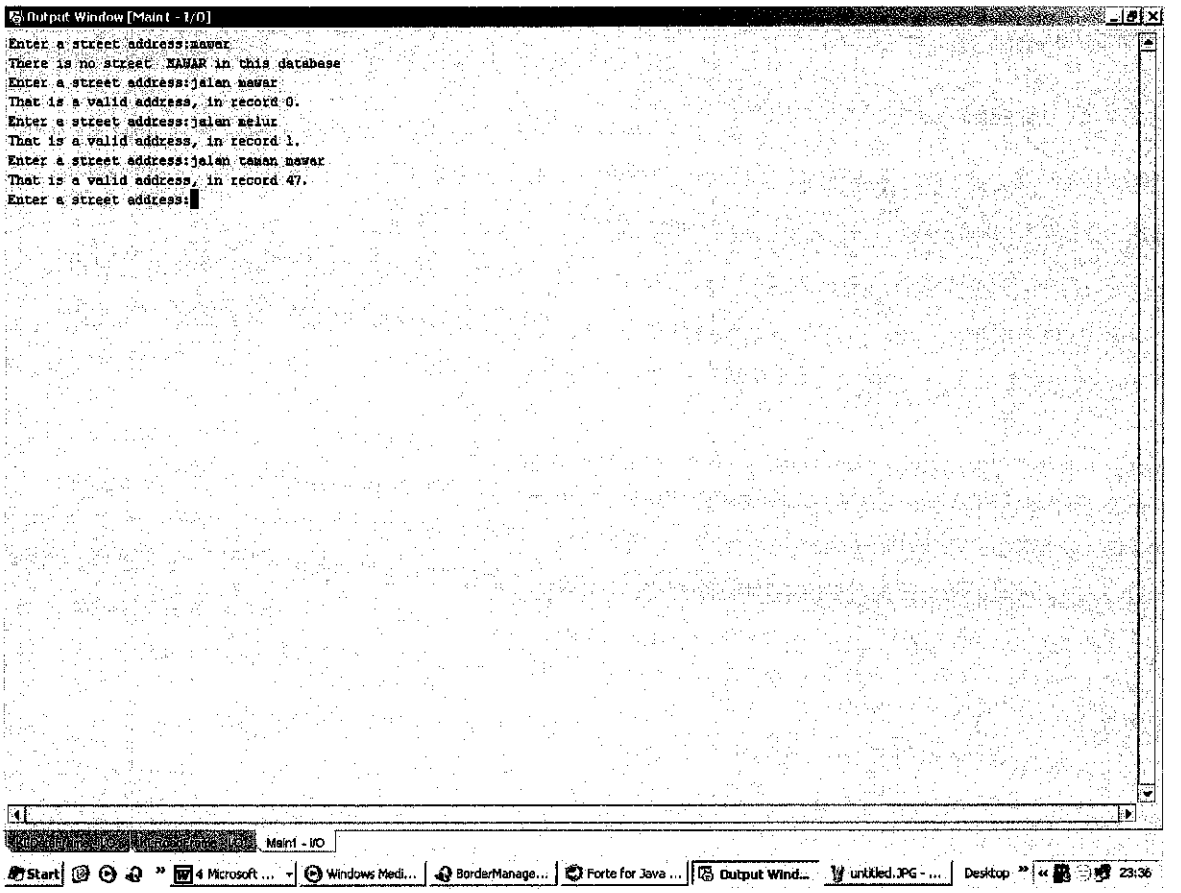

Figure 4.5: Database Interface View

In addition, the database is now available in the combo box which already connected to the map. As the system is a stand-alone basis, the database (.dbf) is pointed using the index file (.shx) to the map (.shp).

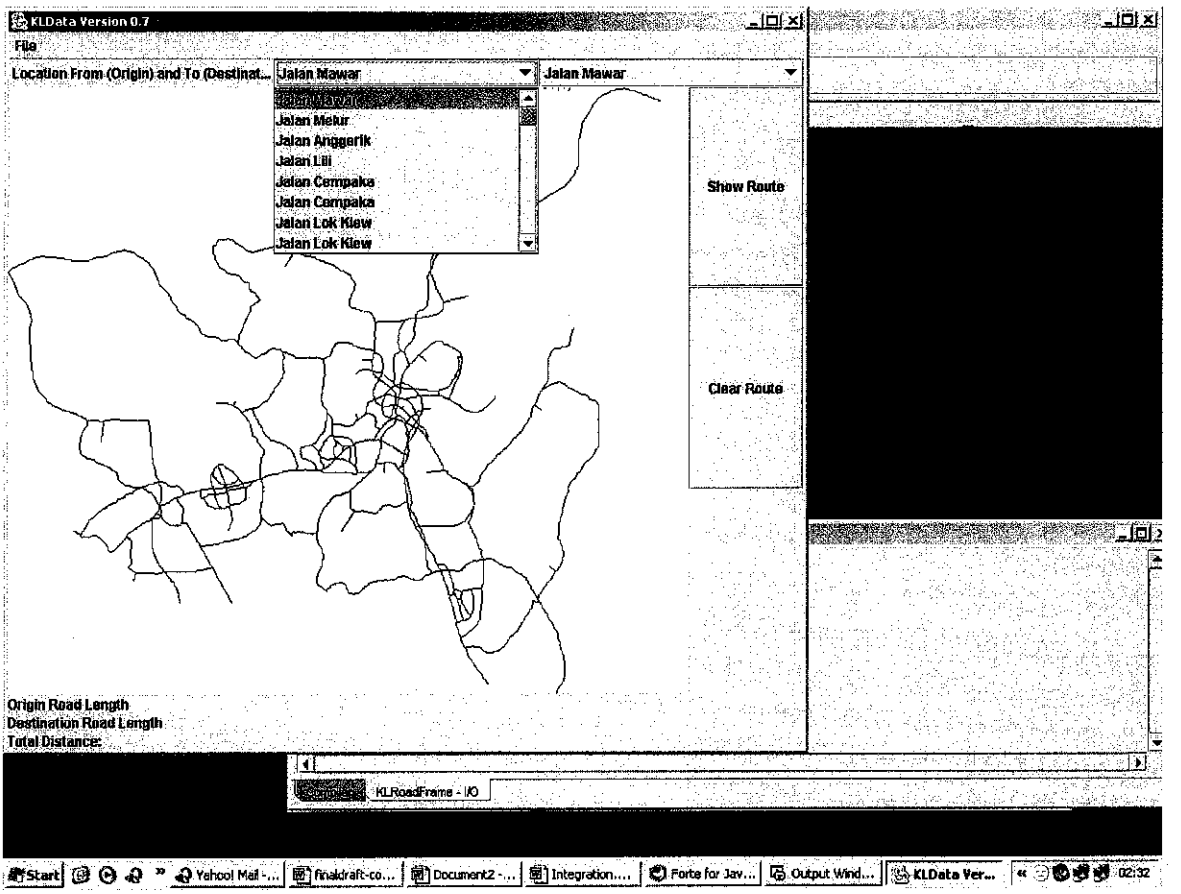

Figure 4.6: Database in the Combo Box Connected to the Map

4.2 Discussion

Based on the findings, several issues are taken into account that generates important indicators for the successful of this project. The issues are discussed in the following sections.

4.2.1 Integration of GIS and AI in Route Optimization System

Based on the research and findings, it is proved that the routing optimization system can be successfully implemented regardless the use of programming language, whether it use Java, VBA or GA. ROS deal with a large volume of spatial data. By incorporating AI application in ROS, it could utilize the capabilities of today's technology from just being a medium of information through their personal computer and internet to a more beneficial device. As GIS is the vital elements in ROS, ROS can be more successful if more GIS functions and features are introduced into the system. Thus, variety of services can be provided via ROS rather than just retrieving the shortest path only as introduced in the prototype. The prototype provides a basis on how the actual ROS should look like and represents the technologies that should adhere in designing reliable Route Optimization System.

Human-Computer Interaction (HCI) principle is applied in designing interface of the system prototype. As usual, the main menu, which is the *File* is put on the top left of the interface. This is to provide standard Windows-like screen representation as other program. This is shown by the use of pull-down menu. The *Help* function is placed next to the *File* menu. This menu function can help the beginner user to browse the system and learn on how to use it. The button provided contains required actions on for the prototype and each button is provided with simple description or notification informing what this control will do when pointing the mouse on the controls' icons. Furthermore, elements in GIS such as the code for displaying the map and their database on the road names are divided into separate package in single interface. However, the usage of this package is implemented in the same interface. The package is divided to make the code

in the system not too chaos and to avoid the difficulties if there is error occurred. The use of colors is also taken into consideration in which standard Windows-like colors are used for the interface design.

4.2.2 GIS Search Query

As mentioned, the research focused on the capabilities of the prototype in performing simple spatial data in finding the shortest path. Users select the current and desired location and click on the button to have the result of the shortest route. The results for the search depend on the performance and data availability in the database. The basis for this prototype is that it is rule-defined in which the road names and the distance have already been generated and stored in the database. It means the administrator needs to update the road names, the distance and generate images in advance if there is any updated information on that particular information. The administrator adds and view whole Kuala Lumpur spatial data area in the prototype and generates particular view on the database as it needs to calculate the distance and provide the shortest path. So, whenever the request made to the system, the data have already there in the database. For the new request that has no result or match, administrator can do it directly by updating the Kuala Lumpur spatial data area into the database and update the image as well upon user requested being made. From the explanation, analysis on the Kuala Lumpur spatial data area must be done first to make sure that the simple spatial data search can execute correctly.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Relevancy to the Objectives

The needs for Route Optimization have increasingly rapidly especially for the vehicle owner and for recent years; it has been introduced into transportation networks. Although it can be said as quite new concept in Malaysia because it still in development stage, it has opened new dimension of vehicle services offerings to transportation enthusiast. With respect to relationship between GIS and Route Optimization, functioning ROS clearly needs GIS functionalities incorporated in the system in order to provide spatial and location information that are relevant to human life. As for the AI perspective, it has high potential to enhancing the capabilities of GIS in realizing the establishment of decision making and act as the agent with a brain in Route Optimization network.

It is proven that the project able to meet all objectives outlined. The project is able to come out with the prototype that benefits traveler in obtaining information on the shortest path with small-to-medium experimental area. In addition, it shows the possibility and the success of integrating GIS and AI in Route Optimization System.

As a whole, Route Optimization System (ROS) is a new practical method to retrieve the shortest path information. By having this system, users will be able to reach desired location in less time.

5.2 Suggested Future Work for Expansion and Continuation

There are several suggestions and recommendations that can be done to this project and the prototype, so that it can be expanded in the future to produce more reliable and practical ROS.

5.2.1 Conversion to Web-Based and Wireless Route Optimization System

It is more reliable to have this prototype up and running in a web-based platform. This is to ensure that the prototype would be able to support more users and is highly available using web-based. For successfully implement this, different kinds of hardware and software are required in order to cater and match the car specification. The equipments must be high-end to support many transactions and requests. Hence, when ROS is converted to web-based platform, it is expected that it could support more spatial data areas and large database on the road names and distance. The system also should be able to work successfully with Personal Digital Assistant (PDA) and latest MMS mobile phones that use Symbian Operating System.

5.2.2 Use High-End Database Management Systems (DBMS)

Currently, the prototype uses Microsoft Access as the DBMS. However, for future enhancement, it could not support as the data stored will become larger and larger. This is due to large data stored on the distance of each road that will be stored in the database. It is suggested that in the future, ROS uses Oracle9i Spatial or MySQL as the DBMS. Oracle9i Spatial really supports the development and integration of location based services. While Oracle routing optimization uses Oracle Spatial internally as a component of the Oracle9i database repository, developers seeking to integrate their products and services to Oracle9i, are not required to have Oracle Spatial. Oracle Spatial as a Spatial Data Option is a component of the database server Oracle9i. It supports spatial data and advanced geographical functionality as an integrated part of the database. Data can be transformed between coordinate systems and projections. The use of advanced multidimensional and spatial indexes enables scalable management of spatial data. Oracle Spatial functions like an actual application, including personalization and integration of spatial and non-spatial functionality. Typically, route optimization is not itself very data-intensive. Rather, it processes and aggregates the information retrieve related data from the algorithm calculation. Applications of Oracle Spatial (such as GIS) are very different.

They tend to have data-intensive core spatial requirements with dependency on high scalability and integration of large amounts of spatial data from different sources and in different coordinate systems. However, ROS within Oracle9i is agnostic with respect to whether the external provider uses Spatial or any other technology. Many external services do, in fact, use Oracle Spatial for its excellent features and scalability. But this is a choice they made based on the merits of Spatial, rather than due to any integration

5.2.3 Integration with Global Positioning System (GPS)

When discussing about having the route optimization based services, it is necessary to consider Global Positioning System (GPS). The author suggests that for future expansion, it is feasible to integrate ROS with GPS. The prototype presented in this paper relies on static image and database. GPS is the most widely known satellite-positioning technology that offers high accuracy readings since the data on location information is in real time. This will help not only to find particular location but also able to determine the location of the users themselves. So, by having real time information in ROS, it will improve the reliability of the system. The system will have the ability to track the transport as an additional feature. Besides, using the GPS application, ROS can have the real time basis whereby it can get the updated information on the road condition. By having GPS, it provides added-value to the capabilities of ROS.

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4. http://www.spatialworks.com.my

APPENDICES

Sample of Coding

```
/*
 * KLRoadFrame.java
 *
 * Created on October 10, 2005, 12:49 PM
 */

package KLFrame;
import java.io.*;
import java.awt.*;
import javax.swing.*;
import graphics.*;
import le.LEDataInputStream;

/**
 *
 * @author  Guest
 */
public class KLRoadFrame extends javax.swing.JFrame {
    protected Map map; //declaring the variable

    /** Creates new form KLRoadFrame */
    public KLRoadFrame() {
        setDefaultCloseOperation(WindowConstants.DO_NOTHING_ON_CLOSE);
        initComponents();
        setTitle( "KLData Version 0.1" );
        setSize( 700, 600 );
    }
    class ShapeFileFilter extends javax.swing.filechooser.FileFilter
    {
        public boolean accept(File f)
        {
            if (f.isDirectory()) return true;
            int index = f.getName().length() - 4;
            if (index > 0)
                return (f.getName().substring(index).equalsIgnoreCase(".shp"));
            else
                return false;
        }
        public String getDescription()
        {
            return "ESRI Shape Files (*.shp)";
        }
    }

    void getInputFilename()
    {
        JFileChooser fileChooser = new JFileChooser();

        fileChooser.setFileFilter( new ShapeFileFilter() );
        int result = fileChooser.showOpenDialog( this );

        if( result == JFileChooser.APPROVE_OPTION )
            open( fileChooser.getSelectedFile() );

    }

    /** This method is called from within the constructor to
     * initialize the form.
     * WARNING: Do NOT modify this code. The content of this method is
     * always regenerated by the Form Editor.
     */
    private void initComponents() {
        jplMap = new javax.swing.JPanel();
        jLabel1 = new javax.swing.JLabel();
        jplQuery = new javax.swing.JPanel();
        jlbOrigin = new javax.swing.JLabel();
        jLabel2 = new javax.swing.JLabel();
```

```
        jcmbOrigin = new javax.swing.JComboBox();
        jlblDestination = new javax.swing.JLabel();
        jLabel3 = new javax.swing.JLabel();
        jcmbDestination = new javax.swing.JComboBox();
        jbtShowRoute = new javax.swing.JButton();
        jbtClearRoute = new javax.swing.JButton();
        jbtMarkRoad = new javax.swing.JButton();
        jMenuBar1 = new javax.swing.JMenuBar();
        jmFile = new javax.swing.JMenu();
        jmiOpen = new javax.swing.JMenuItem();
        jSeparator1 = new javax.swing.JSeparator();
        jmiExit = new javax.swing.JMenuItem();
        jmHelp = new javax.swing.JMenu();

        addWindowListener(new java.awt.event.WindowAdapter() {
            public void windowClosing(java.awt.event.WindowEvent evt) {
                exitForm(evt);
            }
        });

        jplMap.setLayout(new java.awt.BorderLayout());

        getContentPane().add(jplMap, java.awt.BorderLayout.CENTER);

        jLabel1.setText("KL Road Data");
        getContentPane().add(jLabel1, java.awt.BorderLayout.SOUTH);

        jplQuery.setLayout(new java.awt.GridLayout(3, 3));

        jlbOrigin.setText("Location From (Origin)");
        jplQuery.add(jlbOrigin);

        jplQuery.add(jLabel2);

        jplQuery.add(jcmbOrigin);

        jlblDestination.setText("Location To (Destination)");
        jplQuery.add(jlblDestination);

        jplQuery.add(jLabel3);

        jplQuery.add(jcmbDestination);

        jbtShowRoute.setText("Show Route");
        jplQuery.add(jbtShowRoute);

        jbtClearRoute.setText("Clear Route");
        jplQuery.add(jbtClearRoute);

        jbtMarkRoad.setText("Mark Road");
        jplQuery.add(jbtMarkRoad);

        getContentPane().add(jplQuery, java.awt.BorderLayout.NORTH);

        jmFile.setText("File");
        jmiOpen.setAccelerator(javax.swing.KeyStroke.getKeyStroke(java.awt.event.KeyEvent.VK_0,
java.awt.event.InputEvent.CTRL_MASK));
        jmiOpen.setText("Open");
        jmiOpen.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                jmiOpenActionPerformed(evt);
            }
        });

        jmFile.add(jmiOpen);
        jmFile.add(jSeparator1);
        jmiExit.setText("Exit");
        jmiExit.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEvent evt) {
                jmiExitActionPerformed(evt);
```

```
        }
    });

    jmFile.add(jmiExit);
    jMenuBar1.add(jmFile);
    jmHelp.setText("Help");
    jMenuBar1.add(jmHelp);
    setJMenuBar(jMenuBar1);

    pack();
}

private void jmiOpenActionPerformed(java.awt.event.ActionEvent evt) {
    getInputFilename();
}

 private void open(File file) {
        try {

            String path = file.getPath();

            map = new Map(path);
             getContentPane().add(map,java.awt.BorderLayout.WEST);
            setSize (map.getPreferredSize());
        } catch (Throwable t) {
            JOptionPane.showMessageDialog(this, "An error occurred while loading the file",
                "Map viewer", JOptionPane.ERROR_MESSAGE);
            t.printStackTrace();
        }
    }

private void jmiExitActionPerformed(java.awt.event.ActionEvent evt) {
System.exit(0);
}

/** Exit the Application */
private void exitForm(java.awt.event.WindowEvent evt) {
    System.exit(0);
}

/**
 * @param args the command line arguments
 */
public static void main(String args[]) {
    new KLRoadFrame().show();
}


// Variables declaration - do not modify
private javax.swing.JSeparator jSeparator1;
private javax.swing.JButton jbtShowRoute;
private javax.swing.JMenuItem jmiOpen;
private javax.swing.JButton jbtMarkRoad;
private javax.swing.JLabel jlbOrigin;
private javax.swing.JMenu jmHelp;
private javax.swing.JLabel jlblDestination;
private javax.swing.JComboBox jcmbDestination;
private javax.swing.JMenu jmFile;
private javax.swing.JButton jbtClearRoute;
private javax.swing.JPanel jplMap;
private javax.swing.JComboBox jcmbOrigin;
private javax.swing.JLabel jLabel3;
private javax.swing.JLabel jLabel2;
private javax.swing.JLabel jLabel1;
private javax.swing.JMenuBar jMenuBar1;
private javax.swing.JMenuItem jmiExit;
private javax.swing.JPanel jplQuery;
// End of variables declaration

}
```