KL PUBLIC TRANSPORT TRIP PLANNER

By

Maya Atasyah Bt. Sapian (8226)

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Technology (Hons)
(Information Communication Technology)

JAN 2008

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

KL Public Transport Trip Planner

by

Maya Atasyah Bt Sapian

A project dissertation submitted to the
Information Communication Technology Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF TECHNOLOGY (Hons)
(INFORMATION COMMUNICATION TECHNOLOGY)

Approved by,

_____
(Ms Diana Wong Mei Leng)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2006

CERTIFICATE 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 acknowledges and that the original work contained herein have not been undertaken or done unspecified sources or persons.

Maya Atasyah Bt Sapian

(8226)

ABSTRACT

KL Public Transport Trip Planner

Maya Atasyah Bt Sapian (8226)
Universiti Teknologi Petronas (UTP)
Bandar Seri Iskandar, 31750, Tronoh, Perak Darul Ridzuan, Malaysia
mayaatasyah@gmail.com

Urban life depends on transport, for movement of goods from where there are produced to where there are needed, and the movement of people from their places of residence to where they must go to pursue all the activities of life. A good transport system is vital to a city's development, at the same time the factors affecting the development of the city play an important part determining the way in which is most transport system evolve. Most of the transport problems experienced in developing cities are similar to those found everywhere in the world, although there may be significant differences in magnitude. In Kuala Lumpur, there are demands for public transport and therefore the levels of service provided have declined from time to time. As the Public Transport System (PTS) is being expanded and further developed, as is typically the case, the system is becoming increasingly difficult to navigate. To assist passengers in locating and using their services, transit operators often set up web sites to publish their routes. However, due the competitive nature of privately operated services, none of the operators publicize the routes of other operators, and also short of providing useful route guidance information across modes or across operators. The need of a common platform to provide routing information across modes and operators is apparent. This project will be developed to give route guidance to passengers and guide them with combined mode-route choices that can help them to plan their itinerary smoothly. This system forms a platform for disseminating public transit information and enabling travelers to make adequate and best choices.

ACKNOWLEDGMENT

Above of all, thousands of appreciation to God with the completion of my final year project and the preparation of this final report. Firstly, I would like to thank to Ms Diana Wong Mei Leng, for given me an opportunity doing my final year project under his supervision. With her guidance, encouragement and morale support, I was able to complete ***KL Public Transport Trip Planner*** successfully. Next, I would like to thank to Computer Information System (CIS) Department's lecturer, Dr P.D.D Dominic, Mr. Justin Dinesh and Ms. Shakirah Mohd Taib who has given a brilliant advice in order to complete my project. Finally, thank you to all my friends for sharing their knowledge and idea and make this experience as the most valuable treasure for me

TABLE OF CONTENT

1	Introduction	.....	1
	1.1 Project Background	.....	1
	1.2 Problem Statement	.....	2
	1.3 Objective & Scope of Study	.....	3
2	Literature Review / Theory	.....	4
	2.1 Background of Public Transport Service in Kuala Lumpur		4
	2.2 Public Transport Trip Planner	.....	6
	2.3 System Architecture	.....	11
	2.4 Graph Theory	.....	13
3	Methodology / Project Work	.....	18
	3.1 Evolutionary development Model	.....	18
	3.2 Detail Description of Evolutionary Development Model		20
	3.3 Project Timeline	.....	27
4	Results & Discussion	.....	28
	4.1 Data/Information Gathering	.....	28
	4.2 Conclusion	.....	32
5	Conclusion	.....	33
	5.1 Recommendation	.....	34
6	Reference	.....	35
7	Appendix	.....	35

LIST OF FIGURE

Figure 1	Public Transport Trip Planner's System Architecture	12
Figure 2	Graph with 6 nodes	14
Figure 3	Dijkstra's Algorithm Pseudocode	15
Figure 4	Floyd-Warshall Algorithm Pseudocode	16
Figure 5	Evolutionary Development	20
Figure 6	Overall System Flow Chart	22
Figure 7	System Flow Chart - User	23
Figure 8	Sequence Diagram - User	24
Figure 9	Use Case Diagram	25
Figure 10	KL Public Transport Trip Planner – Project Timeline	27
Figure 11	Pie Chart – User of Public Transport	29
Figure 12	Pie Chart – User Preference	29
Figure 13	Pie Chart – User Experience while Using Public Transport .	30
Figure 14	Pie Chart – The needs of KL Public Transport Trip Planner .	30
Figure 15	Pie Chart – Features Needed	30
Figure 16	Pie Chart – Computer Literacy	31

LIST OF TABLE

Table 1	KL Integrated Transit Network Average Daily Commuters .	5
Table 2	Comparison between existence system	30
Table 3	Effect of route planner service	32

ABRERIATION & NOMENDATURES

Public Transport System	PTS
University Technology of Petronas	UTP

LIST OF APPENDIX

Appendix I	Integrated Transit Network of Kuala Lumpur
Appendix II	Integrated Transport Information System
Appendix III	KTM Interactive Train Timetable/Fare/Seat Availability
Appendix IV	Washington Metropolitan Area Transit Authority
Appendix V	London Underground – Journey Planner
Appendix VI	KL Public Transport Trip Planner
Appendix VII	Novo's Trip Planner System Architecture (Example of others system architecture)
Appendix VIII	E-finder System Architecture (Example of others system architecture)
Appendix IX	KL Public Transport Trip Planner - Nodes
Appendix X (a)	KL Public Transport Trip Planner – Main Page
Appendix X (b)	KL Public Transport Trip Planner – User Input 1
Appendix X (c)	KL Public Transport Trip Planner – User Input 2
Appendix X (d)	KL Public Transport Trip Planner – System Output
Appendix X (e)	KL Public Transport Trip Planner – Login Admin
Appendix X (f)	KL Public Transport Trip Planner – Admin Menu
Appendix XI	KL Public Transport Trip Planner Questionnaires
Appendix XII	KL Public Transport Trip Planner Interview Plan

CHAPTER 1
INTRODUCTION

1.1 Project Background

In many transit-oriented cites around the world, the majority of the population depends on the Public Transportation System (PTS) for their daily travels. For example, in Kuala Lumpur most of the population depends on the PTS for their daily travels especially during peak hours, and "certain public services are bursting at the seams in the wake of a 60% jump in population in the past 16 years" (The Star, 26 May 2007).

As the PTS is being expanded and further developed, as is typically the case, the system is becoming increasingly difficult to navigate. To assist users in locating and using their services, transit operators often set up web sites to publish their routes. However, due the competitive nature of privately operated services, none of the operators would publicize the routes of other operators, and also short of providing useful route guidance information across modes or across operators. The need of a common platform to provide routing information across modes and operators is apparent.

Developing a transit route guidance system is equally important so that the PTS can be utilized to its full extent. Such a multimodal route guidance system not only allows travelers to find their ways to destinations, but more importantly aware of the alternatives and choose accordingly, such as minimum cost, time, or number of transfers. Responding to this need, this project develops a transit route guidance system called ***KL Public Transport Trip Planner***, which serves to facilitate users' navigating the sophisticated multi-modal PTS.

1.2 Problem Statement

Rapid urbanization in the developing countries has often been accompanied by the increased need for urban travel. Increased levels of economic activities coupled with the spatial spread of cities beyond their traditional limits have led to an increase in trips made, often considerably longer in distance than before. Increased economic growth and personal incomes have enabled many urban residents to possess their own motor vehicles, be it private cars or motorcycles to improve their access to urban services. Before long, existing road capacity is pushed to its limit resulting in severe traffic congestion. The problem is often compounded by the lack of adequate and responsive public transport system. Kuala Lumpur the capital city of the Federation of Malaysia, is increasingly suffering from similar symptoms of urban movement problems.

1.2.1 Problem Identification

Malaysia government encourages public, especially in Kuala Lumpur to make full used of public transport service to overcome traffic congestion especially during peak hours. By using public transport also, it can give an alternative for private car user to not burden their self as price of petrol and diesel has been increase.

Public transport operators need to enhance their route so that it can be easily accessible and reach by their user. "Until recent year Kuala Lumpur have more than 200 stations including trains and buses services" (Kuala Lumpur Urban City Hall, Urban Transportation Department, 2007). Most of the hot-spots in Kuala Lumpur are well linked, whether using train and/bus; or combination of operators. Due to the competitive nature of privately operated services, none of the operators would publicize the routes of other operators. All the public transport operators have their own web-site to publish their route, price, journey time table and their new promotion but none of them provide routing information across modes and operators.

1.2.2 Significant of Project

As the public transport route have already widen up, it become more difficult for user to choose correct and effective medium to go to certain destination since Kuala Lumpur has more than 200 stations and a numbers of different operators. System that can provide not only information, but more importantly aware of the alternatives and choose accordingly, such as minimum cost, time, or number of transfers are most beneficial.

1.3 Objective & Scope of Study

1.3.1 Objective of Study

KL Public Transport Trip Plannner is a web based application that helps user to plan their travelling route in advance. It provides route alternatives and user is free to choose any that suit them most, base on the number of transfer, time of departure/arrival and cost. This system accommodates travel using different means of transports, including buses and trains services. The application prompts a user to input departure and arrival places, and will find a door-to-door route between the two.

1.3.1 Scope of Study

This system is build to facilitate PTS (buses and train) in Kuala Lumpur city. The targeted users are for everyone that lives or visit Kuala Lumpur city who wants to use public transport for travelling purposes. The scope of study includes advice user on the best route based on their preference in terms of number of transfer, time and cost. The research includes in the study are:

- Public Transport System in Malaysia
- Graph Theory
- Shortest Path Algorithm
- User Ethnographic Study
- System Architecture
- System Development
- Web System

CHAPTER 2
LITERATURE REVIEW / THEORY

2.1 Background of Public Transport Service in Kuala Lumpur

Public transport in Kuala Lumpur and the rest of the Klang Valley covers a variety of transport modes such as bus, train and taxi. The Government of Malaysia has spent millions of ringgit to improve the quality and availability of public transport in the Klang Valley area, including constructing a new Light Rail Transit line. Unlike in most other major Asian cities, utilisation rates are low. Currently, only 16 percent of the population uses public transportation (The Star, 13 October 2006). Commuters cite poor quality of service as the main reason for the low usage. Other reasons are because 80% of Kuala Lumpur residents do not originate from Kuala Lumpur and hence drive their own private vehicles when moving into Kuala Lumpur.

2.1.1 Local Transportation

- Buses

There are several bus operators operating in Kuala Lumpur, linking the city centre with the suburbs of the Klang Valley. The main operator is the government-owned Rapid KL (Rangkaian Pengangkutan Integrasi Deras Kuala Lumpur Sdn Bhd). Rapid KL took over the operations of Intrakota and Cityliner. Other operators include Metrobus, Selangor Omnibus, Len Seng, Transnasional/Kenderaan Klang-Banting, Triton, Permata Kiara and others.

- Rail

Kuala Lumpur's rail-based transit system consists of one rapid transit lines, one light rail transit line, one monorail, two commuter rail system consisting four lines, and one airport rail link (Refer Appendix I).

Different companies operate the various systems and developed them separately at different times. As a result, many of the lines do not integrate well, making transferring from system to system inconvenient for passengers. Moving from one system to another often require a lot of walking, stair-climbing, escalator-use and even crossing busy roads.

There is also no common ticket for all systems, forcing commuters on continuing journeys to buy new tickets when transferring. However, the LRT, monorail, Rapid KL Bus and KTM Commuter now accept the Touch 'n Go stored value farecard, easing the hassle.

Also, Rapid KL Rail, the operator of the three LRT lines as well as Rapid KL Bus (which cover about 70% of the Klang Valley's bus network), has come up with a daily bus ticket which cost as low as RM1, and integrated transit daily pass which can be used on both its rail and bus services that costs RM7.

The monorail is also planning to build a few more stations and tracks which is the Sungai Buloh Line (continued after Titiwangsa), Subang Jaya Line and Cheras Line.

Kuala Lumpur Integrated Transit Network Average Daily Commuters

Rapid KL *Kelana Jaya Line*	143,778	149,105	154,869	160,361	165,695
Rapid KL *Ampang/Sri Petaling Line*	88,201	91,702	107,082	120,426	125,208
KTM Komuter	57,339	60,504	67,522	74,960	85,733
KL Monorail	-	-	23,872	33,837	44,442
Express Rail Link *KLIA Ekspres / KLIA Transit*	-	4,983	7,323	9,990	12,075

Source : Economic Planning Unit, Prime Minister's Department

Table 1: KL Integrated Transit Network Average Daily Commuters

2.1.2 Competitive Nature between Public Transport Services in KL

In many transit-oriented cites around the world, the majority of the population depends on the Public Transportation System (PTS) for their daily travels. For example in Kuala Lumpur, "after 12 years statistics provided by KTM Berhad, the railway corporation that operates the commuter train service, indicate that 34.97 million passengers used the service last year" (The Star, 27 September 2007). It was said that, they will "expected at least 60% increase in next five years" (The Star, 1 August 2007). As the PTS is being expanded and further developed, as is typically the case, the system is becoming increasingly difficult to navigate. To assist passengers in locating and using their services, transit operators often set up web sites to publish their routes. However, due the competitive nature of privately operated services, none of the operators would publicize the routes of other operators, rendering such information to be piecemeal in nature, short of providing useful route guidance information across modes or across operators. The need of a common platform to provide routing information across modes and operators is apparent.

2.2 Public Transport Trip Planner

Parallel to the emergence of a sophisticated PTS, developing a transit route guidance system is equally important so that the PTS can be utilized to its full extent. Such a multimodal route guidance system not only allows travelers to find their ways to destinations, but more importantly aware of the alternatives and choose accordingly, such as minimum cost, time or number of transfers. Responding to this need, this study develops a transit route guidance system, called ***KL Public Transport Trip Planner***, to facilitate passengers' navigating the sophisticated multi-modal PTS.

Most route guidance systems or advanced traveler information systems (ATIS) are developed for private car driving. Recently, in Kuala Lumpur there just begin to have traveler information system for car drivers that called Integrated Transport Information System (ITIS) where it is a comprehensive traffic information system developed for City Hall Kuala Lumpur (CHKL) to provide road users with reliable traffic information and

user-friendly route guidance to ease their traffic woes in the Klang Valley. User can check traffic jams, incidents; road congestions and roadblocks (refer Appendix II). Another system is Interactive Train Timetable/Fair/Seat Availability deployed by KTM Berhad, this system just provide service for KTM train route to go outside Kuala Lumpur for example Ipoh, Butterworth or Gua Muasang, not KTM Commuter service operated around Kuala Lumpur (refer Appendix III).

Like in other developing and transit-oriented cities there begin to have a few traveler information systems developed for transit users. For example "Washington Metropolitan Area Transit Authority" develops for Washington bus and rail user. The system provides internet information transit services by using bus or train, or combination of both (refer Appendix IV). There are also transit itinerary planners called "Transport for London" (refer Appendix V) the simplest way to search door-to-door journey planner which searches for up to five journey options, by joined-up public transport deployed in London. In these types of system, user will obtain transit services information for their trips by entering their origins, destinations and times of departure or arrival. Other examples of itinerary planners available on internet include "OTIS – Trip Itinerary" of San Diego (San Diego Metropolitan Transit System, 2004) and "511 Take Transit Trip Planner" of San Francisco (Metropolitan Transportation Commission and San Francisco Bay Area Transportation Partners, 2004). The emergence of these transit information services shows the increasing demand for such information, and this is crucial for Kuala Lumpur to provide such system for benefit of their user. In Kuala Lumpur, some transit operators just provide their own route in their own web pages; they cover only their own routes but not the whole Kuala Lumpur transit network.

2.2.1 Proposed System

After defining and understanding current problem faced by public transport users, the next step would be solving the problem. ***KL Public Transport Trip Planer*** (refer Appendix VI) is a web based application that has an objective to help user to plan their

travelling route in advance and also provides a few route alternatives that can be taken by user base on the number of transfer, time of departure/arrival and cost

This project are developed as web based system because it enable user to access this system anywhere and anytime as long as they are connected through internet. By using this system, it will give user the clear guideline to go to certain places. Besides, user also can print the selected route suggested by the system, for reference during traveling.

This system are developed using algorithm that will be discuss further, later in this chapter. There are two shortest path algorithms that have been studied which are Dijkstra's Algorithm and Floyd Warshall's Algorithm.

2.2.2 Comparison between Existence System

After studying a few existence systems that can be access through internet, Table 2 shows the comparison between them. Service indicates service they provide to customer where all the websites provide service to facilitate public transport service (bus and train) except for KTM Interactivity Train Timetable/Fare/Seat Availability. As for User Control, it indicates what user should input to system in order to get results. The more information user input to system, the more precise and accurate the results generated.

Flexibility is proportional to Generated Results. It was said as flexible if the Generated Results can help user pick the best options given. Whereas not flexible in a sense of information provide from the Generated Results not clear enough to help user to pick the best options. Accessibility indicates how the system can be access by user. Some of the system can be access through internet and mobile device. For ***KL Public Transport Trip Planner*** it only can be access using internet but future enhancement can be made.

From the study, ***KL Public Transport Trip Planner*** will take Washington Metropolitan Transit Authority and London Underground Journey Planner as a guide to

develop KL Public Transport Trip Planner because this websites provides user friendliness design (is often used as a synonym for usable, though it may also refer to accessibility), usually refers to the elegance and clarity with which the interaction with a computer program or a web site is designed. For example this two websites use "meaningful graphics and it emphasizes the site's top high-priority tasks" (Jakob Nielsen's Alertbox, 12 May 2002), in this case the journey planner itself. While at the same time ***KL Public Transport Trip Planner*** try to avoid designing system which is lack of navigation support; obnoxious backgrounds; and too many moving text, display marquees and animation effects.

The benefits of planning usability project are:

- Increased end-user satisfaction.
- Increased end-user productivity, success, and completion.
- Reduced long-term development costs (costs incurred from fixing poorly designed products).
- Reduced training and support costs.

Category	KL Public Transport Trip Planner	KTM Interactivity Train Timetable/Fare/Seat Availability	Washington Metropolitan Area Transit Authority	London Underground – Journey Planner
Service	Facilitate public transport service (bus and train) operated in Kuala Lumpur, including all operators.	Facilitate intercity train service within KTM Network.	Facilitate public transport service (bus and train) operated in Washington.	Facilitate public transport service (bus and train) operated in London.
User Control	User need to input their origin, destination, preferred travel method and date/time of departure.	User need to input their origin, destination and date of departure/arrival.	User need to input their origin, destination, preferred travel method, date/time and also can minimizing their searching by indicate number of transfer, traveling time or walking distance they preferred.	User need to input their origin and destination. System will assume that user will travel now.
Generated Results	System will generate few results by providing possible route and user can freely choose whether they want to travel by minimum number of transfer, time or cost.	System will generate results by providing train name, departure and arrival time. Few different options will be given.	System will generate results base on previous input. Few different options will be given with combination of traveling mode.	System will generate few different options with combination of traveling mode.
Flexibility	Flexible - Base on result generated, user can choose which option they want. User can compare results on number of transfer, minimum cost/time.	Not Flexible - No information about cost. Users only have an option to choose base on time of arrival/departure.	Flexible - All information already provided in each of suggested itinerary. User can choose which itinerary that suit most.	Not Flexible - Just provide user with time of departure/arrival, not provide user with cost to go to certain destination.
Accessibility	Can be access using internet.	Can be access using internet.	Can be access using internet and mobile device (PDA, mobile phone).	Can be access using internet.

Table 2: Comparison between existence systems

2.3 System Architecture

After studying two examples of system architecture (refer Appendix VII and Appendix VIII), ***KL Public Transport Trip Planner*** come out with its own architecture that has three-tier system architecture with trip planning functions. The system architecture is summarized in Figure 1.

The client tier provides interfaces for users to input their origins and destinations and for the routing results to be presented. ***KL Public Transport Trip Planner*** provides the web-based interface; clients navigate the map and input their origins and destinations. The results of route search are also presented through the interfaces.

The middle tier connects and queries the route database according to the user's inputs and composes the routing results. The middle tier is the kernel of the system. Based on origin and destination information collected through interface, the application server determines the best transit stations or stops for boarding and alighting. It then queries the route database for the optimal routes and converts the results to a format understandable to the users.

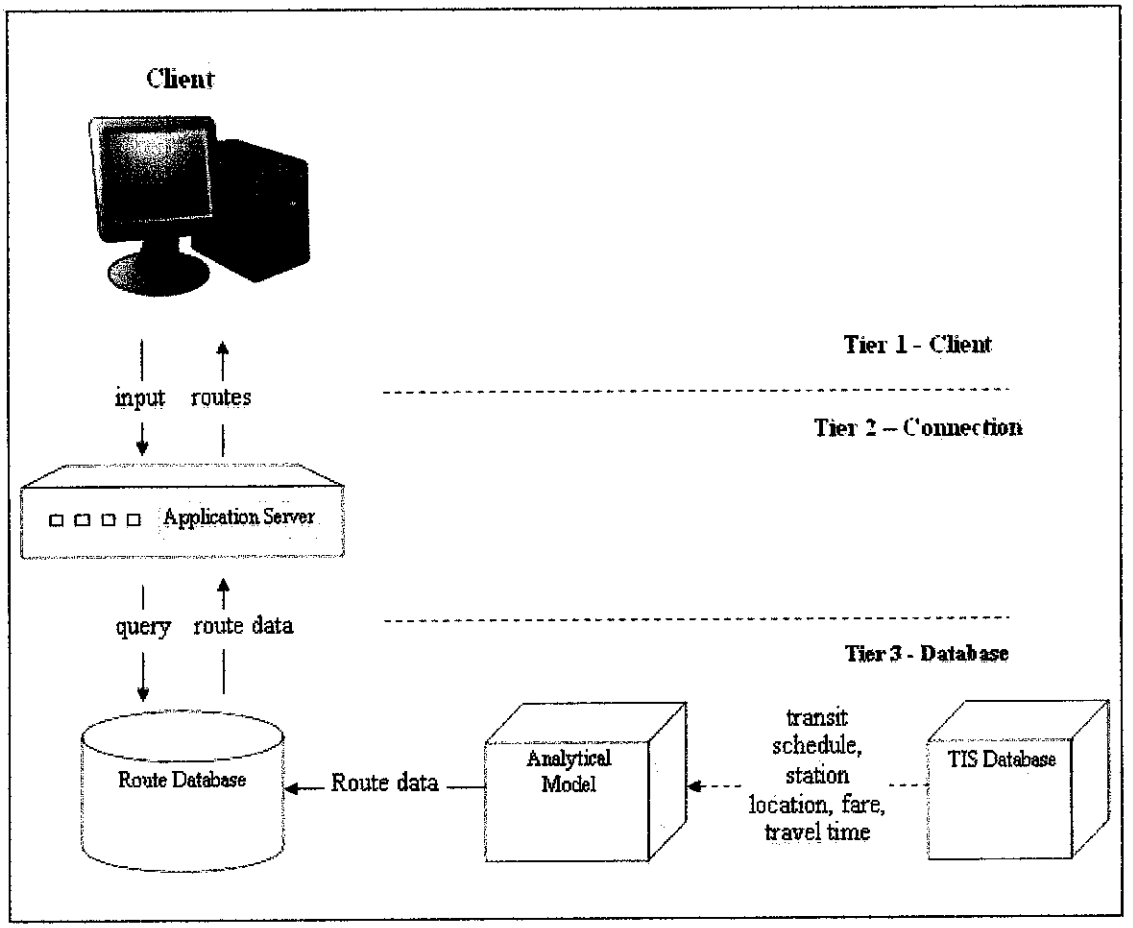


Figure 1: *KL Public Transport Trip Planner's* System Architecture

The database tier mainly consists of the route database that stores the all-pairs optimal paths according to different criteria including the shortest time, cheapest or the balanced choice. The response time of producing the optimal paths per request therefore, does not involve calculating the paths in an online manner, but merely needs to trace back the optimal paths that are already pre-calculated and stored in a tree structure in the route database. This setup substantially reduces the response time to produce the optimal paths. The all-pairs optimal paths are pre-calculated offline by the shortest path. As the transit route and fare information do not change from minute to minute, ***KL Public Transport Trip Planner*** only updates the route database periodically (daily, weekly basis or whenever the transit system is modified).

The transportation information system (TIS) contains the up-to-date transit system information including transit schedule, station location, transit fare and travel time. The TIS are typically maintained by the transport department or to be obtained individually from each of the transit operators and composed together. Other than calculating the optimal paths, the analytical model transforms the transit route, fare, and transfer information from the TIS for the optimal path calculation.

2.3.1 Analytical Model

- **Shortest Path Algorithm**

To prevent excessive response time for calculating the optimal paths online, all-pairs shortest paths from stations to stations are pre-calculated offline and stored in the route database server. For this part, Floyd-Warshall Algorithm will be used. The route database is updated periodically whenever the transit system is modified. The shortest paths are stored with a tree structure through the notation of predecessors. To search for an optimal path, the application server queries all stations then traces back from the one with lowest general cost. Since the calculation of shortest paths is preprocessed, each route query involves only tracing back the predecessors sequentially. This approach is thus suitable for online application in large-scale networks.

2.4 Graph Theory

Definitions in graph theory vary. The following are some of the more basic ways of defining graphs and related mathematical structures. A graph G is an ordered pair $G := (V,E)$ that is subject to the following conditions (J.E. Fields, 2001):

- V is a set, whose elements are called **vertices** or **nodes**,
- E is a set of pairs (unordered) of distinct vertices, called **edges** or **lines**.

The vertices belonging to an edge are called the **ends**, **endpoints**, or **end vertices** of the edge.

The **order** of a graph is $|V|$ (the number of vertices). A graph's **size** is $|E|$, the number of edges. The **degree** of a vertex is the number of other vertices it is connected to by edges. Figure 2 is a graphic representation of the following graph.

- V: = {1,2,3,4,5,6}
- E: = {{1,2},{1,5},{2,3},{2,5},{3,4},{4,5},{4,6}}

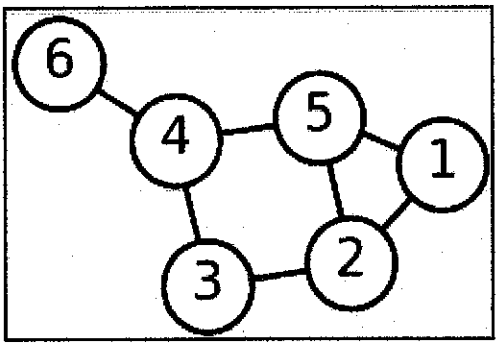


Figure 2: Graph with 6 nodes

2.4.1 Algorithms

Graph algorithms solve problems related to graph theory. There are numbers of shortest path algorithms but only two will be discussed.

- **Dijkstra's algorithm**

Dijkstra's algorithm is a graph search algorithm that solves the single-source shortest path problem for a graph with non negative edge path costs. It was named after its discoverer, Dutch computer scientist Edsger Dijkstra. This algorithm is often used in routing.

For a given source vertex (node) in the graph, the algorithm finds the path with lowest cost (the shortest path) between vertex and every other vertex (Kurose and Ross, 2002). It can also be used for finding costs of shortest paths from a single vertex to a single destination vertex by stopping the algorithm once the shortest path to the destination

vertex has been determined (Mc Hugh and James A., 1990). For example, if the vertex of the graph represent cities and edge path costs represent driving distances between pairs of cities connected by a direct road, Dijkstra's algorithm can be used to find the shortest route between one city and all other cities.

In the following algorithm (Figure 3), `u := extract_min(Q)` searches for the vertex *u* in the vertex set *Q* that has the least *dist[u]* value. That vertex is removed from the set *Q* and returned to the user. `length(u, v)` calculates the length between the two neighbor-nodes *u* and *v*. *alt* on line 10 is the length of the path from the root node to the neighbor node *v* if it were to go through *u*. If this path is shorter than the current shortest path recorded for *v*, that current path is replaced with this *alt* path. The *previous* array is populated with a pointer to the "next-hop" node on the source graph to get the shortest route to the source.

```
function Dijkstra(Graph, source):
    for each vertex v in Graph:           // Initializations
        dist[v] := infinity               // Unknown distance function from source to v
        previous[v] := undefined
    dist[source] := 0                     // Distance from source to source
    Q := copy(Graph)                      // All nodes in the graph are unoptimized - thus are in Q
    while Q is not empty:                 // The main loop
        u := extract_min(Q)               // Remove best vertex from priority queue; returns source on first iteration
        for each neighbor v of u:         // where v has not yet been considered
            alt = dist[u] + length(u, v)
            if alt < dist[v]              // Relax (u,v)
                dist[v] := alt
                previous[v] := u
    return previous[]
```

Figure 3: Dijkstra's Algorithm Pseudocode

- **Floyd–Warshall Algorithm**

Sometimes known as the Roy–Floyd algorithm or WFI algorithm (since Bernard Roy described this algorithm in 1959) is a graph analysis algorithm for finding shortest paths in a weighted, directed graph. A single execution of the algorithm will find the shortest path between all pairs of vertices. The Floyd–Warshall algorithm is an example of dynamic programming.

```
for i = 1 to N
   for j = 1 to N
      if there is an edge from i to j
         dist[0][i][j] = the length of the edge from i to j
      else
         dist[0][i][j] = INFINITY

for k = 1 to N
   for i = 1 to N
      for j = 1 to N
         dist[k][i][j] = min(dist[k-1][i][j], dist[k-1][i][k] + dist[k-1][k][j])
```

Figure 4: Floyd-Warshall Algorithm Pseudocode

Let *dist*(*k*,*i*,*j*) be the the length of the shortest path from *i* and *j* that uses only the vertices $v_1, v_2, \ldots, v_k$ as intermediate vertices. The following recurrence:

- $k = 0$ is our base case - *dist*(0,*i*,*j*) is the length of the edge from vertex *i* to vertex *j* if it exists, and ∞ otherwise.
- *dist*(*k*,*i*,*j*) = min(*dist*(*k* - 1,*i*,*k*) + *dist*(*k* - 1,*k*,*j*),*dist*(*k* - 1,*i*,*j*)): For any vertex *i* and vertex *j*, the length of the shortest path from *i* to *j* with all intermediate vertices $\leq k$ simply does not involve the vertex *k* at all (in which case it is the same as *dist*(*k* - 1,*i*,*j*)), or that the shorter path goes through vertex *k*, so the shortest path between vertex *i* and vertex *j* is the combination of the path from vertex *i* to *k*, and from vertex *k* to *j*.

After *N* iterations, there is no need anymore to go through any more intermediate vertices, so the distance *dist*(*N*,*i*,*j*) represents the shortest distance between *i* and *j*.

2.4.2 Suggestion

Floyd-Warshall algorithm is chosen for solving the shortest path problem between two destinations because Floyd-Warshall used more efficient and effective calculation technique compared to Dijkstra's Algorithm. This is because Floyd-Warshall can identify the shortest path between all pairs of nodes in graph (*all-pairs shortest path*), whereas Dijkstra's only can identify shortest path from the starting node to other nodes in a graph (*single-source shortest paths problem*).

.

Besides that, Floyd-Warshall only calculate shortest path between all nodes once but Dijkstra's will calculate the shortest path again and again base on input given by user. Even though execution time for Floyd-Warshall are a little bit long compared to Dijkstra's but it still suitable to be implement to this system since it already calculate the shortest path for all of the nodes in the graph and will be stored in database.

Floyd-Warshall algorithm is chosen to be used in this project because of the following reason:

- Floyd-Warshall algorithm can solve the optimum shortest path, even though has negative edge path.
- The complexity of theFloyd-Warshall algorithm is $\Theta(n^3)$ compared to Dijkstra's is $\Theta(n^2)$.
- Floyd-Warshall capable to calculate distance for any input source with only single calculation.

2.4.3 Nodes Selection

Node selection are made base on the public transport station (bus and train) located in Kuala Lumpur by referring map that has been provide by public transport operator. Kuala Lumpur has about 200 station (including bus and train), as a sample to develop this system only 15 train station and 15 bus station will be selected. Node that is near with each other will be combined as one node. The distance between two places will be determined by calculation the shortest path starting from the first node. The list of selected nodes is shown in Appendix IX.

CHAPTER 3
METHODOLOGY / PROJECT WORK

Systems methodology is a conceptual model used in project management that describes the stages involved in an information system development project, from an initial feasibility study through maintenance of the completed application. Various system development life cycle (SDLC) methodologies have been developed to guide the processes involved, including the waterfall model (which was the original SDLC method); rapid application development (RAD); joint application development (JAD); the fountain model; and the spiral model. Some methods work better for specific types of projects, but in the final analysis, the most important factor for the success of a project may be how closely the particular plan was followed.

3.1 Evolutionary Development Model

For ***KL Public Transport Trip Planner***, evolutionary development are chosen because this methodology is based on the idea of developing an initial implementation, exposing system to user comment and refining it through many versions until an adequate system has been developed. This project will be refined from time to time when it is presented to supervisor. Through this methodology, the project will start by identifying the features which have been understood and will evolve by adding new features from time to time.

3.1.1 Strengths of Evolutionary Development Model

- **Deliver highest value early**

One of core principles for evolutionary deliver is *Deliver the Juicy bit first* (Tom Gilb, Principles of software engineering management). That is, divide the project in small parts, prioritize the parts by making a cost-benefit analysis, and deliver the most beneficial part first. Either way the result is a clear risk reduction, since customers get the most valuable functionality first, as soon as possible in the process.

- **Manages uncertainty and inherent poor planning**

Research has shown that up to 80 percent of IT projects are delivered late and over budget. It was claim that the failed projects is caused by trying to solve a largely undefined problem in one big step. In evolutionary development, each iterative delivery delivers a fully functional component. This increases both the developers, as the users and customers understanding of the problem domain for each delivery, and thus becomes anticipatory method to stop projects from failing to deliver the right functionality, within budget and on time.

3.1.2 Weakness of Evolutionary Development Model

- **Requires continuous access to users and customer**

Since the foundation of evolutionary development is the frequent iterative deliveries, it is vital to get user feedback after each iteration, a project that uses evolutionary development needs frequent and continuous access to the customer. Besides seeing it as a weakness, it also can be an opportunity to elicit true user requirement.

3.2 Detail Description of Evolutionary Development Model

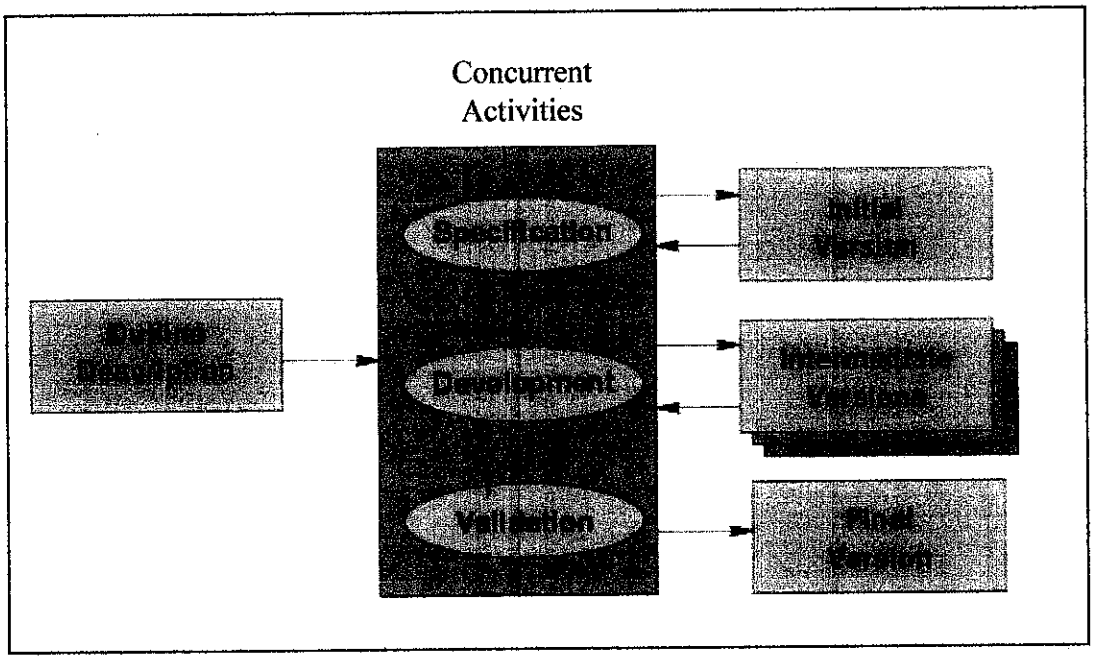


Figure 5: Evolutionary Development

3.2.1 Outline Description

The project will start by the Outline Description phase, where it will clearly define the system to be developed. It can be achieved by defining the project scope and objective through observation of current problem/situation and user experience. In this phase also, project plan will be develop, where all details task will be formalize by estimate the time to start and when it will finish.

3.2.2 Specification

Specification phase is the process to understand and defining what services are required for this system. Some of the specifications have already been obtained from interviewing potential user and customer, and also by doing some research (literature review). This is the most critical phase, where errors defining the specification of project will lead to later problems in the system design and implementation phase.

- **Functional Requirements**

Functional requirements for the system describe what the system should do. These requirements depend on what type of software being developed. A function is described as a set of inputs, the behavior and outputs. Functional requirements also specify particular behaviors of a system (Ian Sommerville, 2004). Here are the functional requirements for *KL Public Transport Trip Planner*.

- User should be able to search all initial set of database or select a subset from it. This will include the trip planner, arrival/departure time and cost store inside the database.
- The system shall provide appropriate user interface for the user to read information provided by the system.
- Alteration of information in the system should only be made by system administrator.

- **Non-Functional Requirements**

Non-Functional requirements as the name imply, are the requirements that are not directly concerned with the specific functions delivered by the system. It will specify criteria that can be used to judge the operation of a system, rather than specific behaviors. They may relate to emergent system properties such as reliable, response time and store occupancy. Alternatively they may define constraints on the system such as capabilities of I/O devices and the data representations used in system interface (Ian Sommerville, 2004). Non-functional requirements for KL Public Transport Trip Planner are:

- Flexibility – Systems will give few suggestion route to user, so that they can choose route that suite them most.
- Accessibility – System can be access by user anytime and anywhere as long as they are connected via internet.
- Usabality – Easy to use system, even though user are not computer literate.
- Extensibility - Adding features and carry-forward of customizations at next major version upgrade.

3.2.3 Development

This is the longest phase, where all the previous defining specification will be execute into a physical system; this will include system design and system development. In this phase, programming code will be debugged and programming errors need to be solved as soon as possible so that the estimated time to finish will be on time and not affecting the next phase.

- **System Design**

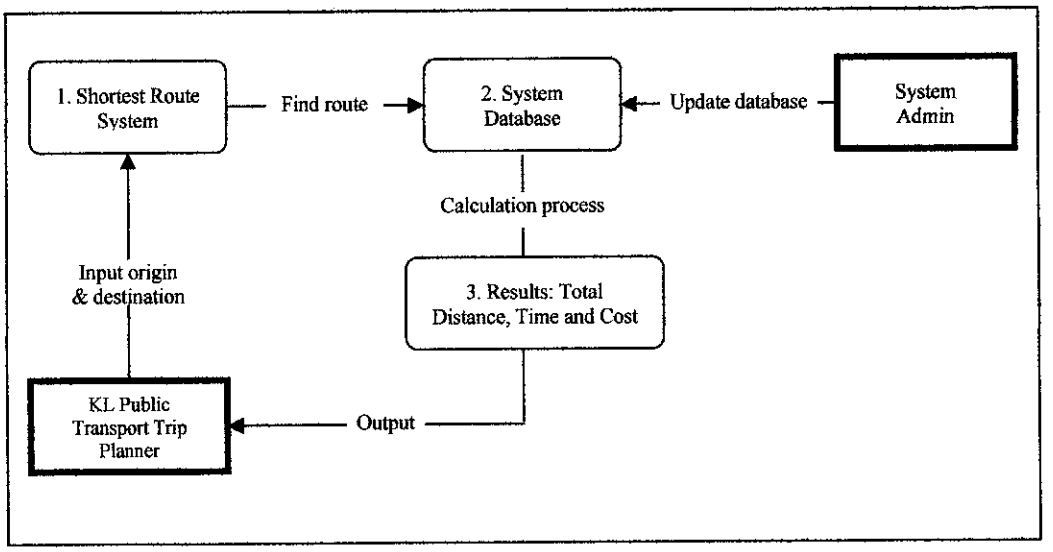


Figure 6: Overall System Flow Chart

System will be executed after receiving input from user. This will include travel method whether using bus, train or the combination of the two. Users also will be required to input the origin and destination. After that system will do calculation base on the algorithm, before returning the result to user. (For more detail on how the system flow, refer to Figure 7: System Flow Chart - User)

Administrators are the person that maintained the system, it may include transport department or to be obtained individually from each of the transit operators.

Administrator can do alteration to the database, if there are changes on the transit schedule, station location, transit fare and travel time.

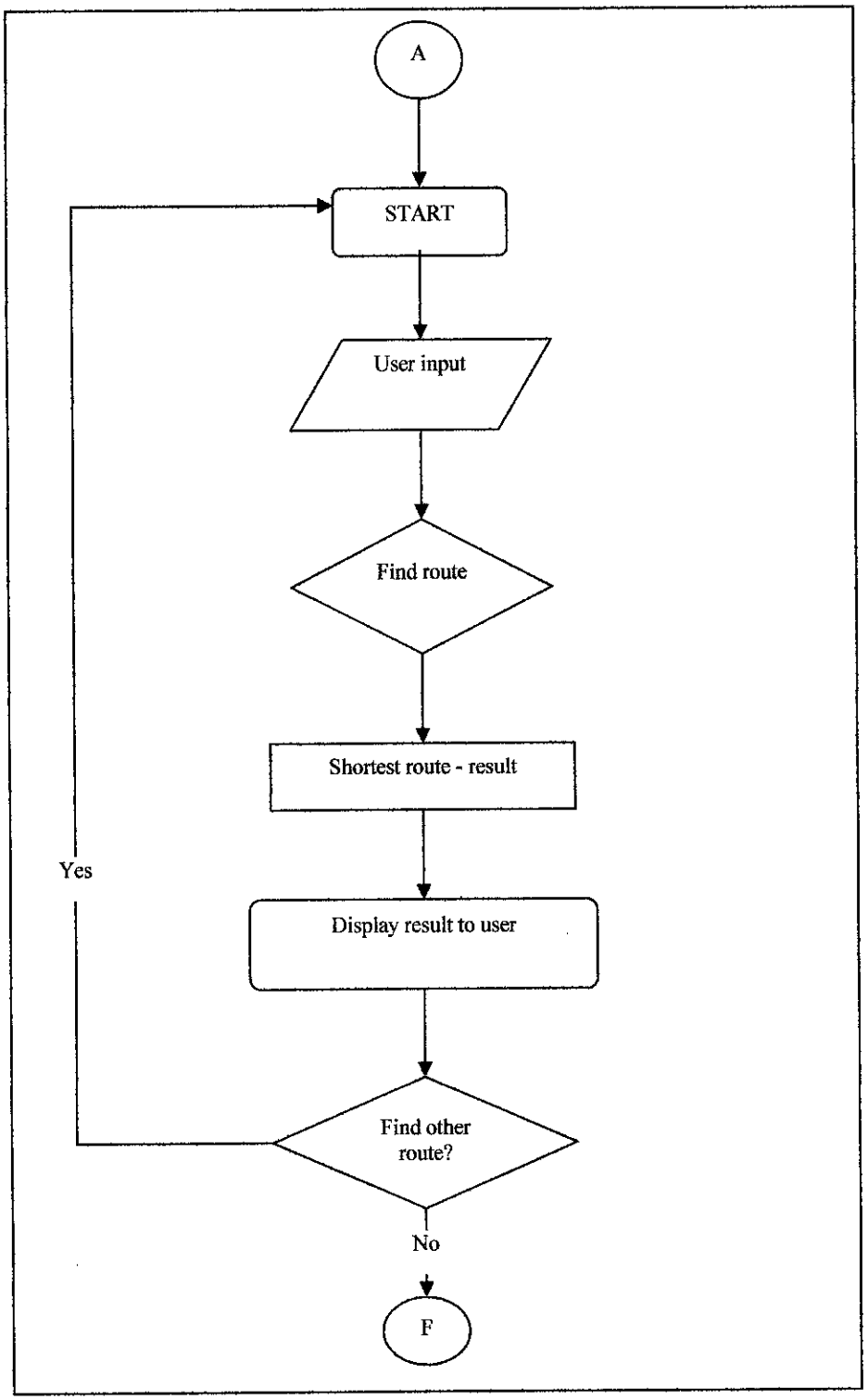


Figure 7: System Flow Chart - User

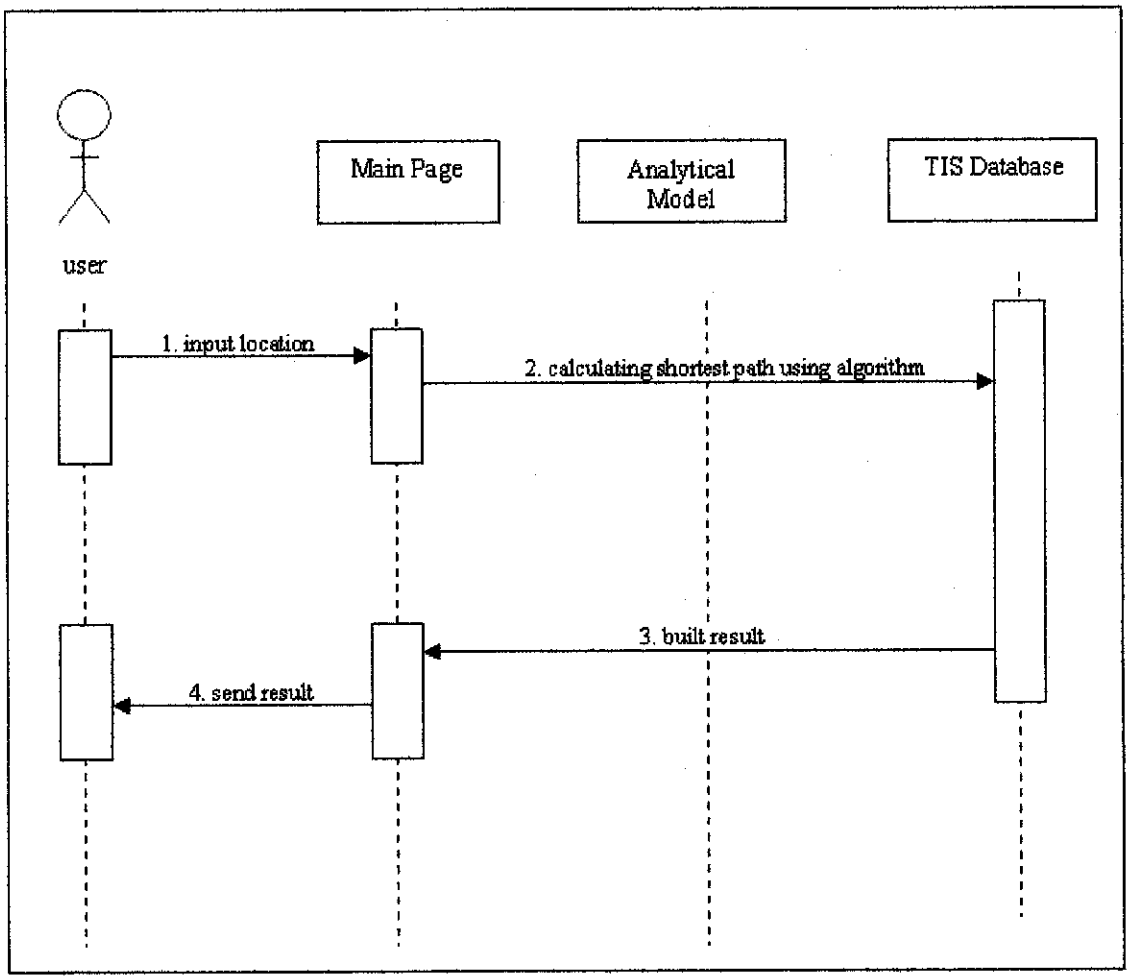


Figure 8: Sequence Diagram - User

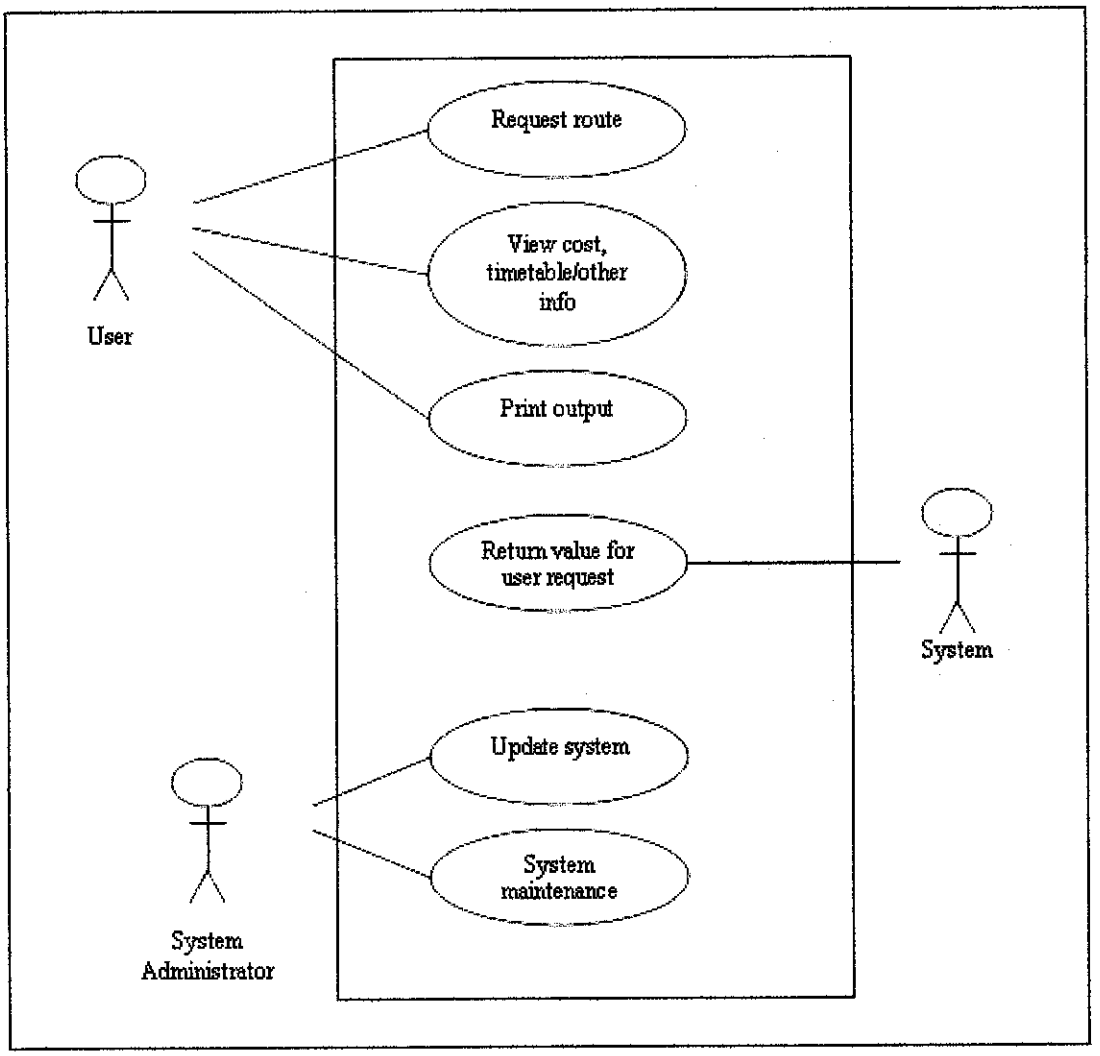


Figure 9: Use Case Diagram

- **System Development**

  To see more on the system development progress, refer to Appendix X.

3.2.4 Validation

Validation phase is intended to test the system whether it confirms to its specification and meet the expectation by potential clients. There are many types of software testing, but only few will be implemented in this system.

- **Stage 1: Pre Release**
  - **Unit testing**, tests the minimal software component, or module. Each unit (basic component) of the software is tested to verify that the detailed design for the unit has been correctly implemented.
  - **Integration testing**, exposes defects in the interfaces and interaction between integrated components (modules). Progressively larger groups of tested software components corresponding to elements of the architectural design are integrated and tested until the software works as a system.
  - **System testing**, tests a completely integrated system to verify that it meets its requirements.

- **Stage 2: Post Release**
  - Alpha testing is simulated or actual operational testing by potential users or an independent test team. Alpha testing is often employed for off-the-shelf software as a form of internal acceptance testing, before the software goes to beta testing.

3.2.5 Concurrent Activities

Specification, Development and Validation phase will run concurrently, where the next move are base on current planning, previous result and feedback from potential user and customer.

3.2.6 Initial Version/Intermediate Version/Final Version

Prototype of this system will be presented to potential customer. Rapid feedback will be received and all the feedback will be examined and implemented in the next phase until an adequate system will be developed.

3.3 Project Timeline

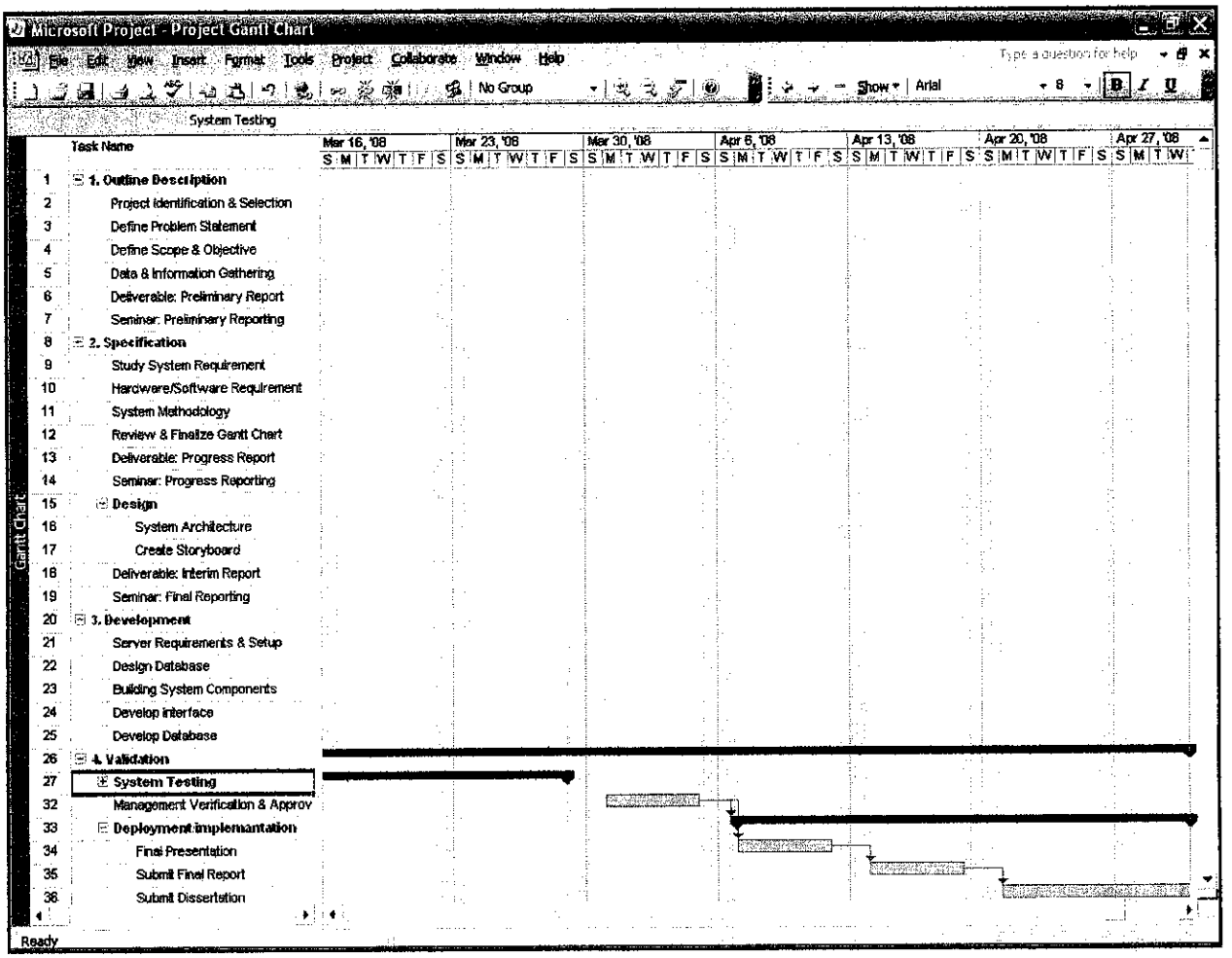


Figure 10: *KL Public Transport Trip Planner* – Project Timeline

CHAPTER 4
RESULTS & DISCUSSION

The provision of public transport in urban areas has become a major problem in most developing cities including Kuala Lumpur. A major cause of this is the rapid urban population growth, resulting in increased demand with which many public transport systems are unable to cope inadequate and inefficient systems. People began to move from place to place at a more rapid rate every day and so does public transport operators. They always widen up their network so that their user can easily reach their service. By broaden up their route, it may easily reach by their customers but as a user it becomes difficult to navigate especially if it involving multi modes.

4.1 Data/Information Gathering

Based on the responses that have been gathered through questionnaires, interview, as well as research from internet; an analysis had been done in order to know what the overview results. The questionnaires had been distributed to the UTP students as well as some of the public transport users, consists of 40 respondents. The sample of questionnaires is represented in Appendix XI. While interview are done informally, where 5 public transport users are interviewed represented in Appendix XII.

4.1.1 Questionnaires/Survey

From question 1-3 in the survey, the questions are on ethnographic study where it done to know and understand the context of use told from a particular perspective (How Theories Inform Interaction Design, October 2005). It can be seen as a useful simplification (enabling communication of findings to people outside the team of field researchers) and also as articulated concepts and theory help to develop a refined understanding of the field. From the question, there are quite a number of users that used

public transport for their daily purpose and most of them preferred to use train rather than bus and taxi because it more convenient and the user come from low income to medium income earner.

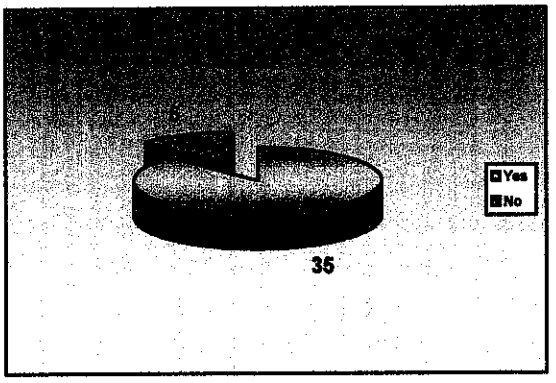


Figure 11: Pie Chart – User of Public Transport

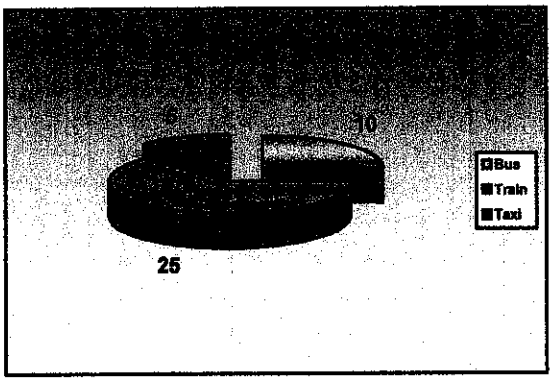


Figure 12: Pie Chart – User Preference

For question 4-6, the questions are about the user experience while using public transport. Most of the user having difficulties to get the information about park and ride facilities provides for them. They refuse to use public transport because some of the stations don't provide them with park and ride facilities, and this may cause difficulties for them to go to train stations where in this case they need to walk or ride a taxi to get to the stations. This will double up their cost to go to one place, so in this case they preferred to use their own private transport. Other difficulties that they arise were the schedule for public transport are not in time and public transport operator not providing good quality of service. Other that that, user also will consider taking public transport

with minimum number of transfer and willing to pay more as long as it travels with minimum number of transfer.

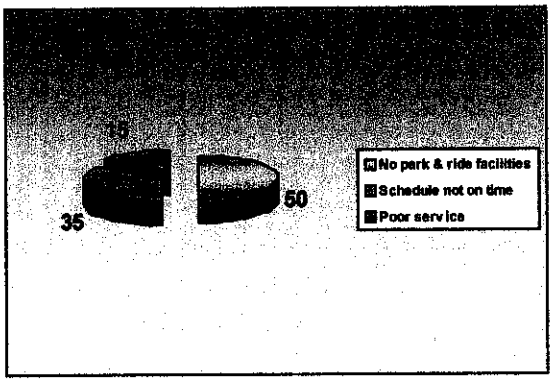


Figure 13: Pie Chart – User Experience while Using Public Transport

For question 7-9, the questions are about the needs for the system and also usability study that user preferred while using ***KL Public Transport Trip Planner***.

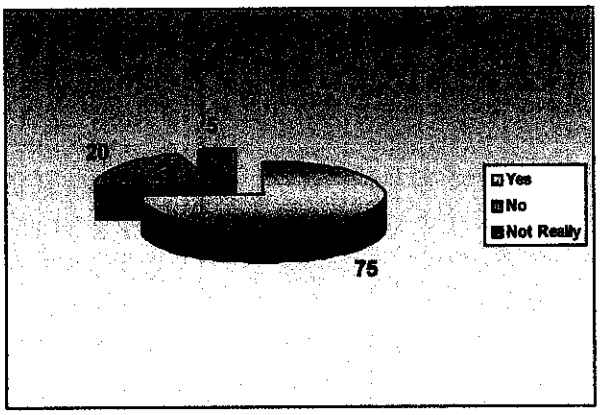


Figure 14: Pie Chart – The needs of ***KL Public Transport Trip Planner***

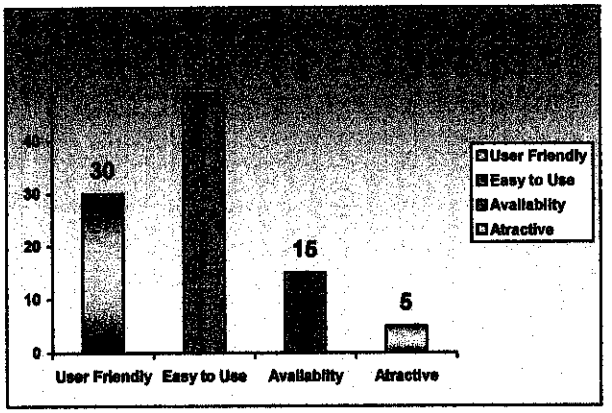


Figure 15: Pie Chart – Features Needed

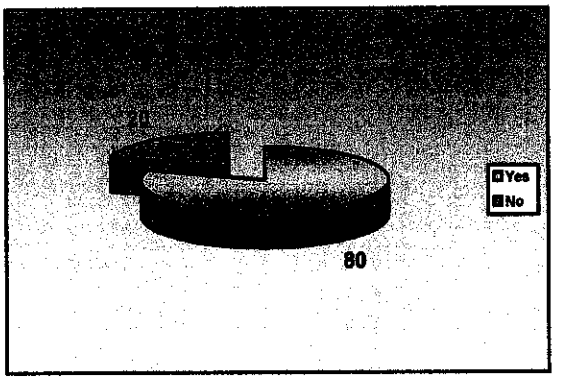


Figure 16: Pie Chart – Computer Literacy

4.1.2 Interview

From the informal interview with the UTP student's who are from Kuala Lumpur, they said that public transport service in Kuala Lumpur is not properly integrated, where all the public transport operators always publish their own route, due to competitive nature. As a user, it's difficult to choose correct and effective medium to go to certain destination since Kuala Lumpur has more than 200 stations and a numbers of different operators. Besides the negative aspect they arise, they also point some positive sites where by using public transport they will experience safe, reliable and commutable journey.

4.1.3 Research from internet

The most important effect of the trip itinerary service is great improvement to the accessibility of public transport information. It allows users to take full advantage of available transport services. In a metropolitan area of nearly 1 million inhabitants, especially as the new land development takes place outside the city centre like in Kuala Lumpur, travel needs are becoming more diverse and impossible to serve with direct lines. Journey planner makes the transport system and required transfers easy to use, and is a necessity in the competition against growing private car usage. In the following table are listed the effects of route planner service according to an internet survey for 1,000 user of Helsinki Metropolitan Area Public Transport Planner conducted by YTV Likenne, developers of the system.

Experienced effect	% of users
Travelling feels easier	70 %
Found faster routes	55 %
Easier transfers	48 %
Reduced necessary trip safety marginal	34 %
Increased use of pre-trip information	73 %
Reduced use of call centre information service	12 %

Table 3: Effect of route planner service

4.2 Conclusion

To sum up, trip decisions have become better informed and traveling becomes more efficient. Study results indicate that trip planner increases the use of public transport and shifts trips from private car.

CHAPTER 5
CONCLUSION

To satisfy user needs and to support government encouragement to make full use of public transport to avoid traffic congestion and to reduce burden for private car owners since the price of petrol is increasing (The Star, 27 September 2007), all the public transport operator (currently have four operators in Kuala Lumpur) take an action to widen up their route so that user can easily access their service. Previously users always refuse to use public transport because the station is far from their house and difficult to reach.

Now there are more than 200 stations in Kuala Lumpur and it not only located in the city of Kuala Lumpur but it also reaches suburb. Since their route is now easily accessible by user, there is another problem arise. User have new problem now where by, they face the difficulties to choose the correct route using different modes with minimum number of transfer and also with minimum cost and time. System can provides such information currently apparent in Kuala Lumpur. By developing this system, public transport's user can get not only information, but more importantly aware of the alternatives and choose accordingly, such as minimum cost, time, or number of transfers that will facilitate users navigating the sophisticated multi-modal PTS. By implementing this system, user will benefit from it by:

- enabling user to take the route that most closely matches his/her requirements. Usually, this means the one that is shortest, fastest and cheapest (or some combination of those).
- helping themselves disperse efficiently so that they fully utilize all available routes.
- reducing travel time.

- improving convenience of using public transport and alleviate traffic congestion since many user already use public transport.

5.1 Recommendation

There are a few enhancements recommended to ***KL Public Transport Trip Planner***, which is:

- Made the system accessible through mobile phone.
- Add Geographic Information System (GIS) features, for example Google Map application for more attractiveness.
- Multiple language selection, made ***KL Public Transport Trip Planner*** can be access in other different language since some of the users are visitors.

REFERENCES

[1] Richard Iles. Public *Transport in Development Countries*. Elsevier, United Kingdom (2005).

[2] White, PR. *Public Transport – Its Planning, Management and Operation*. Spon Press, London (2002).

[3] Jean-Paul Rodrigue, Claude Comtois, Brian Slack. *The Geography of Transport Systems*. Routledge (2006).

[4] Thomas R. Leinbach, Chia Lin Sien. South-*East Asian Transport Issues in Development*. Oxford University Press (1989).

[5] Bob McQueen, Judy McQueen. *Intelligent Transportation Systems Architectures*. Artech House (1999).

[6] C.M. Khoong. *Shortest Path – Reconstruction Algorithm*. The Computer Journal 1993 36(6):588-592.

[7] J.E. Fields. *Introduction of Graph Theory*. Southern Connecticut State University Department of Mathematics Journal (2001).

[8] L. Fu, D. Sun, L. R. Rilett. *Heuristic shortest path algorithms for transportation applications: state of the art*. Elsevier Science Ltd. Oxford, UK.

[9] Robert J. McEliece. *Encyclopedia of Mathematics and Its Applications*. 1984 ISBN:0521302234.

[10] Brenda Cheang, Sherlyn Foo, Andrew Lim. *Using a Divide and Conquer Method for Routing in a PC Vehicle Routing Application*. Journal.

[11] Hong K. LO, C. W. YIP. *Passenger Route Guidance System for Multi-Modal Transit Networks*. Computer Science Journal, Hong Kong University of Science and Technology.

[12] Heraty, M.J. (Ed.). *Urban Transport in Developing Countries*. PTRC, London (1991).

[13] Rallis, T. *City Transport in Developed and Developing Countries.* MacMillan, London (1998).

[14] Jared, Jeff, Keiran, Margot, Jacob, Roslyn, Fiona. 'User Ethnographies' – and how they inform design. Ipswich Campus, University of Queensland (October 2005)

[15] Journal of Transportation Science Society of Malaysia 1 (2005). <http://pkukmweb.ukm.my/~abim/tssm/index.html>

[16] Lo H.K., Yip C.W., Wan K.H.. *Modeling Transfer and Non-Linear Fare Structure in Multi-Modal Network.* Research Articles, Hong Kong University of Science and Technology.

[17] Gunilla Jonson, Emin Tengstrom. *Urban Transport Development: A Complex Issue.* Springer (2005).

[18] Dr Barr Simpson. *Urban Public Transport Today.* Routledge (1993).

[19] Madock Chiwenda, David V. Delano, Fredrik Jonson, Hanna E.T. Scott. *Evolutionary development model – An Introduction and Analysis.*

[20] Jakob Nielsen , *Top Ten Mistakes in Web Design.* 1996-2007 ISSN 1548-5552.

[21] Kuala Lumpur Urban City Hall, Urban Transportation Department. Web Site. URL <http://www.jpbdbkl.gov.my>.

[22] Rangkain Pengangkutan Integrasi Deras Sdn Bhd, Rapid KL. Web Site. URL <http://www.putralrt.com.my>.

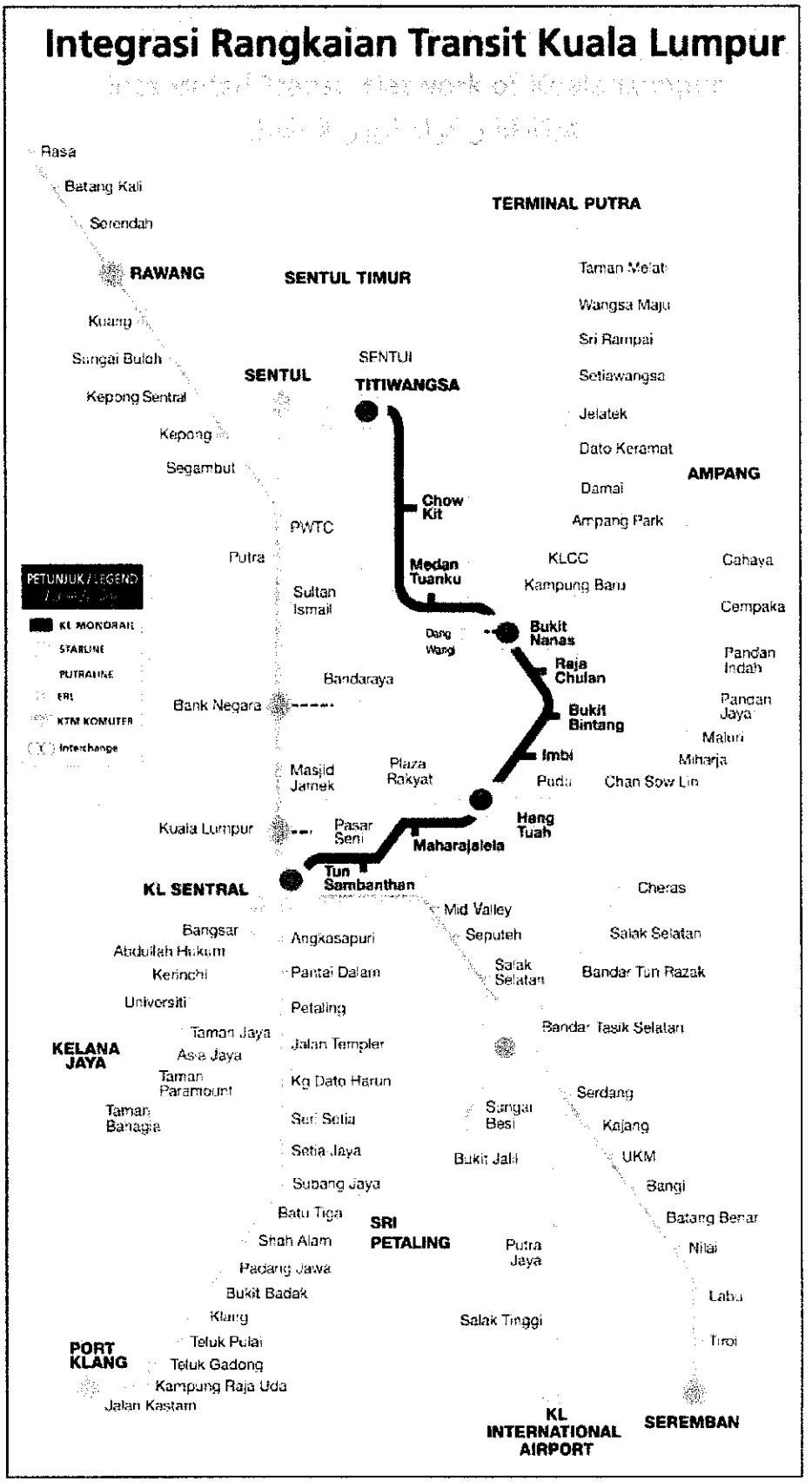
[23] Keretapi Tanah Melayu, KTM Komuter. Web Site. URL <http://www.ktmb.com.my>.

[24] Transport Direct.info – Britain's Free Online Journey Planner. URL <http://www.transportdirect.info/Web/Templates/Home.aspx?NRMODE=Published&NRNODEGUID=%7b9B2CEBBB-B2D4-4022-A0D1-5B939541864D%7d&NRORIGINALURL=%2fTransportDirect%2fen%2f&NRCACHEHINT=Guest&repeatingloop=Y>

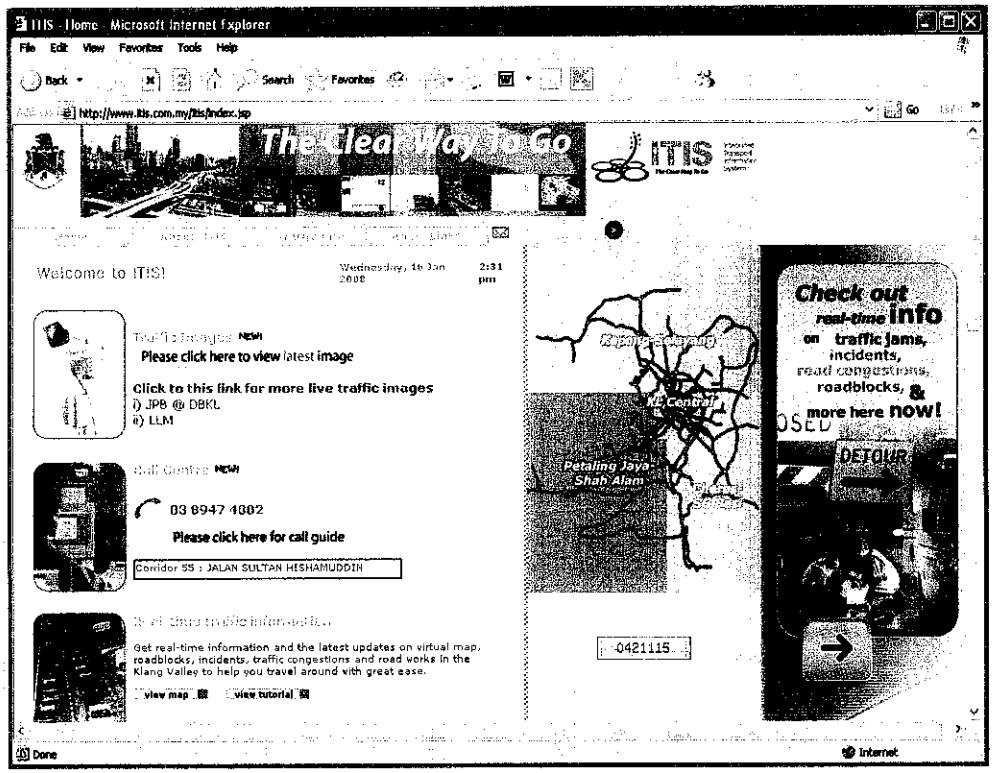
[25] Washington Metropolitan Area Transit Authority. URL <http://www.wmata.com>

[26] The Star Online. Web Site. URL <http://thestar.com.my>.

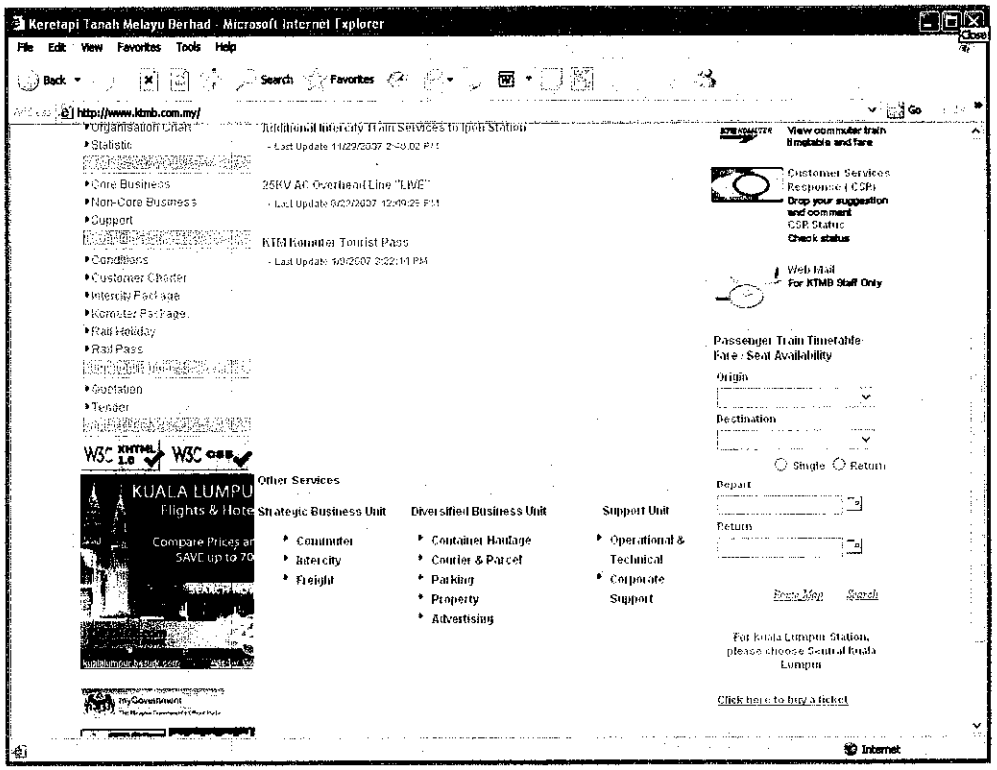
APPENDIX



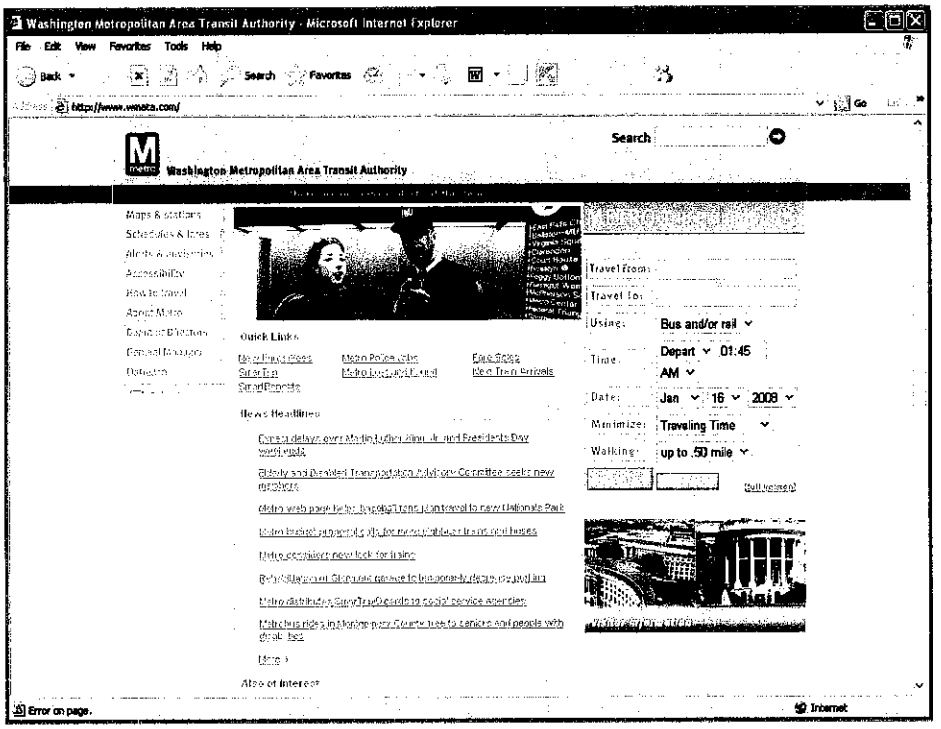
Appendix I: Integrated Transit Network of Kuala Lumpur



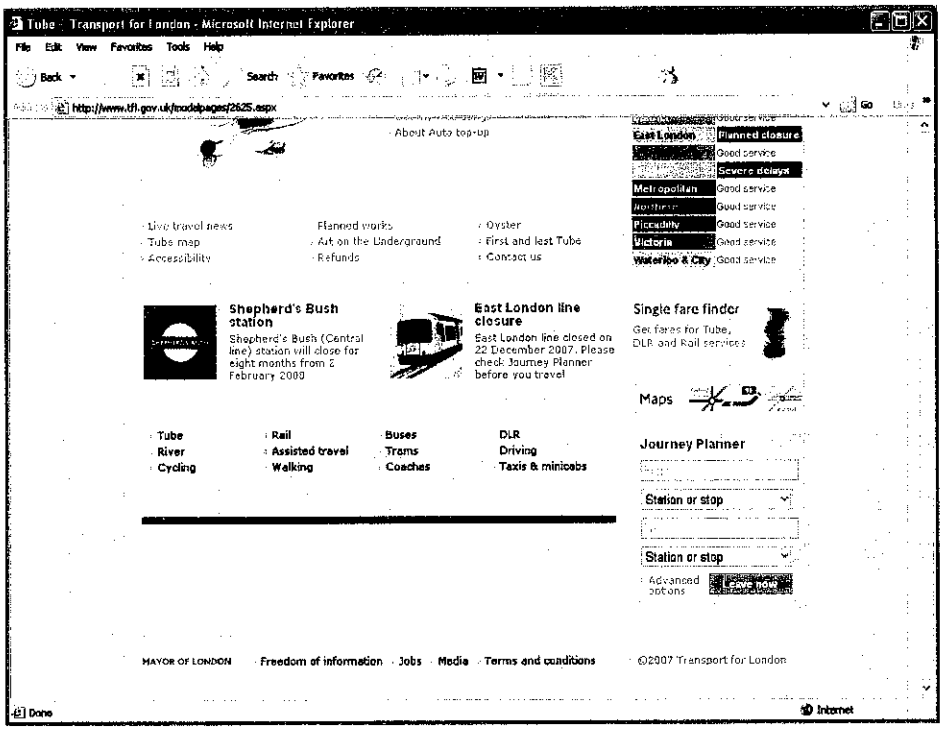
Appendix II: Integrated Transport Information System



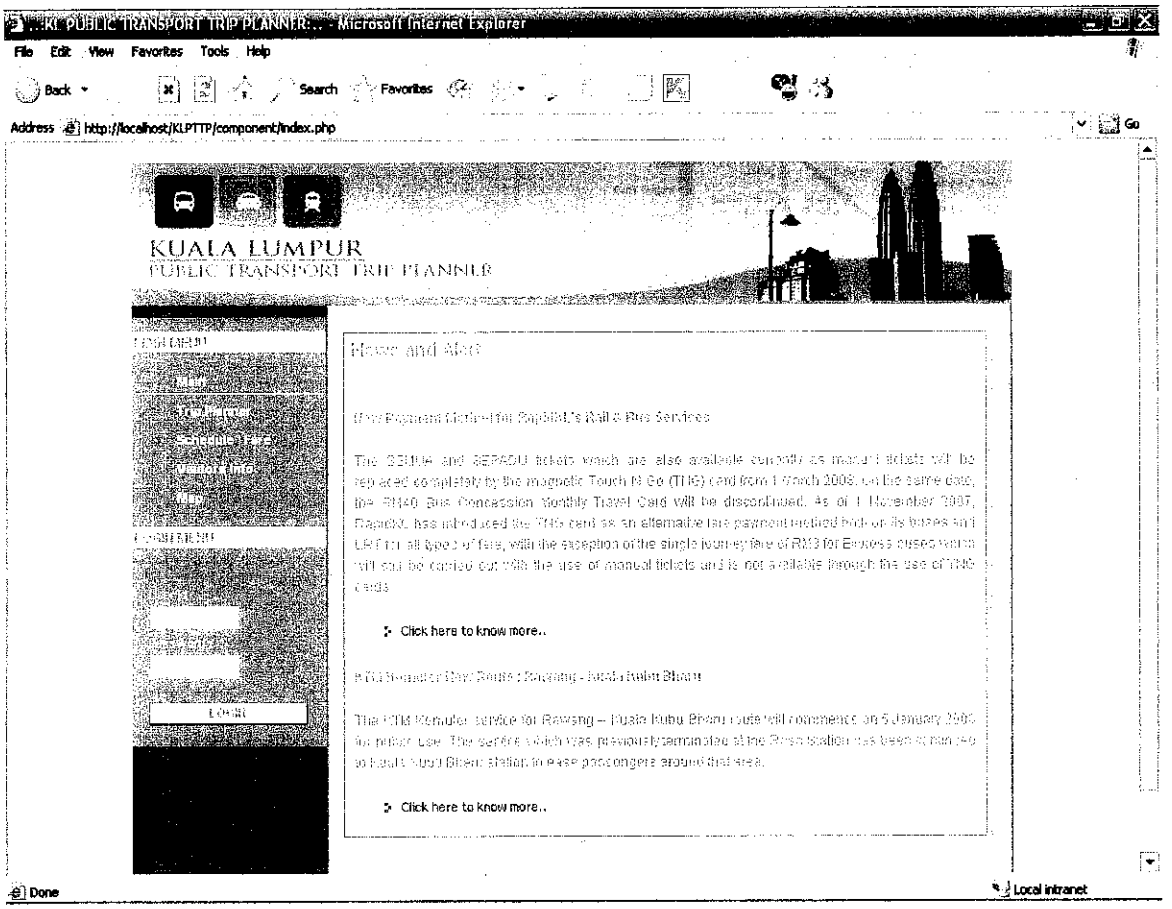
Appendix III: KTM Interactive Train Timetable/Fare/Seat Availability



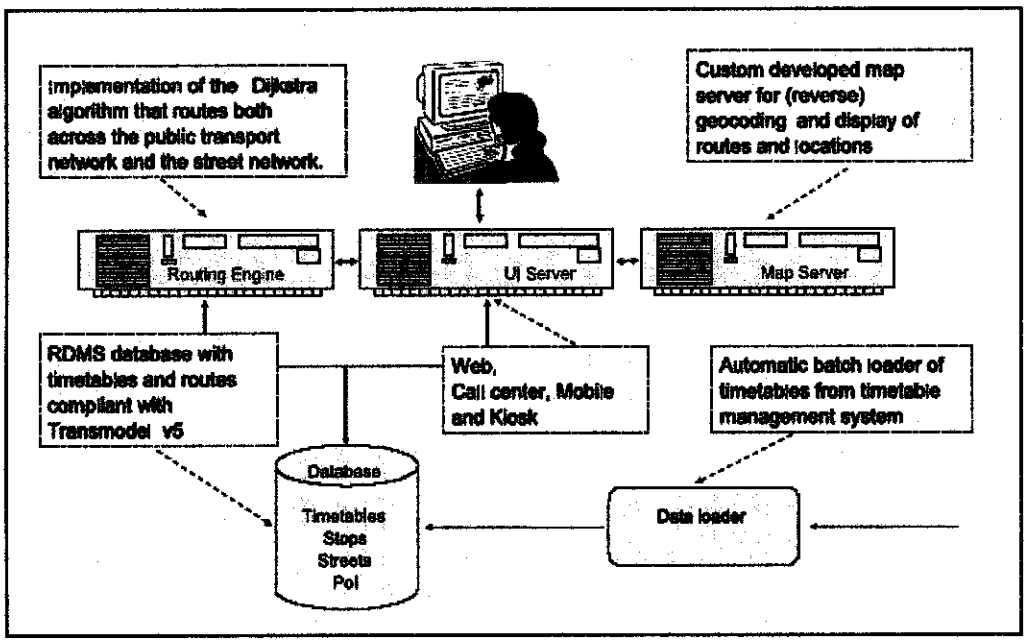
Appendix IV: Washington Metropolitan Area Transit Authority



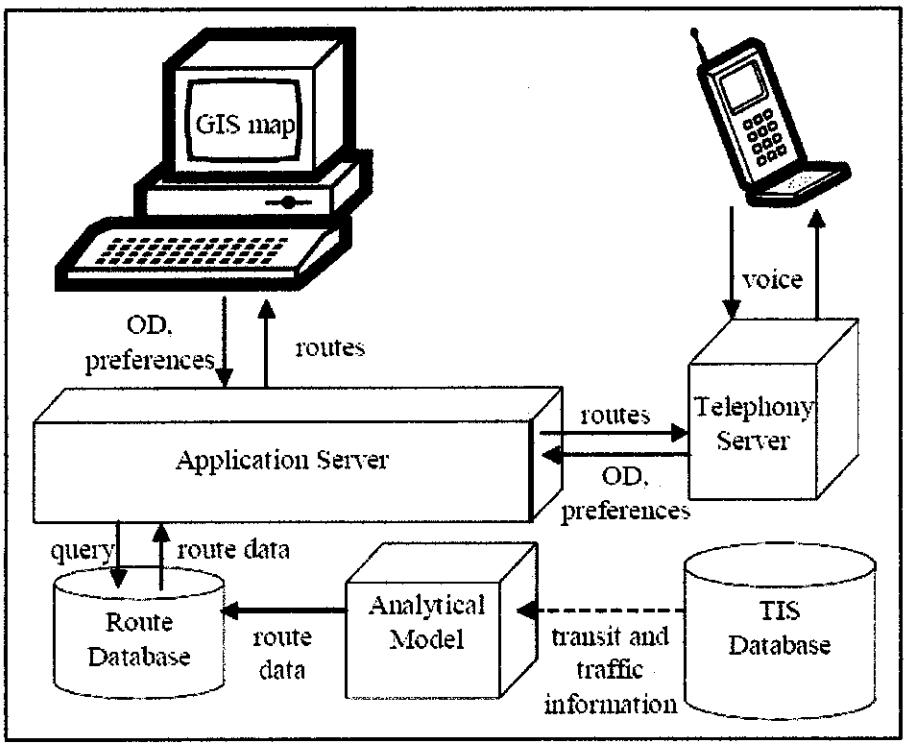
Appendix V: London Underground – Journey Planner



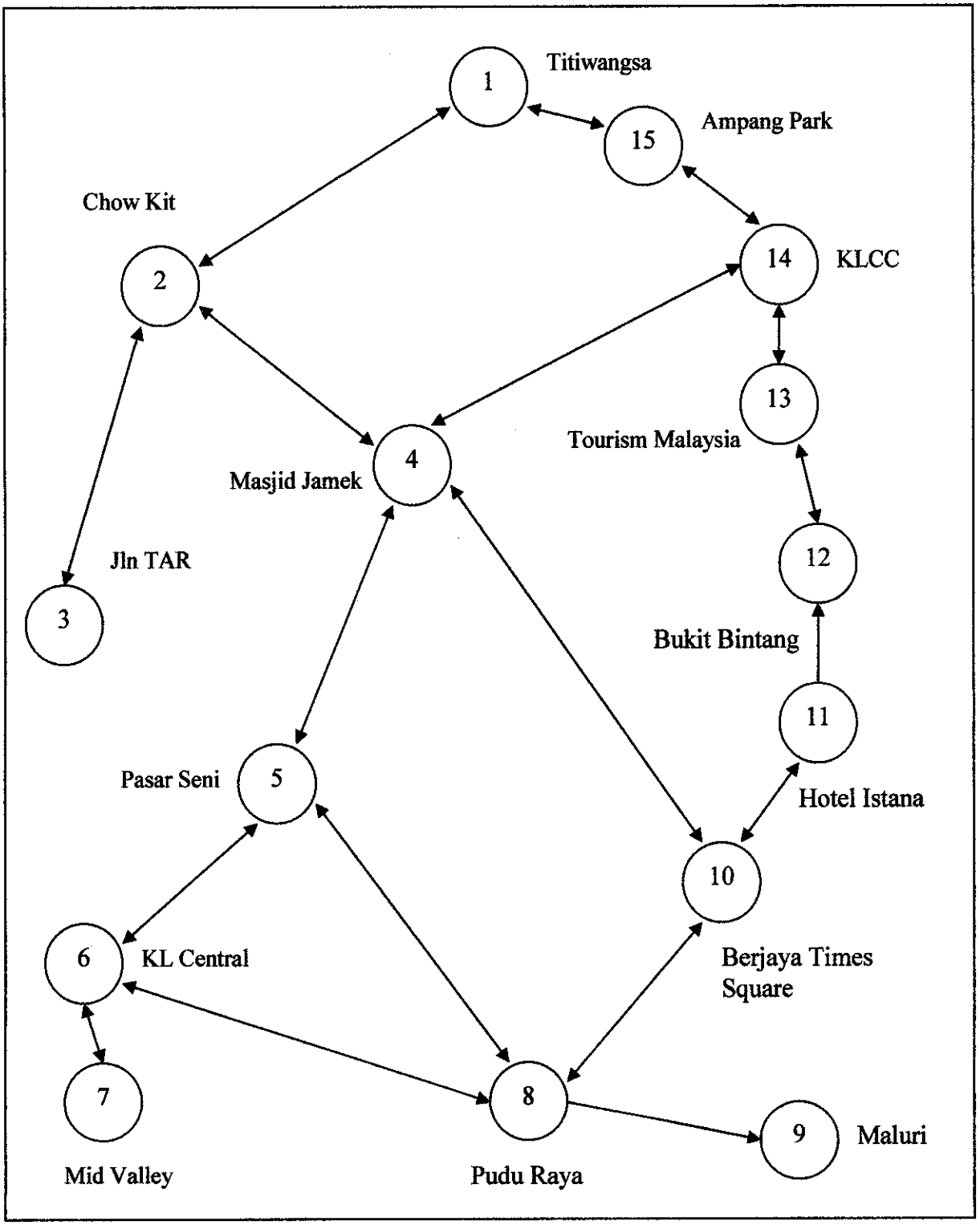
Appendix VI: KL Public Transport Trip Planner



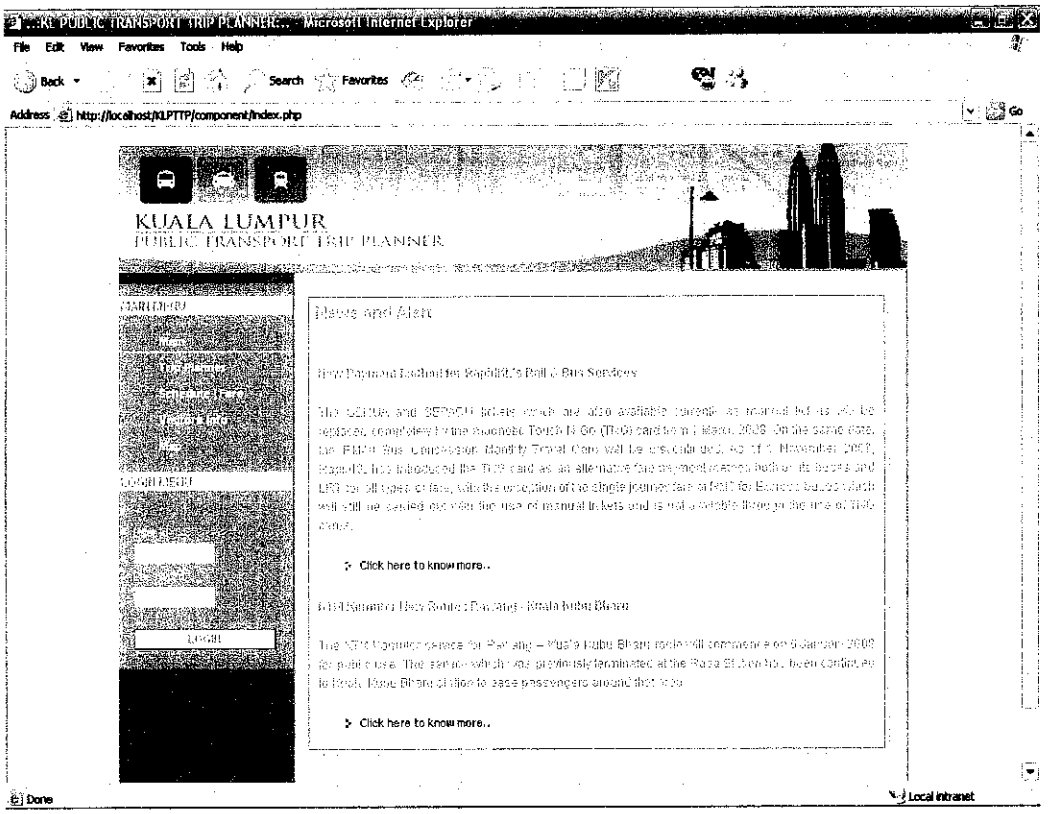
Appendix VII: Novo's Trip Planner System Architecture (Example of others system architecture)



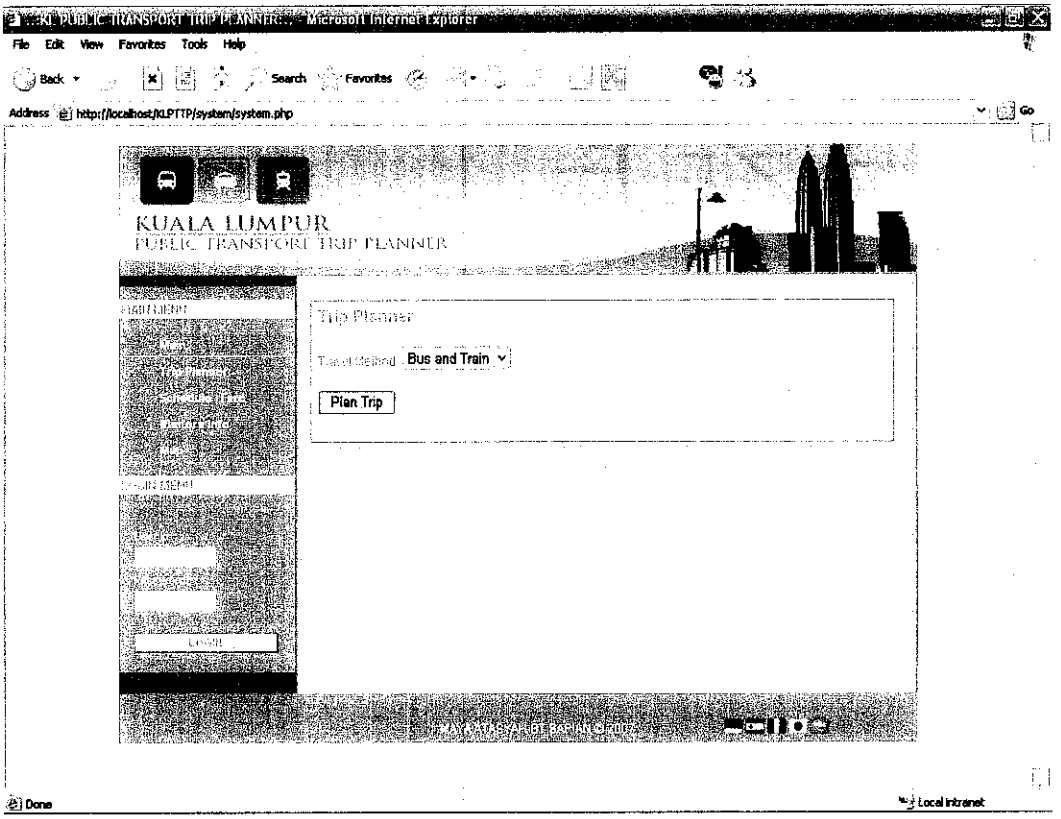
Appendix VIII: E-finder System Architecture (Example of others system architecture)



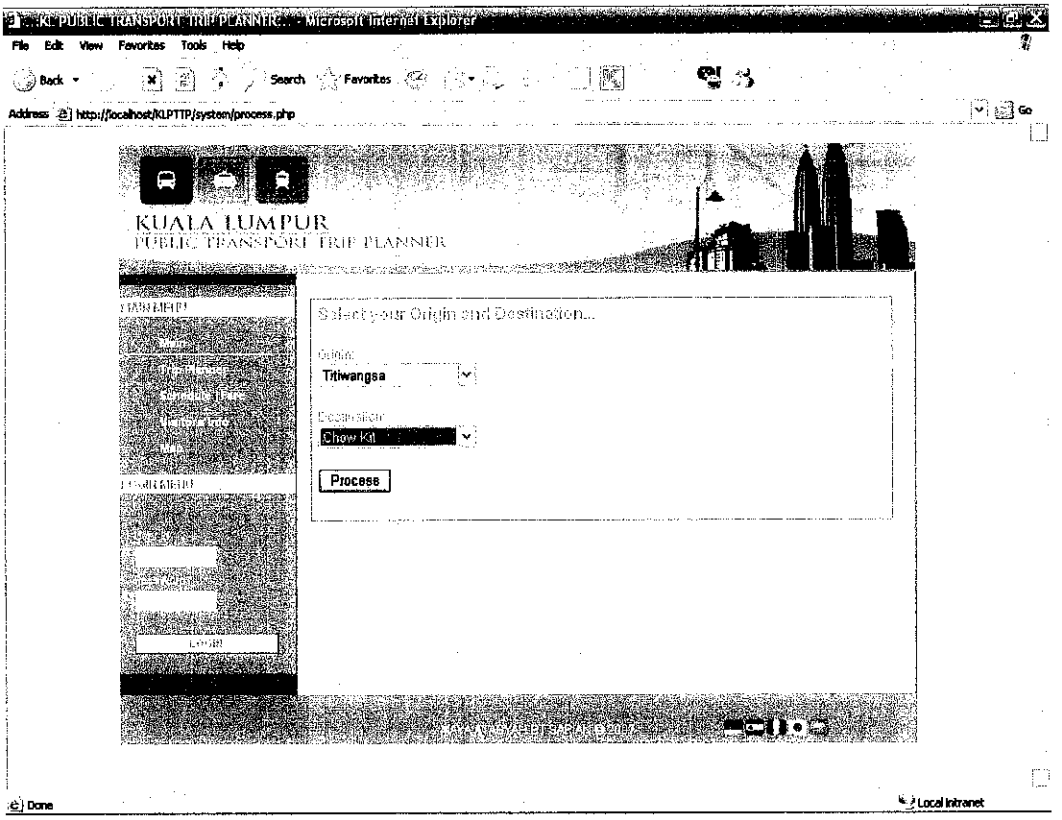
Appendix IX: KL Public Transport Trip Planner - Nodes



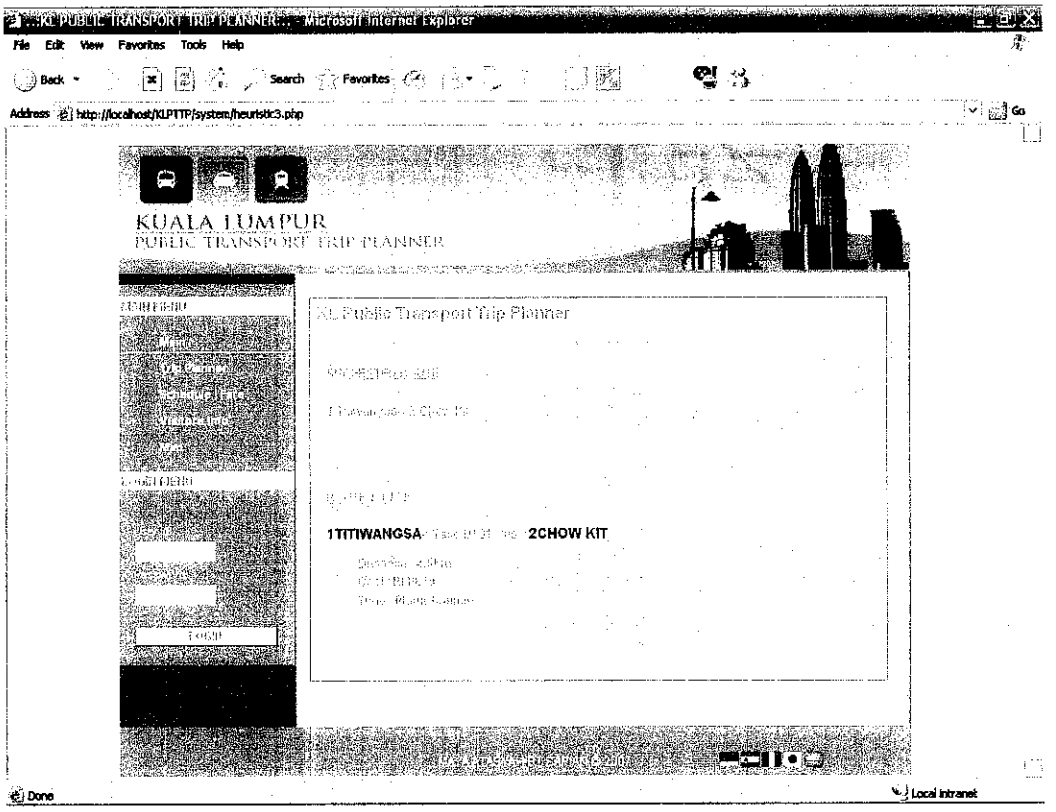
Appendix X (a): KL Public Transport Trip Planner – Main Page



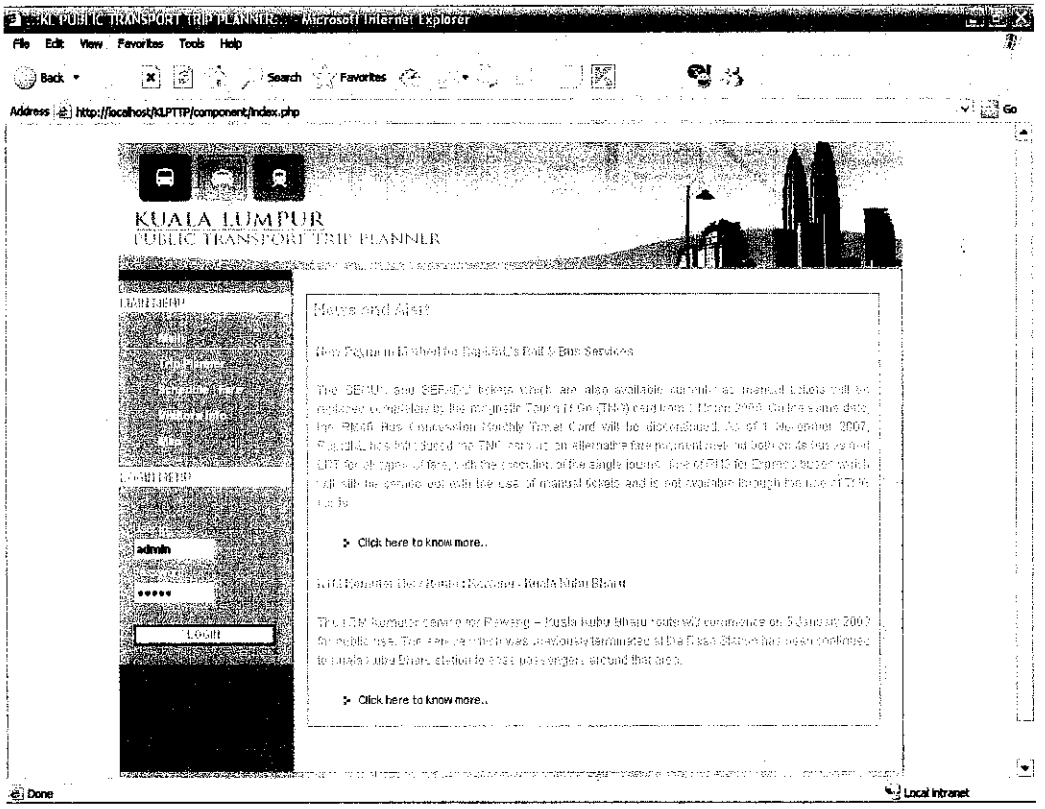
Appendix X (b): KL Public Transport Trip Planner – System (User Input 1)



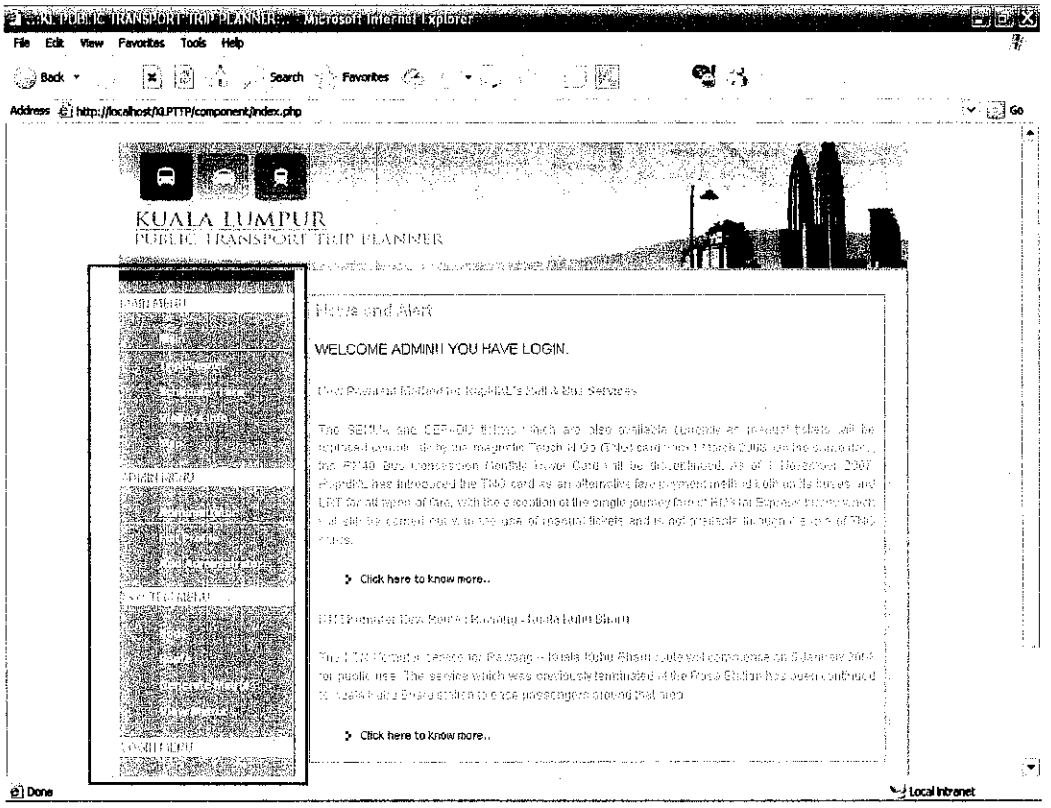
Appendix X (c): KL Public Transport Trip Planner – System (User Input 2)



Appendix X (d): KL Public Transport Trip Planner – System (Output)



Appendix X (e): KL Public Transport Trip Planner – Login Admin



Appendix X (f): KL Public Transport Trip Planner – Admin Menu

SURVEY: KL PUBLIC TRANSPORT TRIP PLANNER

Name: .....

Occupation: ..... From: .....

1. Have you ever using public transport in Kuala Lumpur?
   - ☐ Yes
   - ☐ No

   State your reason:

   .....
2. What type of public transport you usually use? (Multiple answer are allowed)
   - ☐ Bus
   - ☐ Train
   - ☐ Taxi
3. What is your income level?
   - ☐ More RM3, 000
   - ☐ > RM 1, 000 < RM 3, 000
   - ☐ Less than RM 1, 000
4. What are the difficulties you experience while using public transport? (Multiple answer are allowed)
   - ☐ Difficult to find optimum route to go to certain place
   - ☐ Poor quality of service
   - ☐ Not providing park and ride facilities
   - ☐ Schedule not on time
   - ☐ Others (.....)
5. What are the considerations you will take before plan your journey using public transport?
   - ☐ Travel with minimum number of transfer
   - ☐ Travel with minimum cost
   - ☐ Travel with minimum time
   - ☐ Don't care
6. On average how much you willing to spend per day for public transport?
   - ☐ Less than RM 5.00
   - ☐ More than RM 5.00
   - ☐ I'm using monthly pass

7. Do you think by providing system that can help user to facilitate their journey using public transport really needed in Kuala Lumpur?
   - ☐ Yes
   - ☐ No
   - ☐ Not Really
8. If such system exists, what are the features you need to have? (Multiple answers allowed)
   - ☐ Reliable System
   - ☐ User Friendly
   - ☐ Attractive
   - ☐ Easy to use
   - ☐ Available at all time
9. Are you computer literate?
   - ☐ Yes
   - ☐ No

Appendix XI: KL Public Transport Trip Planner Questionnaires

Below are few questions that have been asked regarding public transport service in Kuala Lumpur to some of UTP student's.

Question	Answer
Have all of you been using public transport in Kuala Lumpur?	Yes, frequently especially during internship.
What type of public transport you usually used?	Train because more comfortable than bus and price are affordable.
You use because you don't have other choice?	We don't have other choice, if we drive car the cost might be double.
What are the problems while using public transport?	• Difficult to commute journey. • Schedules are not on time. • Lots of stairs climbing and walk (especially if using bus).
The positive sites while using public transport?	Experience safe, reliable and commutable journey.
Which one you choose, travel with minimum cost or minimum number of transfer?	We willing to pay more, as long it commute us with minimum number of transfer.
Do you think by providing system that can help user to facilitate their journey using public transport really needed in Kuala Lumpur and will you use it?	Of course such system needed and we look forward to use it.

Appendix XII: KL Public Transport Trip Planner Interview Plan