Optimal Route Determination System (ORDS) for Pedestrian Safety

by

Ta Thu Ha

Dissertation submitted in partial fulfillment of
the requirements for the
BACHELOR OF TECHNOLOGY (Hons)
(Business Information Systems)

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Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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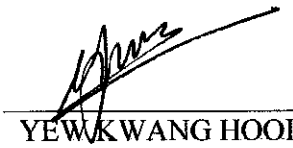
Approved by,



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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.

TA THU HA

ABSTRACT

A common means of traveling in towns, cities and campus is walking because there are many pavements and short-cuts not accessible by motor vehicles. Unfortunately, certain stretches are prone to risks such as high speed traffics and social crimes, hence the need for safe pedestrian routes. This paper proposes a map application designed for pedestrian safety that recommends the safest path based on user inset criteria, safe route determination algorithm and knowledge base. This application may find usage by people who travel alone such as working night shift, missing the last public transport or backpacking tours. The system gives priority to safe route based on database input before looking into the distance. The system is developed using internet aid wireless technology for ease of access. The contribution of this work is system design that provides the mentioned functionalities on handheld devices.

ACKNOWLEDGEMENT

First and foremost, I would like to dedicate my gratitude to my loving family for their continuous support and encouragement.

I am greatly indebted to my project supervisor, Mr. Yew Kwang Hooi, who continuously monitored my progress during the course of the project and never showed a sign of uninvited for my frequent show up in front of his office door. Without his constructive comments, advice and guidance this project will not be a success.

Last but not least, I would also like to thank all of my friends for their invaluable advice, comments and support during development period.

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ABBREVIATIONS AND NOMENCLATURES

UTP	*Universiti Teknologi PETRONAS*
FYP I	*Final Year Project part one*
FYP II	*Final Year Project part two*
ORDS	*Optimal Route Determination System*
GIS	*Geographic Information System*
WAP	*Wireless Application Protocol*
WWW	*World Wide Web*
RDBMS	*Relational Database Management Systems*
DA	*Dijkstra's Algorithm*
HTTP	*Hypertext Transfer Protocol*
HTTPs	*Hypertext Transfer Protocol over Secure Socket Layer*
WAE	*Wireless Application Environment*
WSP	*Wireless Session Protocol*
WTP	*Wireless Transaction Protocol*
WTLS	*Wireless Transaction Layer Security*
WDP	*Wireless Datagram Protocol*
WML	*Wireless Markup Language*
TCP/IP	*Transmission Control Protocol/Internet Protocol*
PDA	*Personal Digital Assistant*
GSM	*Global System for Mobile*
GPRS	*General Packet Radio Service*
CDMA	*Code Division Multiple Access*

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Location awareness to save time and energy in the modern day is a topical issue that receives much concern of people. However, the question of these days is not only: "What is the shortest path to go?" but it has moved to another level of consideration: "What is the shortest and safest path to go?" This is due to fact that crime rate is increasing everywhere. Speaking about crime rate in Malaysia, the numbers are getting bigger and bigger. With rapid increment in population, more and more criminals are born. There are about 161 prisoners per 100 000 people in Malaysia and this number keeps hiking.

How will the system developed to make it convenient for all users? Nowadays, we all know the use of computers and communication devices such as mobile phones are becoming significant as ubiquitous features of daily life. This latest development is linked to the tremendous growth in the number and the sophistication of web-based and mobile applications. Following the trend, the system should be made available not only on website but also on handheld devices so users can carry the application along wherever they go.

1.2 PROBLEM STATEMENT OF STUDY

1.2.1 Problem Identification

Conventional maps lack information on safety whereas some routes may be dangerous for pedestrians to take during certain time of the day.

1.2.2 Significant of the Project

ORDS is a free application which brings benefits to users including:

1. Reducing safety risk – Users of ORDS can obtain information on which route is safer and thus using the route that has less risk of facing danger.
2. Saving time and effort – Instead of locating the directions from the map manually, ORDS provides the ease to the user by identifying the route and the directions in the web server.

1.3 OBJECTIVES OF STUDY

To develop an online map portal on handheld device with optimal safe routes for pedestrians

1.4 SCOPE OF STUDY

- To research and develop algorithm and data structure to determine the safest route to the desired destination
- To deploy the system on mobile technology tools

Optimal Route Determination System will be available in two forms: web-based and handheld. The system will receive three inputs from users including origin, destination and safety criteria. The output is the directions and the location of the destination according to user's choice.

The location chosen to implement this application is UTP Campus. The main reason is that the appropriate area of the campus makes the nodes taken into computation not too big nor too small, just complex enough to check the effectiveness of the algorithm. Besides, it is also easy for the testing purpose since here there are many people who are used to the campus ways and they can verify the accuracy of the system. The system will be a functional prototype that is ready to be used by UTP community at completion of the project (FYP II)

CHAPTER 2

LITERATURE REVIEW

2.1 PREVIOUS STUDIES AND SAFETY CRITERIA

2.1.1 Previous studies

Navigating a dense area such as a town or a sprawling campus can be a daunting task for those unfamiliar with the environment. Even with aid of a map, manual search is often difficult due to thick details contained. Yet, map is the most practical aid of navigation. Information such as safety of the route is important as pedestrians are exposed to higher crime risks as compared to other vehicle users. However, current services provided by Google Maps, Yahoo! Maps, MapQuest and MS MapPoint [1,2,3,4,5] haven't paid much attention to this problem.

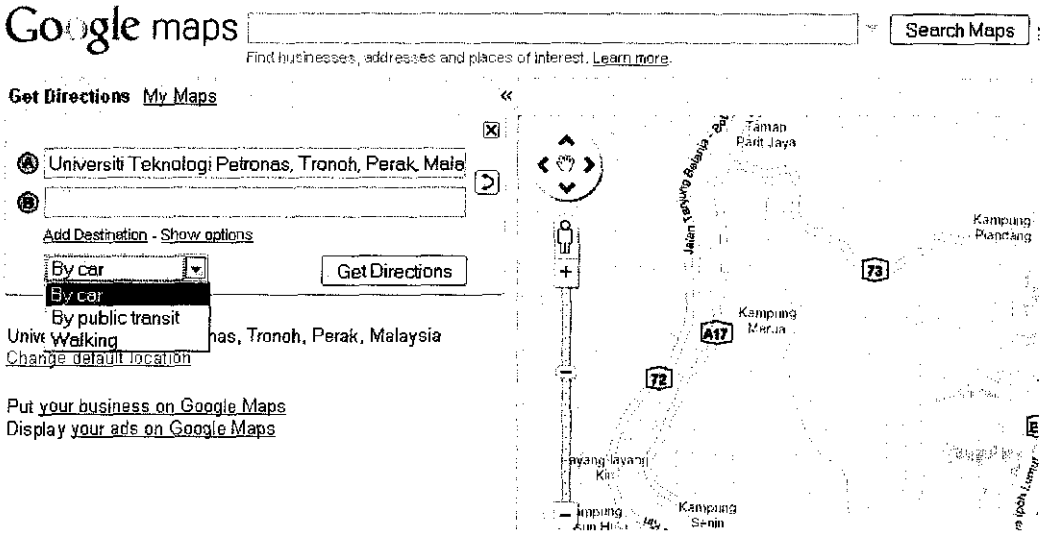

Figure 2.1: Google Map with no selection of safety criteria

In terms of navigating, many researchers have shown their effort in finding the solution for different targeted users. Some explore the mobile journey planning for public transport [6][7]while others figure out the route finding for tourists [8][9]. Along the way of exploration, many new ideas are bloomed such as moving to a concept of talking route planner for the blind [10].

Specifically about safety, there is one proposal for Safe Routes to School (SRTS) which shares the same concern; however the proposed system is just in the early stage and has not been officially implemented [11]. Safe Routes to School is a national and international program to create safe, convenient, and fun opportunities for children to bicycle and walk to and from schools. The program has been designed to reverse the decline in children walking and bicycling to schools. Safe Routes to School can also play a critical role in reversing the alarming nationwide trend toward childhood obesity and inactivity.

Dr. Ruihong Huang in his paper proposes a GIS data model and an Internet GIS framework for SRTS. The data model supports convenient storage and retrieval of diversified walking/bicycling safety-related data and facilitates development of various safety indices. The Internet GIS framework provides a series of web-based functions such as walkability/bikeability evaluation, safe route oriented network analysis, data communication, and web-mapping to satisfy information needs of all users. The GIS data model and Internet GIS framework are implemented in a Safe Routes to School information system for the Sechrist Elementary School in Flagstaff, Arizona.

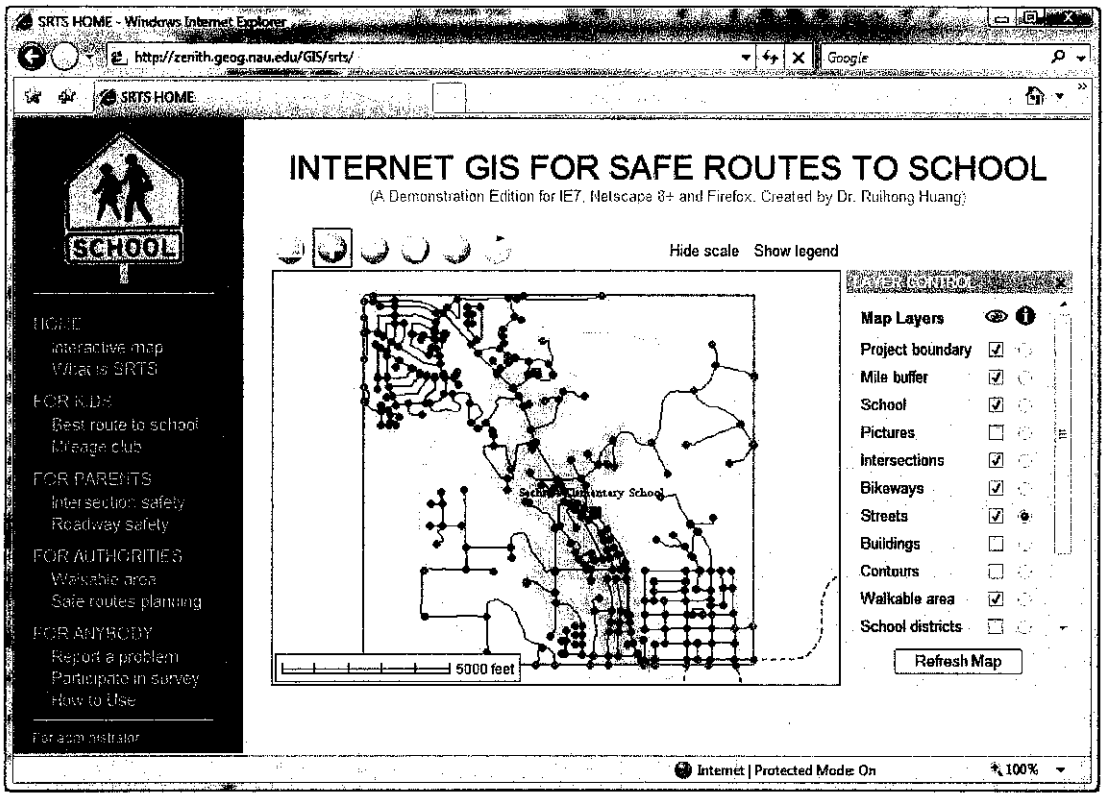

Figure 2.2: A snapshot of the Internet GIS for SRTS

2.1.2 Safety Criteria

The definition of pedestrians includes persons traveling on foot as well as those using some appliance or object to help them fulfill that action or to accompany them in fulfilling it such as a pram or wheelchair. Speed as well as movement patterns vary for different pedestrian types. Particularly vulnerable groups include children, the elderly and the disabled.

According to European Road Safety Observatory[12], a risk rate exposed to pedestrians can be calculated as:

$$\text{risk} = \frac{\text{road safety outcome}}{\text{amount of exposure}}$$

The road safety outcome is usually the number of accidents or casualties, (fatal accidents, accidents with hospitalized or fatally injured victims, fatalities, persons injured). The amount of exposure is mostly selected based on its theoretical importance. This can be restricted to a specific period, area, time of day, vehicle types involved, and condition of the road.

Based on this, three most common safety criteria chosen to be used in ORDS are well-lit, paved and low crime rate.

2.2 REVIEWS ON GEOGRAPHIC INFORMATION SYSTEM

2.2.1 GIS

GIS is the most active technology in Geographic Science and Earth Science. According to Wikipedia, GIS can be defined as any system which captures, stores, analyzes, manages, and presents data referring to location.

2.2.2 Web-based GIS

With the development of computer and network hardware and software, especially Internet building, GIS has got a lot of new features to fit Web applications [13]. The major reason for the increase of map distribution through the Internet is the cost. It is simply less expensive to distribute color graphics through the web than to print and distribute maps on paper. The second reason is the time. Maps on computer networks are delivered in a fraction of the time that was previously required. The third reason is the potential for interaction. Users can interactively choose a location to map and the features to include on the map.

Unlike most micro-computer applications which can be used immediately after the purchase of hardware and software, GIS requires a large spatial database to be created, appropriate hardware and software purchased, applications developed, and all components installed, integrated and tested before it can be used. As spatial data

becomes an enterprise resource that adds value to many existing and future business processes, the requirement for better integration with relational database management systems (RDBMS) becomes crucial. GIS users in the future will want a complete RDBMS to fit with their current GIS needs. GIS-related data will be loaded into the RDBMS with ease and all applications in various departments in an organization will become integrated. Spatial analysis will then be truly deployed throughout organizations via the Internet or intranets.

2.2.3 Mobile GIS

As we know, now the World Wide Web is becoming the primary communication interface. People access the Internet for entertainment and information collection; the intranet for accessing company information and connecting with colleagues; and the extranet for accessing customers and suppliers. We've all enjoyed the happiness offered by the computer system and wire communication at home, at work, at school and maybe at any other buildings. The next thing we will want is to extend this happiness to be accessible anywhere, anytime. So the wireless Internet access service becomes the concern of the multitude.

The use of a portable and wireless device such as Personal Digital Assistance (PDA) and mobile phone is becoming popular and significant. Recent studies stated that more than 50% of the world population is reported to have a ratio of at least one mobile phone to a person [14]. It is also stated that the percentage is expected to increase as the product range in mobile telephony is made more available at reduced prices and equipped with advanced function. And recently, with the new challenge in the work and life, personal computer cannot meet the demand of people in many situations. Many users expect they can access the information under the mobile environment. This emerging demand has dramatically changed the technology of mobile computing and mobile mapping.

GIS has seen many implementations on mobile devices. Many research papers have explored the way to implement GIS on mobile application [15][16][17][20], and even specifically in the area of finding route [18]. Nowadays, with the widespread

adoption of GPS, mobile GIS has come to the next level when it can automatically detect the location of users.

Normally, mobile GIS is the combination of geographic information system (GIS) software, global positioning systems (GPS), and mobile computing devices. Mobile GIS fundamentally changes the way information is collected, used in the field, and shared with the rest of an organization. A mobile GIS allows you to visualize information in a digital map, collect information where you observe it, and interact directly with the world around you, while improving productivity and data accuracy. Below is the picture presenting the components of Mobile GIS:

2.3 REVIEWS ON MOBILE APPLICATION DEVELOPMENT

2.3.1 Characteristics of Mobile Devices and Applications

Web-pages displayed on a computer monitor can be huge and full of pictures including animations, sound and fancy fonts. But all these features that make Web pages so enjoyable and so useful to read on a computer are the very features that make Web pages impossible to view on a cell phone. Unlike Internet users who are tied to a bulky PC or laptop, wireless cell phone users don't want to surf. The most important thing they look for is information, usually small pieces of information that they can access quickly and effectively. Consequently, to meet user's demand, developers have to take into account those following limitation of mobile phone features.

The first easily noticeable is that mobile phones usually have smaller, usually much smaller, display screen than a PC. Typically they are 4 to 11 lines long by 12 to 16 characters across with limited graphics capabilities. Small bitmaps and icons may be displayed but larger graphics are not supported.

Phones also have a limited keypad, so data entry is cumbersome. So interface which requires users to enter large chunk of information is not suitable. Moreover, cell phones also have a smaller memory and smaller random access memory than computers do, so the data that can be transmitted, received and displayed is limited. The transmission limitations depend on the network and the gateway used. Typically the limit is about 1.2KB but it is often recommended to keep the size of a data stream to fewer than 600 bytes. In addition to that, the electric power of mobile phones is provided by battery. Despite all those facts, users still expect their applications to deliver a responsive, interactive experience. As a result developers often find themselves facing a tension between resource/memory usage and application performance when developing.

Lastly the widely varying microbrowser type can make it difficult for developers to provide an acceptable user experience across a significant range of devices. If in PC platform there are only a few major web browsers namely Microsoft Internet Explorer, Mozilla Firefox, Netscape Navigator, in microbrowser platform there are much more than that. Each company has different kinds of browsers, and the browsers from the same company can even vary in different models. There is a very little standard among those. When different devices support different markup features and different screen sizes may demand different sized images, it is very challenging for developer to deliver content to be displayed properly in almost all kinds of hand phones.

2.3.2 Wireless Application Protocol (WAP)

WAP is an international set of standards and rules that is intended to define and regulate how users access Internet-based information and services from their wireless devices [21]. Since WAP is global, it is now the link of the Internet to the mobile world, bridging a gap between two of the top industries of the world. WAP covers most cellular networks and is supported by nearly all operating systems. It also takes into consideration of other limitations such as smaller display, different input method, less powerful CPU, less memory and low bandwidth network connectivity.

WAP has some of the following basic advantages:

- Ease of use: almost all that is necessary to use WAP applications is a basic knowledge of the internet. Besides this, one needs only to know how to use one's wireless telephone
- Doesn't depend on the type of bearer for compatibility within wireless technologies: WAP technology doesn't depend on the type of bearer, which is why services provided for subscribers of wireless networks with any standard (eg GSM) can be used by subscribers of other networks(eg CDMA)

WAP model is very similar to the WWW model. One of the main components of the architecture is WAP gateway, which acts like a proxy server between origin server and the mobile clients. The architecture of how WAP works is shown in figure 1 below:

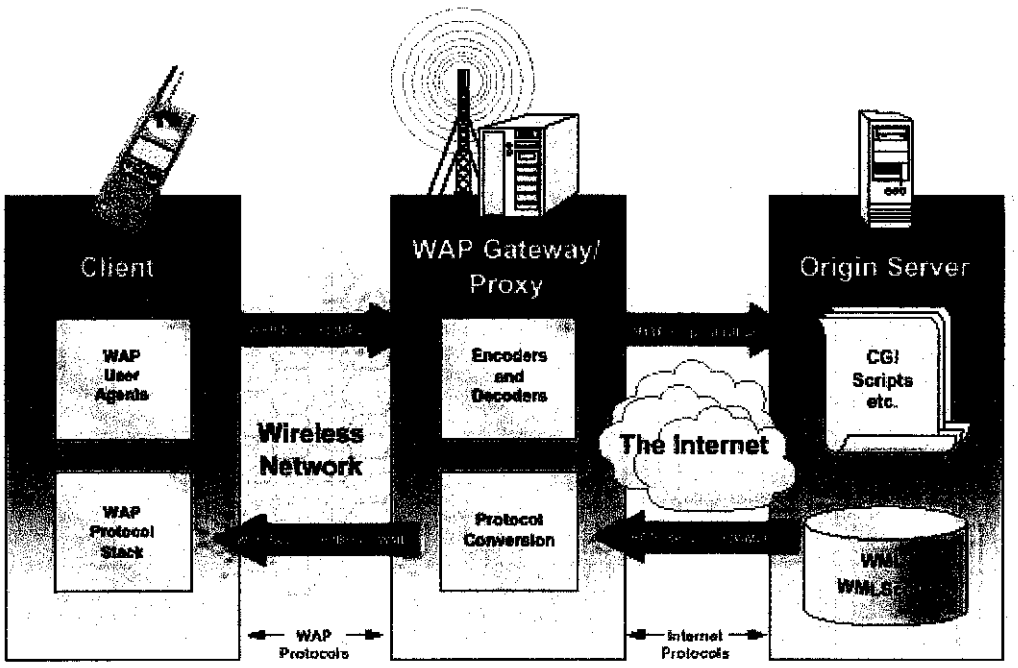

Figure 2.3: WAP Model

There are several steps to do a WAP session [22]:

1. A user uses a WML browser to enter the URL

2. The browser analyses the URL, forms a request according the WAP protocol and sends it to the WAP gateway using the WTP transport protocol
3. The WAP gateway forms an HTTP and HTTPs request and sends it to the HTTP server over the ICP/IP protocol
4. The HTTP server analyses the request and either extracts a static page located in a certain directory r gives control to the CGI program. The execution of the CGI program results in an already-formed WML document coming back to the server
5. The HTTP server adds HTTP headers to the received content and sends the results to the WAP gateway using TCP/IP as the transport protocol
6. The WAP gateway checks the correctness of the received content, transforms it into binary format if necessary and sends results to the WML browser using WTP as the transport protocol
7. The WML browser analyses the answer and displays part of the document on the wireless terminal screen.

WAP architecture is divided into several layers which follows the OSI model fairly closely .Below is the picture of WAP layers:

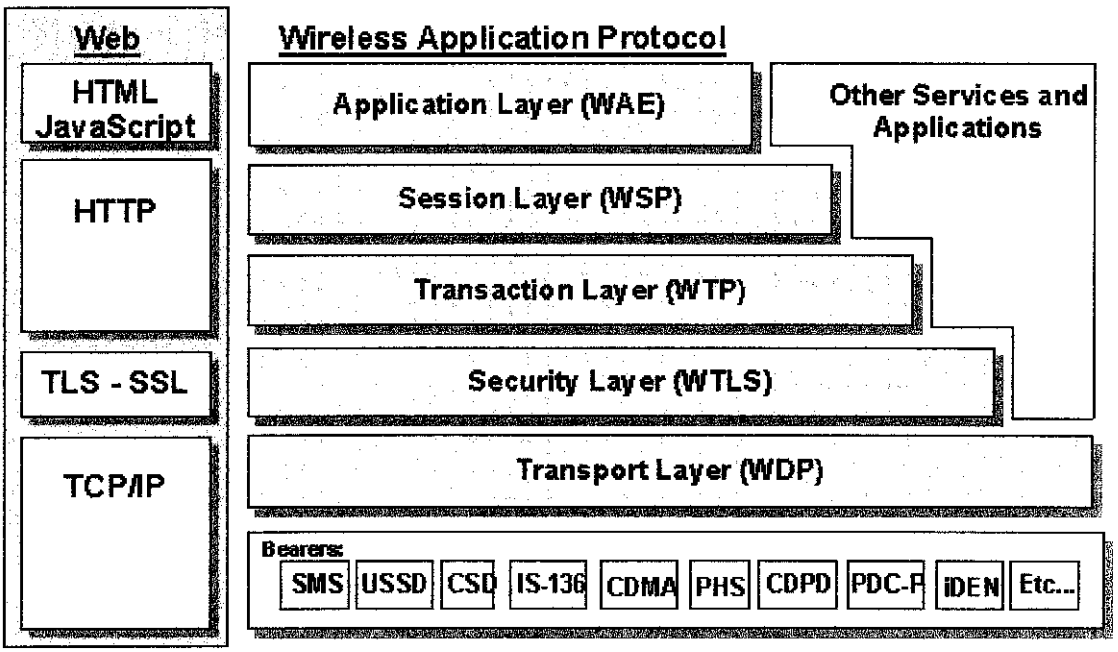

Figure 2.4:WAP Layers

Application Layer

WAP's application layer is the Wireless Application Environment (WAE). WAE directly supports WAP application development with Wireless Markup Language (WML) instead of HTML and WMLScript instead of JavaScript. WAE also includes the Wireless Telephony Application Interface (WTAI, or WTA for short) that provides a programming interface to telephones for initiating calls, sending text messages, and other networking capability.

Session Layer

WAP's session layer is the Wireless Session Protocol (WSP). WSP is the equivalent to HTTP for WAP browsers. WAP involves browsers and servers just like the Web, but HTTP was not a practical choice for WAP because of its relative inefficiency on the wire. WSP conserves precious bandwidth on wireless links; in particular, WSP works with relatively compact binary data where HTTP works mainly with text data.

Transaction, Security, and Transport Layers

These three protocols can be thought of as "glue layers" in WAP:

- Wireless Transaction Protocol (WTP)
- Wireless Transaction Layer Security (WTLS)
- Wireless Datagram Protocol (WDP)

WTP provides transaction-level services for both reliable and unreliable transports. It prevents duplicate copies of packets from being received by a destination, and it supports retransmission, if necessary, in cases where packets are dropped.
WTLS provides authentication and encryption functionality.
WDP acts as the communication layer between the upper level protocols and the bearer services. The function of WTP layer is to provide a stable environment so that any of the underlying bearers can operate using WAP.

Bearer Interfaces

The bearers of WAP are the products or other types of medium that implements WAP in their network and in their technology, such as GSM, CDMA or GPRS.

2.4 ALGORITHMS RELATED TO THE STUDY

Optimization is the art of selecting the best alternative among a given set of options The algorithm related to the study should be the one which could solve the problem of finding the shortest path. In addition, the algorithm must be easy to modify to find the safest path as well. Several algorithms are taken into consideration.

2.4.1 Bellman–Ford algorithm

Bellman–Ford algorithm computes single-source shortest paths in a weighted digraph where some of the edge weights may be negative. Bellman–Ford is usually used only when there are negative edge weights, however Dijkstra's algorithm can accomplish same results with a lower running time given edge weights are non-negative.

The main disadvantages of Bellman–Ford algorithm in this setting are

- Does not scale well
- Changes in network topology are not reflected quickly since updates are spread node-by-node.
- Counting to infinity (If link or node failures render a node unreachable from some set of other nodes, those nodes may spend forever gradually increasing their estimates of the distance to it, and in the meantime there may be routing loops.)

2.4.2 Generic Algorithm

Genetic algorithms are a part of evolutionary computing, which is a rapidly growing area of artificial intelligence. Inspired by Darwin's theory of evolution - Genetic

Algorithms (GAs) are computer programs which create an environment where populations of data can compete and only the fittest survive, sort of evolution on a computer. Generic Algorithm can be used effectively for searching multiple routes from a real road map with a rank order i.e: shortest, second shortest, third shortest and so on. One of the major disadvantages of genetic algorithms is that they are very slow so this kind of algorithms will not suitable to develop ORDS which interaction speed is a highlighted feature.

2.4.3 A* Algorithm

It is a graph search algorithm that finds a path from a given initial node to a given goal node. It employs a heuristic estimate $h(x)$ that ranks each node x by an estimate of the best route that goes through that node. It visits the nodes in order of this heuristic estimate. The A* algorithm is therefore an example of best-first search.

One disadvantage of A* search algorithm is its heavy dependency on the heuristic function chosen whereby a good one will allow the algorithm to run quickly and find the optimal solution and bad one may just increase the running time or even mislead the algorithm into returning sub-optimal solutions or not find solutions at all.

Another issue is how quickly the heuristic function can be computed. There's always a trade-off between the accuracy of the heuristic and the time it takes to compute its estimates therefore when choosing the heuristic function for a specific implementation of A-Star, one should always think carefully about whether speed or accuracy is more valuable in the context of the problem.

2.4.4 Dijkstra algorithm

Dijkstra's algorithm (DA) is the best known algorithm for the shortest path problem in theory and the most robust in practice.
It works as follow:

1. Let's call the node we are starting with an **initial node**. Let a **distance of a node X** be the distance from the **initial node** to it. Dijkstra's algorithm will assign some initial distance values and will try to improve them step-by-step.
2. Assign to every node a distance value. Set it to zero for our initial node and to infinity for all other nodes.
3. Mark all nodes as unvisited. Set initial node as current.
4. For current node, consider all its unvisited neighbors and calculate their distance (from the initial node). For example, if current node (A) has distance of 6, and an edge connecting it with another node (B) is 2, the distance to B through A will be 6+2=8. If this distance is less than the previously recorded distance (infinity in the beginning, zero for the initial node), overwrite the distance.
5. When we are done considering all neighbors of the current node, mark it as visited. A visited node will not be checked ever again; its distance recorded now is final and minimal.
6. Set the unvisited node with the smallest distance (from the initial node) as the next "current node" and continue from step 3

A potential advantage of Dijkstra's algorithm for our purposes is that the algorithm often does not have to investigate all edges. If edges are relatively expensive to compute, then Dijkstra's algorithm might turn out to be faster. The original algorithm computes the shortest paths from one source to all other vertices in the graph, but it can be easily modified for the problem of computing the shortest paths from one source to several specified other vertices.

For the purpose of developing ORDS, I believe DA is the best choice to implement, as has been suggested in the above arguments.

CHAPTER 3

METHODOLOGY

3.1 METHODOLOGY SELECTED

3.1.1 System development methodology

The methodology which is applied during the project development is the Spiral model. This model of development combines the features of the prototyping model and the waterfall model. Using this methodology, the project will be divided into several phase with particular deliverables. In each phase, it can be seen a full project life cycle with the review of the previous prototype.

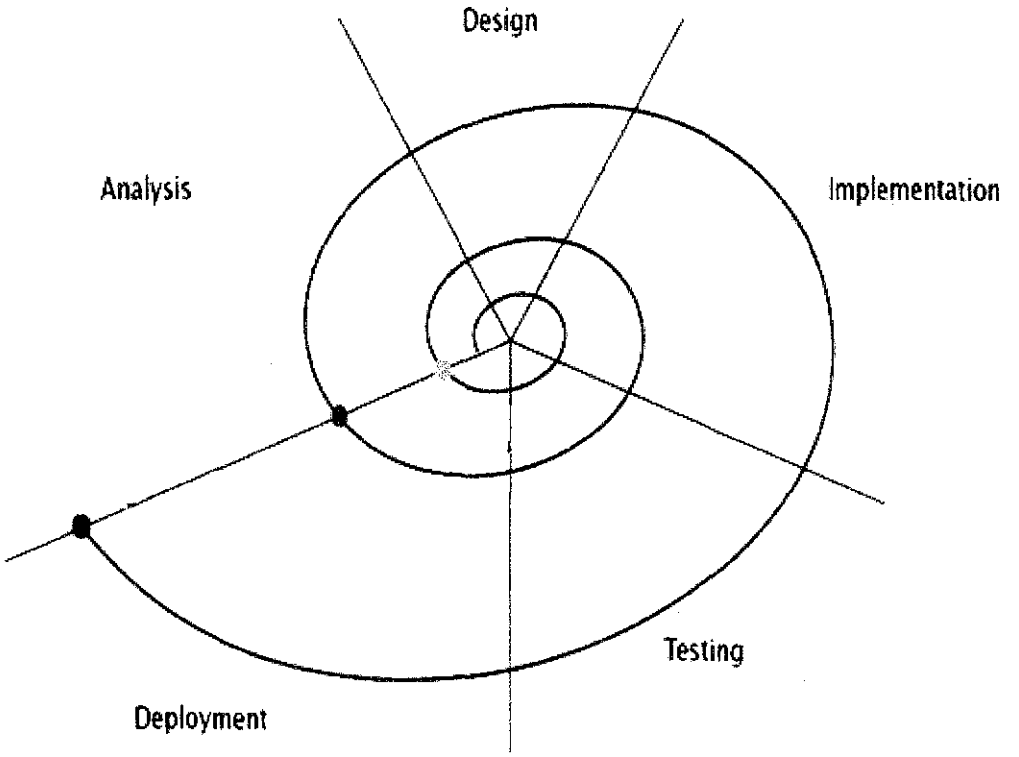

Figure 3.1: Spiral Model for system development

There will be two main phases during the development:

Phase one: the main task in the first phase is to set up a platform for that web-based system. At the end of this phase, the system would be ready to perform fundamental functions in PC platform. The main task in the phase include:

- Task 1: set up the server environment. The package is Microsoft Windows XP, Apache Server, PHP, MySQL. The environment should be configured formally and tested before proceed
- Task 2: Study on Dijkstra's Algorithm
- Task 3: Design the website interface
- Task 4: Design the database
- Task 5: Create PHP code that handles the functions
- Task 6: Integration and testing

Phase two: During this phase, a study on mobile technology and WML language will be carried out. At the end of this phase, the system would be ready to perform functions on mobile phone micro browser. The main tasks in this phase include:

- Task 1: Review the previous prototype
- Task 2: Study on WML
- Task 3: Develop the system using WML
- Task 4: Integration and testing

3.1.2 Research Methodology

In the first part of the project, researching and gathering information will play a key role. Some research methodologies that will be used are:

- *Observation:* Observation is done to see the route system of UTP and try to identify any problems faced by UTPians.

- *Questionnaire*: One set of questionnaire is prepared to confirm the result from observation phase. It also gather information about how UTPians think about ORDS, what problems they are facing and what they expect in the new system.
- *Interview:* An interview with Mr. Zakaria, Universiti Teknologi PETRONAS Security Officer is done to get information about UTP map and UTP roads.
- *Statistical methods*: will be used to analyze the results of the questionnaires and coming up with some graphics and visual aids about the statistical numbers collected.
- *Searching on Internet:* Gathering basic information about other existing similar systems to see the possibility to adapt their techniques in ORDS.

3.2 SYSTEM ANALYSIS

3.2.1 System architecture

The proposed architecture for ORDS is tiered server-client architecture. The server will run on Apache with SQL server as backend database. Clients who use PC platform can access directly to the service at the server. Mobile users which use laptop, PDA or cell phone, can access the service via Wireless LAN or GSM/GPRS/3G network.

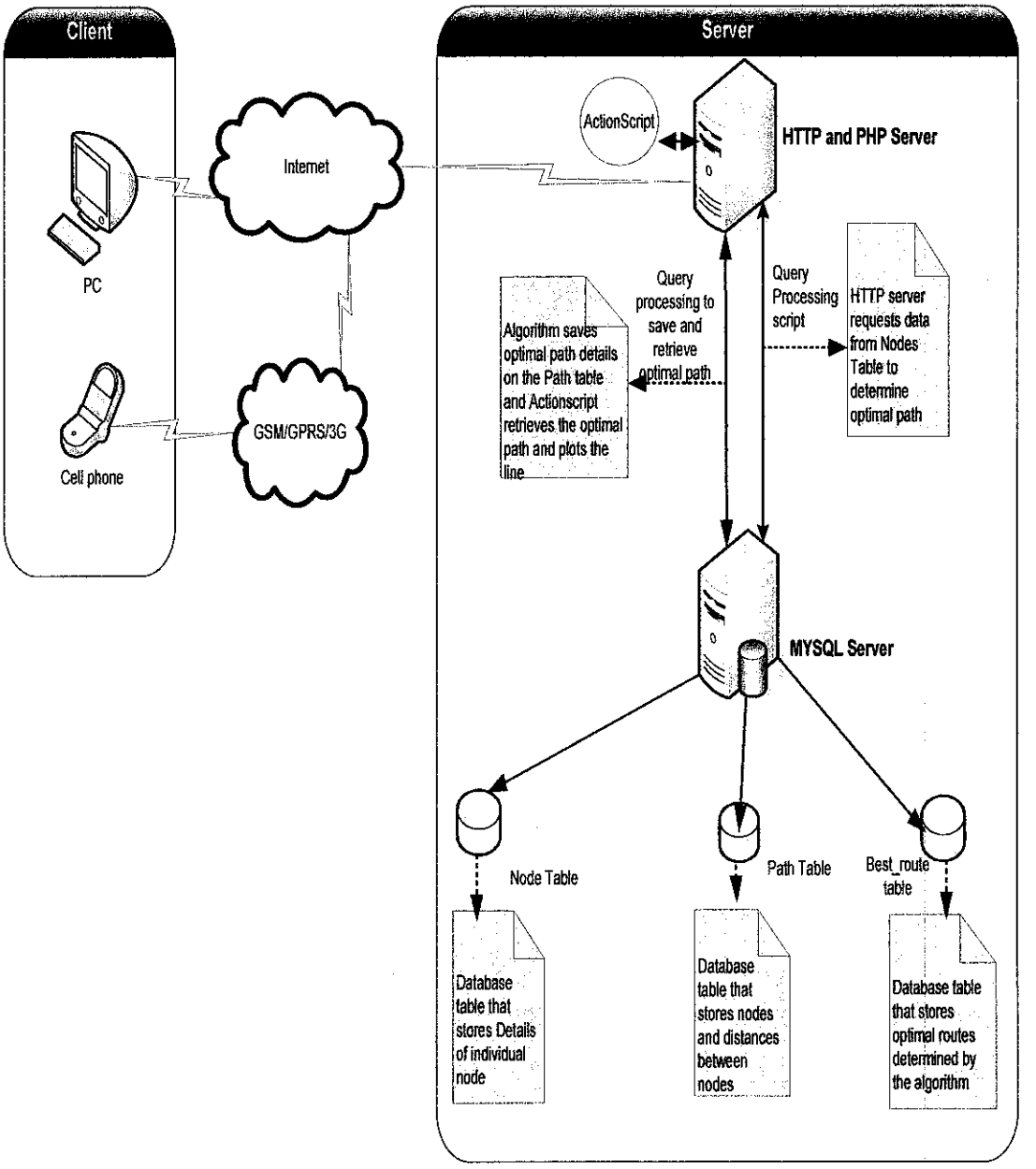

Figure 3.2: System Architecture

3.2.2 Use Case Diagram

Users can use the system by choosing origin and destination along with the safety criteria. They can also view the result sent back by the system after processing.

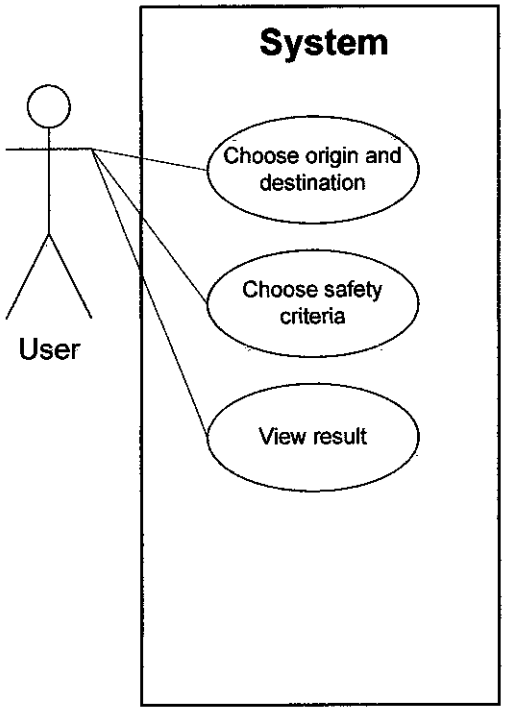

Figure 3.3 : Use Case Diagram

3.2.3 Activity Diagram

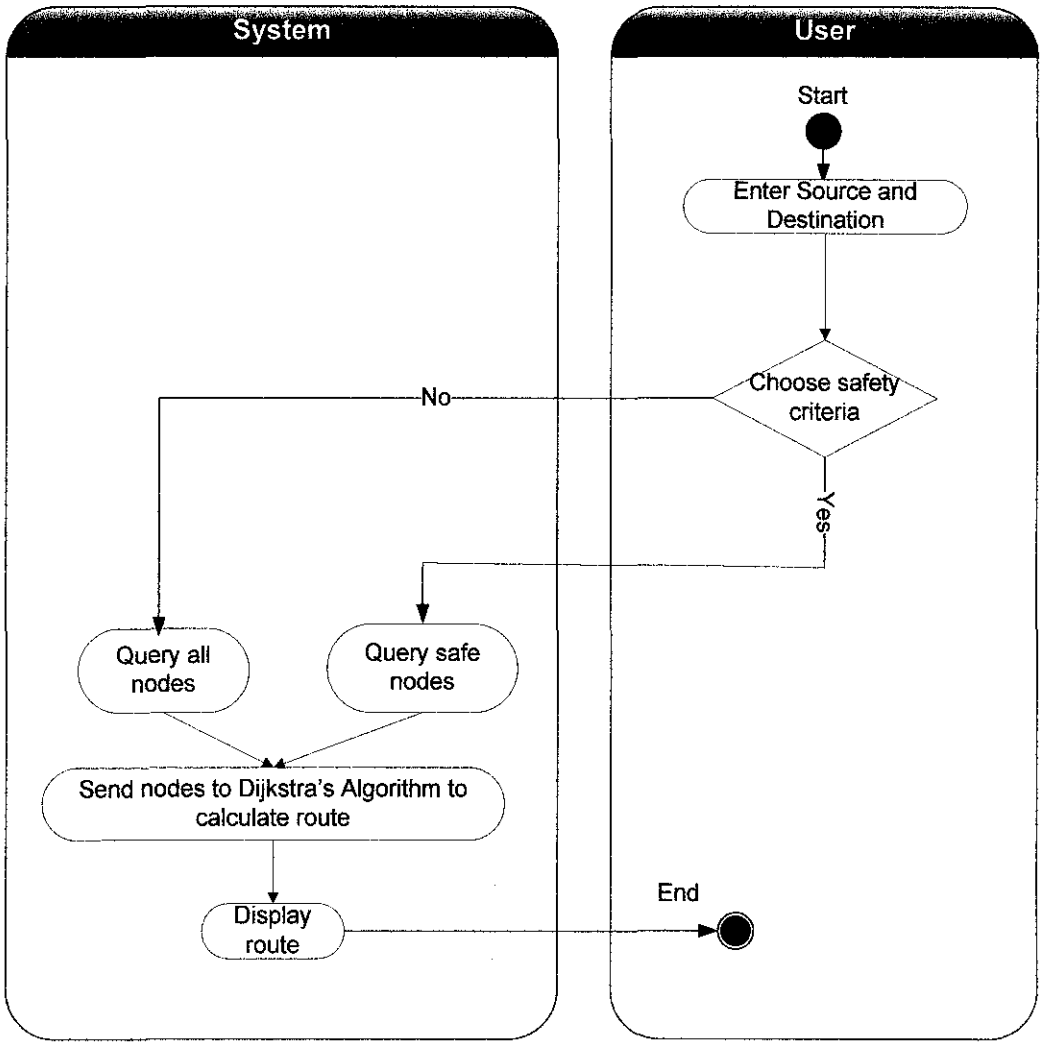

Figure 3.4: Activity Diagram

First, user interacts with his/her computer or mobile phone and connects it to the Internet. The user will enter his/her current location and the destination as well as other criteria. At the moment, safety criteria are based on three conditions: well lit, paved and low crime rate. Well lit means that the route is bright while paved means the path is has pavement for pedestrians. In Malaysia, darker path is usually more dangerous. And if the path is not paved (for example, a short cut path where not

many people are using), the risk of facing danger is higher than the paved route. Another criteria, low crime rate, which is analyzed through data collected, is also added. If no criterion is selected, by default the application will return the shortest route.

3.2.4 Entity Relationship Diagram

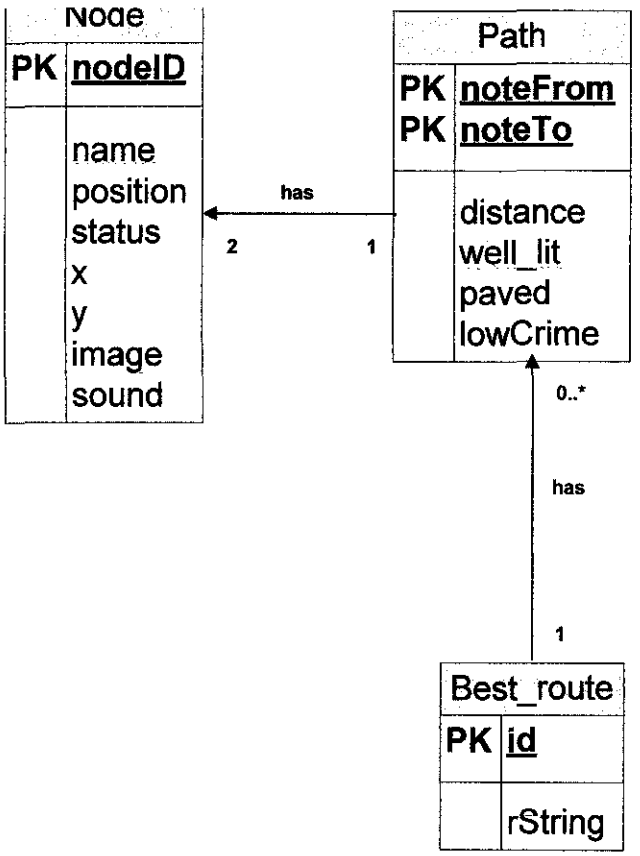

Figure 3.5: Entity Relationship Diagram

A relational database management system (RDBMS) is used to store information of each node and its distances with adjacent nodes. The followings are the tables used in the database:

- Table "Node" stores data of each node including nodeID, name, coordinates on the map (x, y) , image and sound of the location.
- Table "Path" stores data about certain pairs of nodes including nodeFrom, nodeTo, distance and the criteria of the path: well-lit, paved or interesting.

- Table "Best_route" stores data about the best path returned after the Dijkstra's Algorithm processed data.

3.3 TOOLS AND TECHNIQUES

A number of tools and techniques have been identified to accomplish the project.

Component	Reason of Usage
Apache	Web Server: to implement the web service of the system
MySQL	Database Server: to implement the database structure of the prototype. It is used to separate database from application interface to improve the security and better data management issues of the system
PHP	Server-side scripting language that can generate dynamic content for the system as well as perform fundamental functions.
Macromedia Dreamweaver	Web authoring tool with advanced features for multiple language (HTML, XML, PHP, Javascript...)
Adobe Photoshop CS2	To create the look and feel of the system
Macromedia Flash Player	To provide interactive output on the map
Mobile Emulator(Openwave, Nokia Mobile Browser)	To test the mobile version

CHAPTER 4

RESULT AND DISCUSSION

4.1 RESULT

4.1.1 Survey result

The objective of distributing questionnaire is to get better understanding about user requirements and expectation, about the digital map concept on website and mobile through the view of users.

The questionnaire is divided into three main sections.

Section A collects some general information about users as well as their habit of travelling. When asked to self-evaluate the navigation ability or sense of direction, 44% of the interviewees said "Yes" when others chose "No". From here, we can see a demand for a convenient digital map to guide people when travelling.

However, traditional paper map is enough for the current demand. 41% of the people don't want to carry a paper map when they travel and the reason given is that paper map sometimes not up-to-date and not interactive enough. That costs the user a span of time to identify the place they are currently at, the place they want to go to as well as the best way to get there.

Section B introduces the concept of ORDS to users and surveys its possibility to be implemented in campus zone.

In the campus, number of people who travel on foot (72%) outweighs other vehicle users. Pedestrians are the ones that have to most probability of being exposed to danger when travelling at night, so ORDS can be developed to target those users.

Safety criteria receive much concern of interviewees when travelling. Question 3 asks for student's opinions about defining a safe route. Well-lit, paved and some other criteria such as low crime rate and physical disturbance are mentioned.

Question 5 asks for student's opinions about implementing this system.71% of the students are eager to have such system. They said they want to see the whole campus through digital map as well as to know the shortest and safest routes while travelling.

Question 6 further surveys to see how the system will most benefit users if it is implemented. The availability on mobile device received much concern from users because it enhances the mobility and convenience.

Section C ends the questionnaire by asking for recommendations from users and what they expect if the system is implemented. Low-cost is the significant feature that most of the students mention. Besides, visualization with nice GUI, user-friendly navigation and speed are also among their concerns.

4.1.2 System development result

At the moment this report was written, the author has finished the Optimal Route Determination System in both PC and Microbrowser version.

Apache, MySQL and PHP were setup and configured successful in a local server. Author uses PHPMyAdmin to manage the database and three tables have been created: node, path and best_route. The server is also configured to support WML in order to run the dynamic WAP site.

All of core functions are finished such as code to connect the presentation level with MySQL server, connect Flash to retrieve coordinates and draw line on map. Algorithm to find safe route is also completed and now able to show user safe way according to their chosen criteria.

The system can currently run on localhost and WAP emulator. Next step, author will find the host for the website and WAP to test the system.

PC version

Input field

Input field is designed to allow user to choose the origin "From", the destination "To" along with the criteria of the route either well-lit, paved or low crime rate.

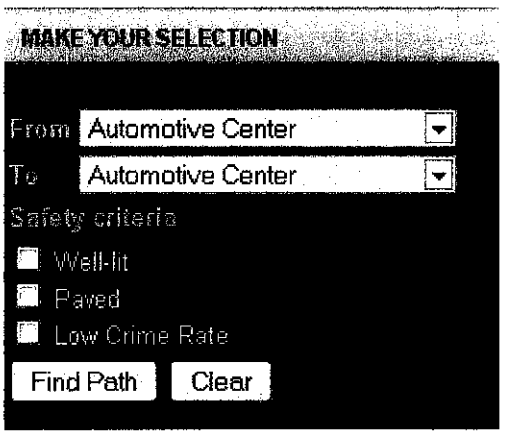

Figure 4.1: Input field

Data in combo boxes are not embedded directly in HTML; instead they are retrieved from database table "Node" (Appendix II, line 48 to 76). This makes the system more flexible and easy to be updated. Safety criteria including well-lit, paved and low crime rate are three checked boxes for user's choice.

Output

Once the user has selected his location, his destination, and safety criteria and submitted the information using Find Path button, the information will be sent to the server using POST method.

From line 83 to 91, appendix II is the design of safety criteria checkboxes. All the checkboxes of safety criteria have the exact same name and each name ends in []. It indicates that the selected values will be accessed by PHP as an array. That is, $_POST['criteria'] will return an array consisting of all the values of the checkboxes that were checked. If no criteria are selected, the system will print out "You selected

no criteria". Otherwise, all criteria chosen will be listed to remind users of their choice.

Based on the chosen criteria, the system will retrieve the database table "Path" accordingly to take all the paths that match user's choice. For instance, if user selects "well-lit" criteria, the system will retrieve all the paths in "Path" table which has "well-lit" field (boolean type) equal to 1. A switch case was developed to solve this retrieving task as you can see in appendix II, line 118 to 159.

To be able to display a line on the map to show the way, Flash is chosen. Coordinate of each node (x,y) on the map is inserted into table "Node". Flash action script does not connect directly to MySql database, instead it uses a server side services to connect to the database and retrieve the needed information, and then Flash reuses these values to draw the line.

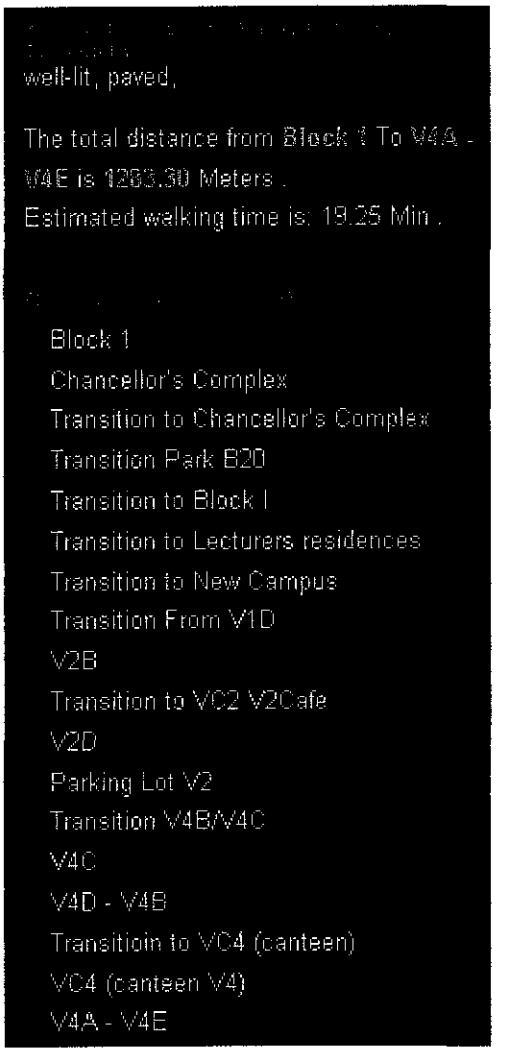

Figure 4.2: Text output (from Block 1 to V4A-V4E with safety criteria: well-lit and paved)

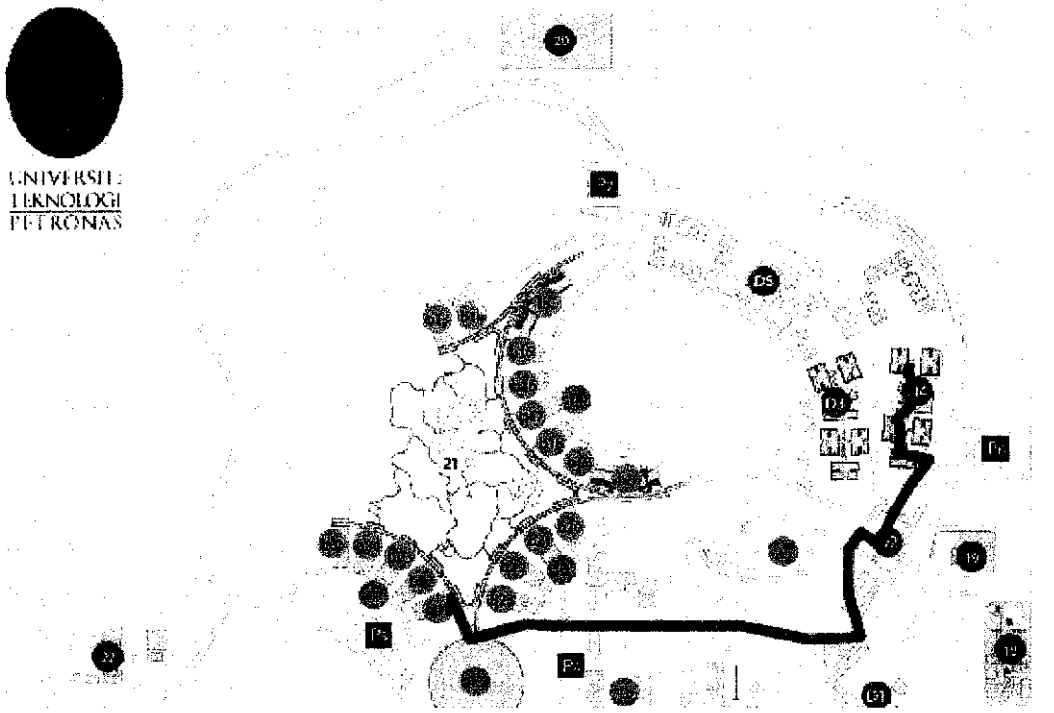

Figure 5: Line on map (from Block 1 to V4A-V4E with safety criteria: well-lit and paved)

If no criteria is selected, by default the system will determine the shortest route.

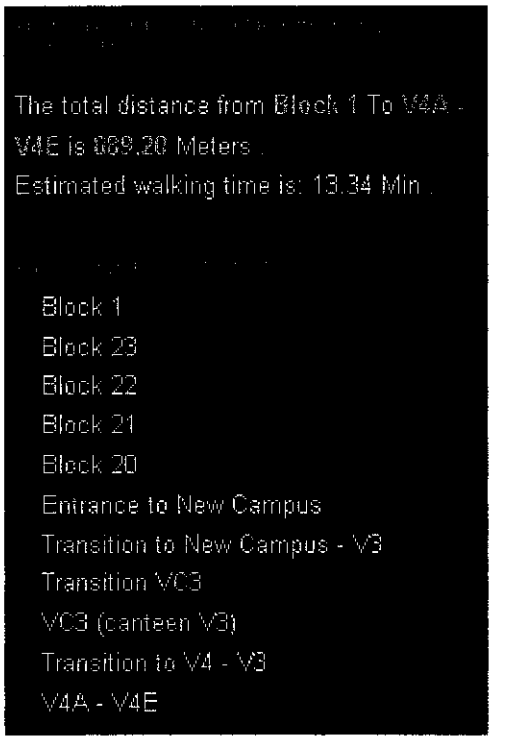

Figure 4.4: Text output (from Block 1 to V4A-V4E with no safety criteria selected)

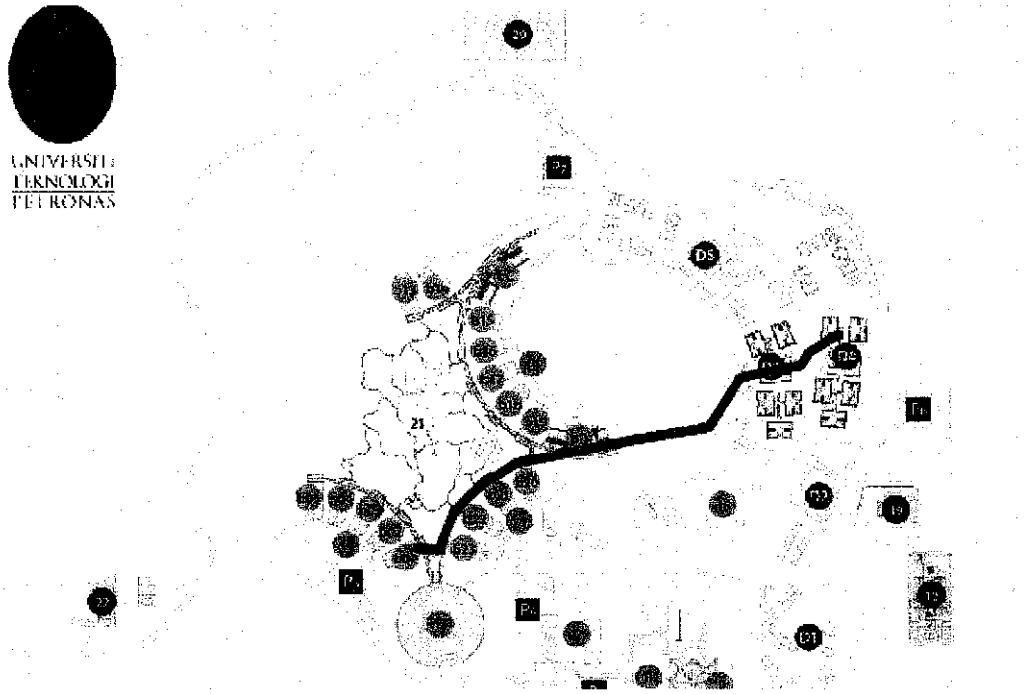

Figure 6: Line on map (from Block 1 to V4A-V4E with no safety criteria selected)

Mobile microbrowser version

Due to the characteristics of microbrowser as discussed earlier, the version of ORDS on mobile has some changes compared to web-based version. After user's selection, the result displayed is not the full map with line drawn by Flash. To still successfully guide users, the mobile version will display picture and sound of each location step by step.

```
echo "The Path is as Follow <br/></a>";
$b=0;
$num = 1;
$rString ="";
while($row=mysql_fetch_array($nt)){
$sqlQuery = "SELECT nodeID, name, status,imgLink, soundLink FROM `node` WHERE `nodeID` = '$splited[$b]'";
$response = mysql_query($sqlQuery);
$results = mysql_fetch_array($response);
$st = $results['status'];
if( $st === "Main" or $st ==="Not"){
echo "<img src='images/" . $results['imgLink'] . "'>".'<BR>';
echo  $results['name'].'<BR>';
echo "<a href='sound/". $results['soundLink']. "'>Sound</a>";
echo "<br><br>";
}
$rString .= $splited[$b].";";
$b++;
$num++;
}
```

Figure 4.6: Code to return image link and sound link for mobile version

Instead of returning only nodeID, name, status as in web-based version, in this mobile version, the system returns also the link of the image and sound of the location. First, images and sound were designed to store in database using BLOB type; however they are memory-consuming and time-consuming during retrieval. So images and sound finally are stored in a separated folder and only links to this folder is stored in databse.

Figure 7: Home page on mobile

Figure 4.8: Example of user's choice (From Block 20 to Block 23 with safety criteria: well-lit and paved)

Figure 4.9: Result page – Step by step with image and sound

Figure 4.10: Sound of location are read when user click on Sound link

4.1.3 Testing result

There are two kind of testing methods that were used by the author in the development life cycle: Performance Testing (including Unit Testing and Integration Testing) and Acceptance Testing.

Unit Testing

In the unit testing, the author has carefully checked all the functions and modules of the system with all predefined data. Most of the functions and modules such as Dijkstra algorithm, text output module, flash output module on website, picture and sound on mobile are tested in isolation environment to eliminate any effect from others components.

Integration Testing

After passing the Unit testing, the system was checked for its integration during the system testing. Its mainly purpose is to make sure that all the module are workable with each other, data can be sent and received correctly between functions. There are some challenges during this phase as expected however, the system would pass and work flawlessly during Seminar and Engineering Design Exhibition.

User Testing

Right after the system was successfully implemented; it was put on the server for students to test. Users are questioned about the functionality, speed, visualization and ease of use of the system. During 2 weeks running, there was a lot of good feedback and also recommendation, and proudly to say, all of them are positive.

One noticeable point is that there are difficulties in testing the effectiveness of the system. The study on "safety" is currently based on only three criteria namely: well-lit, paved and low crime rate; and in the implementation for UTP campus, author

made quite a number of assumptions about each path. However, the idea of the system is creative and the prototype showed a successfully well-functioned design , hence it has big potential to apply in real world to serve human-beings. To be implemented in actual world, the quality of each path and its criteria (well-lit, paved, low crime rate and more) needs to be analyzed carefully and real field experimentations are required to be carried out in order to test the effectiveness.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Optimal Route Determination System is a new proposed system which can detect safest routes for pedestrians. The system is available on both website and handheld devices for the convenience of users. Prototype of this system is designed for UTP campus and it has received much concern and encouragement from users.

The system is successfully developed within the cost and time frame. It can provide all the needed functions and operate smoothly. The system also meets the entire objectives that were stated from the beginning of the report which are:

- To research and develop algorithm and data structure to determine the safest route to the desired destination
- To deploy the system on mobile technology tools

The system still has limitation in showing the effectiveness of safety. To be able to successfully implement the system in actual world, real field experimentations are recommended to be performed. Needless to say, the system is a good design and with the ability to guide users with safety criteria in an interactive way, it not only passed all requirements for a final year project but also has big potential to be implemented and commercialized.

5.2 RECOMMENDATION

During the system development process, there are several ideas that were generated but could not be implemented due to the time constraint. However, it will make the system better with some enhancements:

- Using GIS database to store map information: by doing this, the map can display many layers and will be able to show users more useful information such as terrain of the location
- Possibility to use Global Positioning System (GPS): it is current emerging technology which can let the system provide real-time result to users such as automatically detect user's current location.

CHAPTER 6

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CHAPTER 7

APPENDIX I

OPTIMAL ROUTE DETERMINATION SYSTEM QUESTIONNAIRE

Optimal Route Determination System is a system that can detect shortest and safest paths for users. Prototype will be built for UTP campus. This project is done in conjunction with Final Year Project. Please take a moment to fill in the questionnaire. Thank you for your cooperation!

SECTION A: GENERAL

1. Which year are you in?

   [ ] 1st year [ ] 2nd year [ ] 3rd year [ ] 4th year [ ] Other

2. Do you find yourself easily get lost when you are in a new place?

   [ ] Yes [ ] No

3. Do you have the habit of bringing a paper map along with you when you travel?

   [ ] Yes [ ] No

4. Do you own a Global Positioning System (GPS) device?

   [ ] Yes [ ] No

5. Have you ever tried Digital Map?

   [ ] Yes [ ] No

SECTION B: ROUTE DETERMINATION

1. Most often, how do you travel inside the campus?

   [ ] On foot [ ] By bike [ ] By motorbike [ ] By car

2. Have you ever got confused about which way to take when you travel inside UTP campus?

   [ ] Yes [ ] No

3. How do you define a safe route?

   [ ] Has light

   [ ] Has people walking up and down

   [ ] Others (Please specify)

.....

4. Do you want a digital map that can detect shortest and safest route guiding you to travel in unfamiliar place?

   [ ] Yes [ ] No

5. Do you think such system is applicable in UTP for visitors, new comers and other UTPians?

   [ ] Yes [ ] No

6. It's convenient if the system is available on...

   [ ] Website [ ] Handheld device [ ] Both

SECTION C: RECOMMENDATION

Please tell us what you expect if there is an optimal route determination system implemented in UTP.

.....

.....

.....

.....

APPENDIX II

DESIGN CODE FOR INPUT FIELDS

```
<td align="left">
<select name="from">
<?PHP
require_once('class.php');
mysql_connect("localhost", "root", "mysql"); // Connection to MySql database
mysql_select_db("fyp"); // selection of database
$sqlQuery = "SELECT * FROM `node` Where `status`='Main' order by `name`";
$response = mysql_query($sqlQuery);
$comp=FALSE;
//$results = mysql_fetch_array($response);
while ($results = mysql_fetch_array($response))
{
?>
<option value="<?PHP echo $results['nodeID'];?>"><?PHP echo $results['name'];?></option>
<?php } ?>
</select>
</td>
</tr>
<tr>
<td>
<span class="style2">To</span></td>
<td align="left">
<select name="to">
<?PHP
$Query = "SELECT * FROM `node` Where `status`='Main' order by `name`";
$Mresponse = mysql_query($Query);
while ($result = mysql_fetch_array($Mresponse))
{
?>
<option value="<?PHP echo $result['nodeID'];?>"><?PHP echo $result['name'];?></option>
<?php } ?>
</select>
</td>
</tr>
<td colspan=2 class="style2">Safety criteria</b></td>
</tr>

<tr>
<td colspan="2"><span class="style5">
<input type="checkbox" name="criteria[]" value="well-lit"/>
Well-lit<br>
<input type="checkbox" name="criteria[]" value="paved"/>
Paved<br>
<input type="checkbox" name="criteria[]" value="low crime rate"/>
Low Crime Rate</span><br>            </td>
</tr>
```

APPENDIX III

DIJKSTRA ALGORITHM

```
class Dijkstra {

    var $visited = array();
    var $distance = array();
    var $previousNode = array();
    var $startnode =null;
    var $map = array();
    var $infiniteDistance = 0;
    var $numberOfNodes = 0;
    var $bestPath = 0;
    var $matrixWidth = 0;

    function Dijkstra(&$ourMap, $infiniteDistance) {
        $this -> infiniteDistance = $infiniteDistance;
        $this -> map = &$ourMap;
        $this -> numberOfNodes = count($ourMap);
        $this -> bestPath = 0;
    }

    function findShortestPath($start,$to) {
        $this -> startnode = $start;
        for ($i=0;$i<$this -> numberOfNodes;$i++) {
            if ($i == $this -> startnode) {
                $this -> visited[$i] = true;
                $this -> distance[$i] = 0;
            } else {
                $this -> visited[$i] = false;
                $this -> distance[$i] = isset($this -> map[$this -> startnode][$i])
                    ? $this -> map[$this -> startnode][$i]
                    : $this -> infiniteDistance;
            }
            $this -> previousNode[$i] = $this -> startnode;
        }

        $maxTries = $this -> numberOfNodes;
        $tries = 0;
       while (in_array(false,$this -> visited,true) && $tries <= $maxTries) {
           $this -> bestPath = $this->findBestPath($this->distance, array_keys($this -> visited, false));
           if($to !== null && $this -> bestPath === $to) {
               break;
           }
           $this -> updateDistanceAndPrevious($this -> bestPath);
           $this -> visited[$this -> bestPath] = true;
           $tries++;
       }
    }

    function findBestPath($ourDistance, $ourNodesLeft) {
        $bestPath = $this -> infiniteDistance;
        $bestNode = 0;
        for ($i = 0,$m=count($ourNodesLeft); $i < $m; $i++) {
            if($ourDistance[$ourNodesLeft[$i]] < $bestPath) {
                $bestPath = $ourDistance[$ourNodesLeft[$i]];
                $bestNode = $ourNodesLeft[$i];
            }
        }
        return $bestNode;
    }

    function updateDistanceAndPrevious($obp) {
        for ($i=0;$i<$this -> numberOfNodes;$i++) {
            if(     (isset($this->map[$obp][$i]))
                &&  (!($this->map[$obp][$i] == $this->infiniteDistance) || ($this->map[$obp][$i] == 0 ))
                &&  (($this->distance[$obp] + $this->map[$obp][$i]) < $this -> distance[$i])
            )
            {
                    $this -> distance[$i] = $this -> distance[$obp] + $this -> map[$obp][$i];
                    $this -> previousNode[$i] = $obp;
            }
        }
    }

}
```

```
76      function printMap(&$map) {
77          $placeholder = ' %' . strlen($this -> infiniteDistance) .'d';
78          $foo = '';
79          for($i=0,$im=count($map);$i<$im;$i++) {
80              for ($k=0,$m=$im;$k<$m;$k++) {
81                  $foo.= sprintf($placeholder, isset($map[$i][$k]) ? $map[$i][$k] : $this -> infiniteDistance);
82              }
83              $foo.= "\n";
84          }
85          return $foo;
86      }
87
88      function getResults($to) {
89          global $from;
90          $ourShortestPath = array();
91
92          $foo = '';
93          for ($i = 0; $i < $this -> numberOfNodes; $i++) {
94
95              $ourShortestPath[$i] = array();
96
97              $endNode = null;
98              $currNode = $i;
99
100             $ourShortestPath[$i][] = $i;
101              $ourShortestPathName[$i][] = '';
102
103             while ($endNode === null || $endNode != $this -> startnode) {
104
105                 $ourShortestPath[$i][] = $this -> previousNode[$currNode];
106
107                 $endNode = $this -> previousNode[$currNode];
108                 $currNode = $this -> previousNode[$currNode];
109             }
110
111             $ourShortestPath[$i] = array_reverse($ourShortestPath[$i]);
112
113             if ($to == null || $to == $i) {
114             if($this -> distance[$i] >= $this -> infiniteDistance) {
115                 $foo .= sprintf("no route from %d to %d. \n",$this -> startnode,$i);
116             }
117             else {
118             //retrieve value of Inicial Node
119             $sqlQuery = "SELECT * FROM `node` WHERE `nodeID` = '$from'";
120             $response = mysql_query($sqlQuery);
121             $results = mysql_fetch_array($response);
122             $Name = $results['name'];
123
124             //Retrieve value of to node
125
126             $Query = "SELECT * FROM `node` WHERE `nodeID` = '$to'";
127             $resp = mysql_query($Query);
128             $result = mysql_fetch_array($resp);
129             $name = $result['name'];
130
131             //separating values from the array using comma
132             $my = (implode(',',$ourShortestPath[$i]));
133             //Spliting values of the array into individual values
134             $splited =split(",",$my);
135
136                 printf('<span class="style5">The total distance from  </span><span class="style2"> %s </span>
137                         $Name,$name,$this -> distance[$i],
138                         $this -> distance[$i]/65.67);
139                     //This is the script to print individual values from database using the array
140                     $q = '';
141                 while(list($key,$val)=each($splited)){
142
143                 if($val<>" " and strlen($val) > 0){
144                     $q .= " `nodeID` = '$val' or ";
145                     }
146             }
147
```

```
148                 $q=substr($q,0,(strLen($q)-3));
149                 // this will remove the last or from the string.
150                 $query="select * from node where $q";
151                 echo "<br><br>";
152                 $nt=mysql_query($query);
153                 $rows = mysql_num_rows($nt);
154                 echo mysql_error();
155                 echo '<h6 class="style1" >The Path is as Follow</h6>';
156                 $b=0;
157                 $num = 1;
158                 $rString ="";
159                 while($row=mysql_fetch_array($nt)){
160                 $sqlQuery = "SELECT nodeID, name, status FROM `node` WHERE `nodeID` = '$splited[$b]'";
161                 $response = mysql_query($sqlQuery);
162                 $results = mysql_fetch_array($response);
163                 $st = $results['status'];
164                 if( $st === "Main" or $st ==="Not"){
165                 echo '<img src=images/6pntbullt.gif width=14 height=14><span class=text-grey-bold>'. $results['name'].'</span><BR>';
166                 }
167                 $rString .= $splited[$b].";";
168                 $b++;
169                 $num++;
170                 }
171             }
172             $foo .= "\n";
173                 if ($to === $i) {
174                     break;
175                 }
176             }
177         }
178         return $rString;
179     }
180 } // end class
181 ?>
```

APPENDIX IV
GANTT CHART

ID	Task Name	Start	Finish	Duration
1	Sound and image feature	7/20/2009	8/28/2009	30d
2	Submission of progress report I	7/29/2009	7/29/2009	1d
3	WML and mobile implementation	8/31/2009	10/9/2009	30d
4	Submission of progress report II	9/9/2009	9/9/2009	1d
5	Pre-EDX	9/30/2009	9/30/2009	1d
6	Submission of dissertation (soft bound)	10/7/2009	10/7/2009	1d
7	Testing and evaluating	10/12/2009	10/30/2009	15d
8	EDX	10/12/2009	10/14/2009	3d
9	Oral presentation	10/21/2009	10/21/2009	1d
10	Submission of dissertation (hard bound)	11/11/2009	11/11/2009	1d