E-Waste Collection System Applying Location-Based Service

By

Muhammad Alif Bin Azaman

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Technology (Hons)
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CERTIFICATE OF APPROVAL

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Approved by,

_____
(Professor Dr. Alan Oxley)

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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.

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MUHAMMAD ALIF BIN AZAMAN

ABSTRACT

Electronic waste (E-Waste) has been a major problem not only in Malaysia but the to the whole world. The huge amount of e-waste is due to technological development that is growing rapidly. On the other hand, the buying powers around the world have increased gradually which permit user to buy more and more new electronic products. The result is, old product being dispose irresponsibly which would harm the human and environment. There are countless methods designed to control the problem such as laws, awareness program and well-designed electronic waste management system. Unfortunately, the methods seem not helping. The situation is more severe when the household group users were not well-aware of this problem. To improve the collection rate of e-waste from the household group, a web-application that operates with Location-Based Service functionality will help household users to easily locate recyclers or collectors and dispose e-waste at the appropriate place. With household users as the client or user of the application, this project aimed to help e-waste collectors (scrap metal collectors, the second-hand / repair shops, and the DOE licensed e-waste contractors) to be more reachable by most of household users. The web-application functions as an intermediate between household users and e-waste collectors. It will help users to locate and suggest a route to collector's location. As the project goes, the deliverables would be in web-based application. The methodology to develop the project is using feature driven development. Finding have shown there are yet to be any web application in Malaysia that provide e-waste collection center locator that would create a platform for user to easily recycle e-waste.

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CHAPTER 1

INTRODUCTION

1.0 PROJECT BACKGROUND

Electronic waste (E-Waste) can be refer to as various types of electronic devices which is obsolete and end-of-life for example cellular phone, printer, refrigerator and many more. Rapid growth of technology has turn development of electronic product at a fast pace. The reasons are, low initial cost and a well plan end-of-life duration have resulted in a fast growing electronic products around the world.[1] Therefore, more and more E-Waste produce every day. Reckless disposal of E-Waste could harm the environment. Most e-waste contains harmful chemical for instance lead, cadmium and mercury that will pollute the land. This problem will occur when improper disposal of e-waste that usually end up in landfill. The common solution to this problem is E-Waste Management System. Managing e-waste consist of 3 steps which is collection, transportation and recycling and treatment.[2] The first stage of managing e-waste is collection which this project will help to improve. Few common method of collecting e-waste from e-waste generator are [3]:

i. Permanent Drop-Off Sites
ii. Special Collection Events
iii. Regular curbside pick-up
iv. Requested scheduled pick-up

Collection is the first step to reduce amount of e-waste being disposed. It is very important to ensure the effectiveness of e-waste management system. In addition, a proper collection system can helps to respect the waste policy pyramid.

An effective collection system can lead to prevention, minimization, re-use, recycling and energy recovery section. The least user can expect is to assume the e-waste that was collected, the e-waste elements recovered and being used for other electronic products.
Creating a user friendly e-waste collection system could encourage more and more people to send their e-waste to a designated location. A user friendly e-waste collection

system would be a web-application that provides information to users about the collectors. The information presented will not in from of lines of address, however by applying Location-Based Service concept to the web-application functionalities will create a better presentation of information and recommendation according to the user's needs.

Location-based services (LBS) like foursquare, Gowalla, Where, and Facebook Places use the geolocation functionality to provide people with various categories of information such as food, entertainment and businesses. LBS web-application need to focus on blending software, hardware, and wireless connectivity into a plan for serving LBS content. Designing low-cost, reliable, and high-quality systems from a complex puzzle of disparate software, hardware, and connectivity components presents a challenge. However, success in this area will accelerate networking effects that lead to widespread adoption, an increase in the customer base, and improve the effectiveness of current collection method of e-waste.

1.1 PROBLEM STATEMENT

The existing e-waste collection methods are vulnerable to every citizen in Malaysia. Unfortunately the amount of e-waste collected is still in an unsettling figure. The problems that need to be solved is why the amount of e-waste collected still low even though there are various methods of collecting the e-waste in the country. According to Kalana, 2010, a study done in state of Selangor only 22% of e-waste being sent to recycling facilities as there are no efficient take back scheme from the producer. Unfortunately, 48% store e-waste in their own premises. Extensive literature has proven that the most consumer store their unused or broken electrical and electronic equipment for years before the equipment being resold or dispose [4]. According to Kalana, 2010, this is due to lack of awareness on where to dispose of old technology In fact Over 300 million computer monitors have been sold in the U.S. since 1980. Yet, in 2008 only about 1.7 million monitors in the US were "recycled," the majority of which - about 1 million monitors surprisingly was shipped abroad to countries such as China or India. According to the survey done, most people do not know the proper ways of disposing their e-waste even though there are various awareness campaign done by the government to promote e-waste recycling. This explains why they tend to store e-waste in their houses or premises and to throw away the waste with other general wastes.

From a developmental perspective, e-waste were not being recycled even though ample of awareness program being done is because there are no official and user friendly web application platform specially created for consumer that is easy to refer. The web application purpose is to find the nearest e-waste collection center within user’s location and how to get there. If user unable to drop-off the e-waste, the platform could provide a functionality which allow to schedule a pick-up.

The most promising strategy that could increase the collection rate with the help of awareness program in by having an official channel that is user friendly and easy to access. The channel would also guide users (household e-waste generator) to recycle their e-waste effectively and efficiently to the authorized e-waste collector. The web application service applying Location Based Concept (LBS) will help to spread awareness and at the same time improve the e-waste collection methods that are currently operating. There are various existing project that that will be discussed in

literature review section. Yet, there are still improvements to be made to make the functionalities more effective.

1.2 SCOPE OF STUDY

This report will address a key element that is important in having a web-application provided to consumer that depends on location information functionality. The main concept that is used in this web-application is Location-Based Service (LBS). In the existing LBS concept, the report will cover 2 key elements which are routing and communicating. Table 1 is the summary of the 2 key elements that is will be addressed in this report.

	Action	Questions	Operations
Routing	**Navigation** Navigation through space, planning a route.	How do I get to…?	positioning, geocoding, geodecoding routing
Communication	**Search** Searching for people and objects	Where is the nearest/most relevant…?	positioning, geocoding, calculating distance and area, finding relationships
	Orientation and Localization Locating	Where am I?	Positioning, geocoding, geodecoding

Table 1 : Main elements in Location-Based Service

Besides that, the report also covers the analysis on the existing web application that is using the either one of the key elements mentioned above being implemented in a website. The report will cover on how to combine these 2 elements to create the functionality in the web-application. On the other hand, the basic framework on how each element works will be explained in brief.

The major part of this report will address the web-application functionality and how the function can help solve the problem. The main subject of this web-application is on e-waste collection system but the core scope is referring to location-based service application functionality. The two main functions in the project is:

1. Finding the nearest location nearest e-waste collectors from a particular location
2. Getting a direction that guide users to the collector

The user of this application is strictly for e-waste household generator. The functionalities would be useful to the household e-waste generator because it will guide the user to deliver e-waste effectively to the authorized facilities. The directory data in the web-application will be controlled by the developer such as user's details and collectors database. In general, the maintenance and technical support will be done by the developer.

The report will concentrate on the functionality of the web-application that will help improve e-waste collection rate thus reduce the amount of e-waste being dispose recklessly. In general, the subject matter of this paper is on Location-Based Service. It is where the functionalities concept comes from.

1.3 OBJECTIVES OF PROJECT

1. Enhance the current collection method which will eventually increase the electronic waste collection rate.
2. Create a platform which allow user to easily find various alternative to dispose e-waste.

1.4 THE RELEVENCY OF THE PROJECT

The implementation of e-waste collection system applying Location-Based Service in a web platform aimed to improve the old way of collection method which is hardly effective. This would help users to learn, at the same time having a better experience to recycle e-waste with less effort. The project is relevant within the time frame with the help of Google Map API version 3. Google Map API version 3 offers various functionalities that would help to create functions for the project. For instance, getting direction from various points, getting latitude and longitude for a location, providing information window for a location and many more. Therefore, the project is relevant in the sense of scope and timeframe.

CHAPTER 2

LITERATURE REVIEW

2.1 DEFINITION OF LOCATION-BASED SERVICE (LBS)

LBS is a service derived from the desire in E-Commerce to identify and transmit location information. Chen (2002) defined the LBS as application which the service and information provided depend on user location.[5] There have been various definition of LBS from different perspectives. LBS as "any service or application that extends spatial information processing or Geographical Information System (GIS) capabilities to end users via the Internet and/or wireless network" (Koeppel, 2000)[6]. LBS is also a "geographically-oriented data and information services to users across mobile telecommunication networks" (Shiode, Li, Batty, Longley, & Maguire, 2004)[7]. The definitions have point out that LBS targeted a wide range of user. In another word, LBS could be explain as users able to receive the most suitable service and information provided by the service provider according to their location at a particular time. The definitions clearly inform that LBS will use a better approach which is using a geographical interface to determine location and process the information to help users to go to the location easily.

2.2 GEOGRAPHICAL INFORMATION SYSTEM (GIS)

As Location-Based Service (LBS) is the extension of Geographical Information System (GIS) according to Koeppel, 2000, it is important to analyze the use of GIS which will also be implemented in the application. GIS has been used to explain on various of software and applications. The most suitable definition that can be apply into this project is:

"A geographical information system is a system for capturing, storing, analyzing and managing data associated attributes which are spatially referenced to the earth"

GIS can be view from different perspectives:

- GIS can become a database storing geographic information to the world, an information system for geography. The entire GIS system can describe the world through geographic referenced features.
- A GIS can also be associated with maps. A GIS system can be viewed as a set of map views that graphically present in the map interface feature. For example, a map can be used to give a view of a certain area. The graphic markers (lines, coloured dots) can be placed in the map to give an indication of a certain area(e-waste collection centers, recycle centers, e-waste drop-off point and etc.).

Moreover, the power to integrate all sorts of geographical referenced information into a graphic presentation has been a great breakthrough. Nowadays, GIS have been used in different kind of fields such as:

- Environment control - environmental issues can be described by a list of environmental problems such as water, air, soil, noise. Geographically data can be extracted from the measurements of these environmental data. GIS systems are then used to assist in the analysis and assessment of the different kinds of environmental problems, such as park usage, pollution assessment, waste collection management and situations in natural disaster control.
- Public Security - GIS systems have been utilized by police forces for use in a variety of operational situations. GIS systems such as crime mapping tools are used in analyzing crime patterns in working towards reducing crime rates.
- Transportation - GIS systems have been playing an important role in managing, planning, evaluating and maintaining transportation systems. A real time traffic analysis using GIS systems provides assistance in the development of high way infrastructures.

The definition of GIS fit the project criteria is because the basic concept of e-waste collection system is to store the entire directories for e-waste collection centers in Malaysia, then the information will be analyze by the application. This occur when user request to find the nearest collection center available around them. Lastly the data will be spatially referenced to the earth through Google Map interface. Analyzing process also will occur when user choose to self-drop their e-waste to a specific collection center. A route will be suggested by the application and display in the Google Map interface.

2.3 LOCATION-BASED SERVICE USER GROUP

There are various national and international studies concentrate on LBS applications. Various studies covers different context of functionalities such as emergency management purposes, health care, tourism, government, business and consumer situation. This project is strictly for consumer but the benefits mutually gain by consumer and businesses. Consumer could easily recycle e-waste while businesses could collect more e-waste and generate more profit. For example corporate users can potentially extract value from LBS application from efficiency and cost management perspective through the use of fleet and customer management perspectives. On the other hand, consumer groups enjoys the fact that convenience, time/money saving and general interest benefits. For example the use of GPS portable navigation (location-based service application) devices reduce the amount of time required to reach a particular destination. Additional user group of this study include emergency services, whose main driver is the immediate access to timely location information crisis situation.

According to Schiller and Voisard (2004), the common approaches distinct LBS applications are person/device oriented and the "push" or "pull" services. The "Push" service is information that is proactively sent to subscribers. This service model is widely used in mobile advertising which is an effective way to send discounts, promotions, and contests to consumers who give their permission to receive such alerts. "Pull" services are used by users to retrieve area information. Examples of this type of LBS being used include:

- Driving Directions - Obtain directions from your location to your desired destination
- Maps View- maps on your phone, detailing your current location
- City Guides - Find local ATMs, restaurants, stores, and attractions

On the other hand, person oriented application is define as a service is user based. While for device oriented it is based on the location of an object.

Therefore, in this project, the propose architecture is LBS. The reason is LBS can deliver open interfaces that enable interoperability and making possible delivery of actionable, multi-purpose, distributed, value-added location application services and content to a wide variety of service points, wherever they might be, on any device.

Furthermore, studies such as Micheal (2004) focus on LBS applications in the following group area: consumer, business and emergency by providing a brief method of classification in studies concerning LBS application [10]. Other author concentrates on certain areas such as business application. For instance, Rao and Minkasis specify on corporate implication of LBS in view of how LBS can provide best performance of the existing services to consumer [11] while others such as Zeimpekis et al., and Zeimpekis and Giaglis are more concerned with real time fleet-management and predicating unforeseen incidents in urban location[12, 13]. The paper will focus on the consumer domain which is a huge market to approach. The project not only helps consumer but helping collectors (business group) to collect and recycle more e-waste.

2.4 RELATED APPLICATION

Presently, there is very limited information relating to the current state of the LBS industry in Malaysia. Nevertheless, a number of location-based service web-applications not specifically in Malaysia have been released to the market currently being tested by business and consumers. Al-Bayari, 2011, had developed a tracking application created which is AVL System for Local Public Transportation Company [14]. Vehicle tracking is one of the fastest growing applications for consumer today. The principle benefits of AVL system is the opportunity for increasing and improving efficiency use of human and environmental resources in an effective manners. This type of application uses the concept of tracking which similar to one of tracking function in the proposed web-application. The function is to track e-waste collection truck nearest to the customer's location and contact details of the track will be available if consumer wishes their e-waste to be collected immediately. This method will help to save money, time, pollution and energy for citizen and country.

Apart from the previous web and mobile application available using LBS concept, the next part will explain on the web application that have similar functionalities in managing not just e-waste but also other wastes. As there are no specific documentation or literature on development process of each existing web application, therefore, the

review is done based on the writer's own testing on the functionalities provided by the websites.

A similar web-application that use LBS as core functionality in which is Earth911 web application. Earth911 helps consumers find local recycling information through the largest and most accurate recycling directory in the U.S. There are few functionalities of this web application. The Earth911 Recycling Directory is the only centralized source of recycling or proper disposal guidance for more than 300 materials across the U.S. Recycling is hyper-localized and rapidly changing similar to traffic and weather information. Earth911 has been the leader in gathering, analyzing and distributing dynamic recycling information since 1991. The functionality can refer as below:

i. Locate any possible nearest e-waste and recycling collection center available in Europe. The collection center could be location by input a zone area.
ii. Find articles that related to the green activities according to location.
iii. Locate events available according to the location area.

In general the functionalities provided use a concept of push and pull service in LBS. The website is really helpful in order to locate a collection center, nevertheless, it only permit user to search for the location without suggesting a route should be taken if user decide to drop their recycling or e-waste. The routing function is very helpful to encourage more individuals to keep on recycling. On the other hand, suggesting route would also reduce the effort for individual to recycle their e-waste. For example, in Malaysia it is very hard for household users to locate e-waste collection facilities. The e-waste recycling industries only concentrate on huge industry such as electronic manufacturer. Thus by having the proposed project, it is easier for household group to locate e-waste collection center. Furthermore, with additional routing function, it is much easier for user to find the collection center even the user is not familiar with the location. In addition, Earth911 project does not allow users to request or scheduled a pick up if user does not have the time to drop their e-waste or recycling materials. Why the request a pick-up is important? Nowadays most people have a very tense work schedule and do not have time to drop e-waste at drop-off point. Request pick-up allows users with busy schedule make appointment with e-waste collection center. This would

allow the e-waste to be collected when the user is available. The function would also improve the collection rate of e-waste because it listens to user, and if user request for it, user really want it.

There is another web application that conveys almost similar solution which is to provide easy access information on recycling e-waste to the user. A website www.yellowpagesgoesgreen.com is a website that provides directories for various recycling industry such as e-waste, paper recycling and many more. Unfortunately, the directory for this web application covers limited location. The location only covers United States and Canada. The web-application does not filter their directory based on user's needs. Besides that, the functionality of the website is all about viewing which is less friendly which require users has to find the location themselves.

In United States there is a company named Green Citizen which provide not only e-waste collection service but also the entire chain to recycle e-waste. Green Citizen also provides service to repair electronic product. In their website www.greencitizen.com, the company provides 3 types of collection services which are recycling drop-off, recycling pick-up by filling a form and building-wide pick-up which is collecting e-waste in an area on monthly, quarterly or semi-annually basis. There are a few disadvantages in this web-application. Firstly the web-application does not provide any user friendly method to use the service. For instance, for users to drop-off at San Francisco, the web-application do provide a data on where the area but unfortunately in the website there is no map interface which proven to be more effective. Secondly, the website only covers for one recycling company which is Green Citizen. In United States there are various e-waste recycling companies available. Similar concept also applies to this website such as electronicrecyclers.com, batteryrecycling.com, crc.org and myboneyard.com. The websites mentioned above in general provide the information to locate e-waste collection center unfortunately the information provided in form of static information. On the other hand, the information provided requires user to interpret by themselves. For instance, a website provide an address, if user is not familiar with the address location, it requires user to go to another website for example Google map website to interpret the information. In Google map user will be able to view the information in a more meaningful way. Thus by providing information on address, it is

sufficient to group of people who are familiar with the location but not for newcomers at the location.

A website named www.recyclingnearyou.com.au is a website contains information about the recycling and waste services offered by Australian council as well as local drop-off options for items including computers, batteries, printer cartridges, mobile phones and many more. The website functionality is to tailored based on user's location and product that user want to recycle. The products include chemical paint, chemical drum, cooking oil and many more. Therefore the advantage of this website is larger product group can be recycle. Nevertheless, this paper only concentrate on e-waste product which also included in this website. The website works by user entering either location or product scope and the website will display list of collection center available. When a collection center is selected, details such as contact details, fees, service option and materials accepted by the collector. Besides that, the website also provides a map on where the collection center located. This function is merely similar with the proposed project function, but there is lack of routing functionality. It is to help user finds the collection center when the website itself suggest the best route to get there.

2.5 CRITICAL ANALYSIS

Lastly is to summarize the above literature. There are various web-application services that display collection center location details. Yet the functionalities still have the area of improvement to be made.(1) The drawback of most web-application mentioned above, they does not track the user's exact location or user's required location and suggest a route to get to a particular collection center.(2) Some of the website mentioned above does not integrate various collection center. Most website only represent for their own collection company.(3) Besides that, the function of request for pick-up is very tedious when user have to keep filling a form. It would be better if user only have to fill up the form once and when user want to request pick-up for the second time, the website already have user's information. As the matter a fact, there is currently no website with similar functions available in Malaysia. The entire websites cover area for United States, Canada, Australia and Canada. A similar web-application with some improvements mentioned above should be made in Malaysia as the country is receiving huge number of electronic products from other countries. More and more e-waste generated every year, these e-wastes should be treated appropriately.

CHAPTER 3

METHODOLOGY

3.0 SYSTEM DEVELOPMENT METHODOLOGY

In this project, the methodology used to develop this project feature driven development which is one of the effective and adaptive method for developing system. One of the most useful benefits of feature driven development approach is the iterative development with the best practice found to be effective in industry. This approach emphasizes quality aspects throughout the process. On the other hand, it also allows accurate monitoring of the progress of the project.

Feature Driven Development consists of five main sequential processes when building the system. The sequential processes are developing overall model, build feature list, plan by feature, design by feature and build by feature. The main processes in this methodology are design and building the application by features. E-waste collection system will be build according to features that had been designed. Iterative process will occur in the main processes due to satisfy the requirement that has been designed.

3.1 METHODOLOGY FLOW CHART

This part focuses on overall development workflow using PHP, MySQL and Google Map. As for start, an e-waste collection center locater is develop which is the communication element in e-waste collection system based on location based system. Secondly, after locating e-waste collection center, it is time for the application to locate user's approximate location using the concept of W3C Geolocation property which is a class that is already available in Google Map API.

When location of the user is identified and locations of e-waste collection center is determined, user will have two option whether to find a specific collection center or request a pick-up from their location by using a new feature call one click request pick-up. If user chooses to self-drop their e-waste materials, the web application will suggest a route to the user. On the other hand, if user decides to request a pick-up from a particular e-waste collector, user can use a feature named one-click request pick-up.

One-click request pick up will schedule a pick up for user with the collector to ensure that user will have the authority to choose which collection center will pick up their e-waste. Flow chart of methodology is given below:

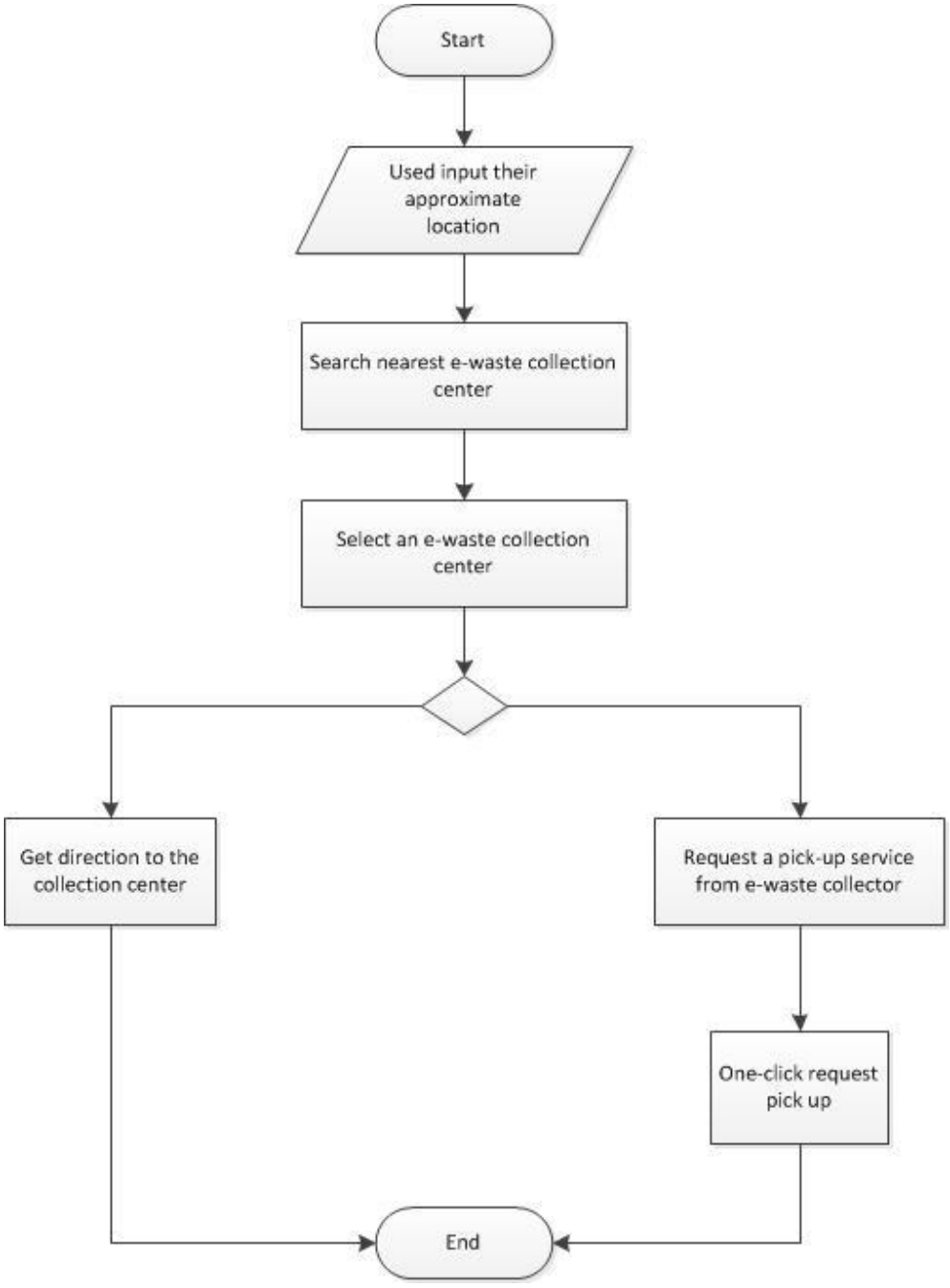


Figure 1 : Methodology Flow Chart

3.1.1 E-Waste Collection Center Locator

To develop an E-Waste Collection Center locator, three important components are required. PHP, MySQL and Google Maps are three components to create a locator type of application. MySQL will store directories for entire E-Waste Collection Centers in Malaysia, while combination of PHP and Google Maps will allow user to enter their

address and see markets on the map for the e-waste collection center nearest to them. Below is the sample of screen shot for E-Waste Collection Center Locator.

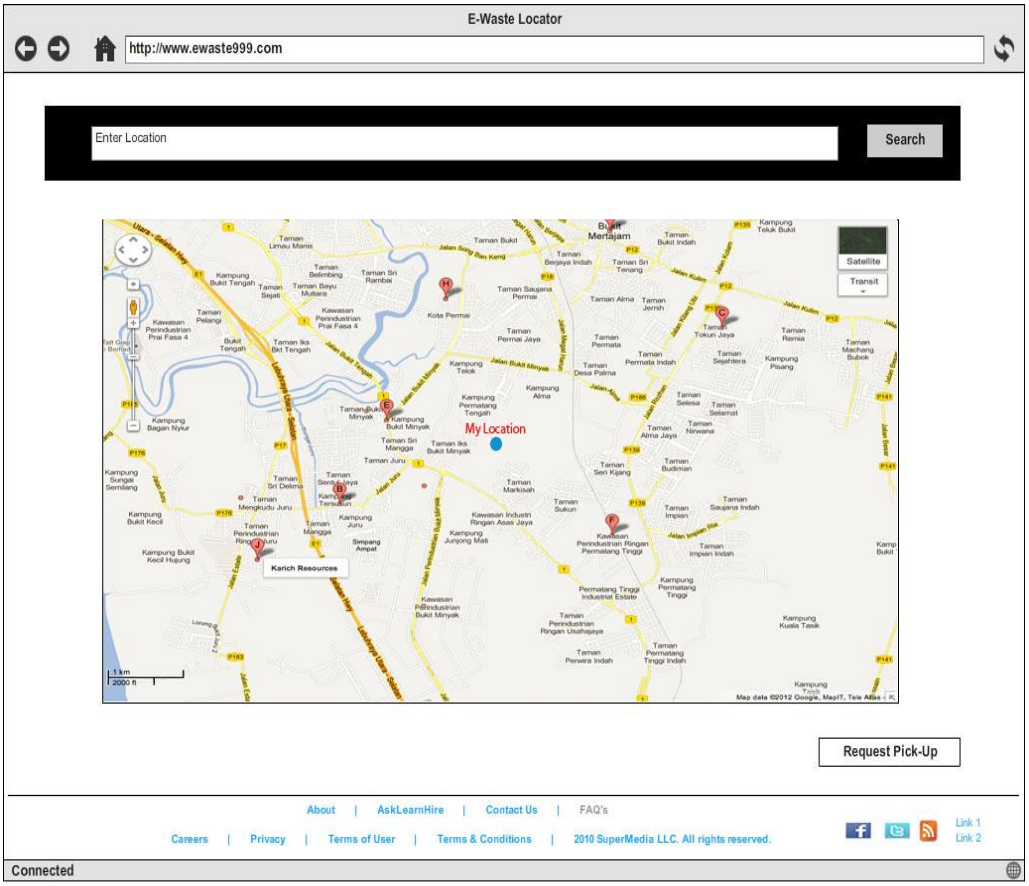


Figure 2 : E-Waste Collection Center Locator sample.

There are two parts to the functionality of the locator. Firstly is to find the locations in database directives within a certain radius of user's location. Secondly is to display marker in Google Map. To find selective directive of e-waste collection center in the database, Haversine formula is used. The Haversine formula is used for computing the distance between two pairs or coordinate through great-circle. A great circle is the largest circumference for the earth. Below is the equation for Haversine formula:

$$\Delta Longitude = longitude_2 - longitude_1$$

$$\Delta Latitude = latitude_2 - latitude_1$$

$$a = (\sin(\frac{\Delta Latitude}{2}))^2 + \cos(latitude_1) * \cos(latitude_2) * (\sin(\frac{\Delta Longitude}{2}))^2$$

$$c = 2 * \text{atan2}(\sqrt{a}, \sqrt{(1-a)})$$

$$d = R * c$$

Where R is the radius for the great circle. The value of R is constant which 6367 km is. The final distance between two points in the map is the value of d.

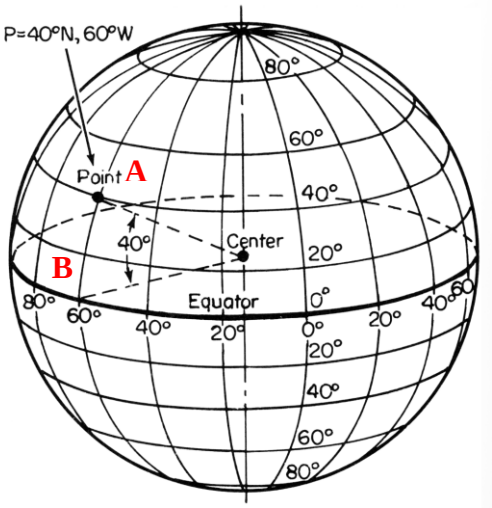


Figure 3 : Location of two different points in a sphere and position of great circle

Source: *http://blog.karmona.com/index.php/2010/10/09/karmona-labs-on-geo-distance/*

The figure shows how two points on earth is located on a globe. To calculate the distance between two points (point A and point B), the radius of a great circle is required. A great circle is a section of a sphere that holds the exact diameter of a particular sphere.

To generate a marker in Google map, an XML file is required. PHP code will convert the information of location such as the longitude, latitude, and name of the collection center from MySQL database and convert into XML file format for Google Map to understand and display the Market on the map.

3.1.2 Get User Approximate Location

To identify location of a user, address need to be input. To perform this, Google map can only identify the location according to latitude and longitude. Thus, in Google Map there is Geocoder class which converts address into coordinate. The coordinate will help marking the location on Google Map Interface.

When user's location is obtained, user can choose two options whether to self-drop e-waste to a certain collection center or request a pick-up from e-waste collector. When user chooses to self-drop their e-waste, the web application will suggest a route for user

to the collection center. Whereas, if the user request for a pick-up, user need to login and use one-click request pick up feature.

3.1.3 Suggest Route for Self-Drop Off

The mechanism used for route suggestion is by using a DirectionService class from Google Map API. This will provide a step-by-step of multi-point driving directions. The required information is longitude and latitude of user's location and e-waste collector's location.

3.1.4 One-Click Request Pick Up

In this function, the mechanism is identical to submitting a contact form. User will have to register in the web application. Information of the user will be stored in database. When user request a pick-up, the necessary information will be captured in the database and sent to the selected e-waste collection center. Information that will be sending to the collection center will be address, contact number and time for request pick-up. Different collection center will have different email address, the application will select email according to user's selection.

3.2 OVERALL MODEL

This entire application is going to answer two main questions which is:

1. 'Where am I?'
2. 'How do I go there from here?'

The questions are the main problem face by consumer nowadays. The overall model of this web-application would answer these questions. In general the overall web-application model can be categories in Location Based Service (LBS).

LBS have the ability to locate a mobile user geographically and use the information to provide a service using location information obtained. The category involve in the functionalities is push and pull service. In the section below will explain the feature.

3.2.1 Lists of Feature

1. Push and pull service

3.2.1.1 Push and Pull Service

Push and pull service will help the proposed application to answer the three basic questions discussed earlier. (1) User could know their current location or find a different location. (2) User could find the nearest e-waste facilities or collection truck around the location. (3) User could view the best route to the e-waste facilities that is selected. In addition, there is additional sub-features which is user would be able to request home pick-up service from this application even though the e-waste facilities center owned by different owner. To develop this function, php programming language is used because it is the most widely used programming language for web-application. To setup php development environment, below are the hardware and software requirement:

Hardware System Requirement

Supported Operating Systems:

1. Windows 7

Minimum System Specifications:

1. 1.5GHz processor recommended
2. 1024 MB RAM

3. 20GB hard disk space

Software Requirement

1. Script Editor – Netbean IDE
2. MAMP Pro
    a. Apache HTTP Server – Web Server
    b. MySQL Database – Database Server
    c. MySQL Server - Database
3. XDebug 2.0 or later – Debugger
4. Google Map API

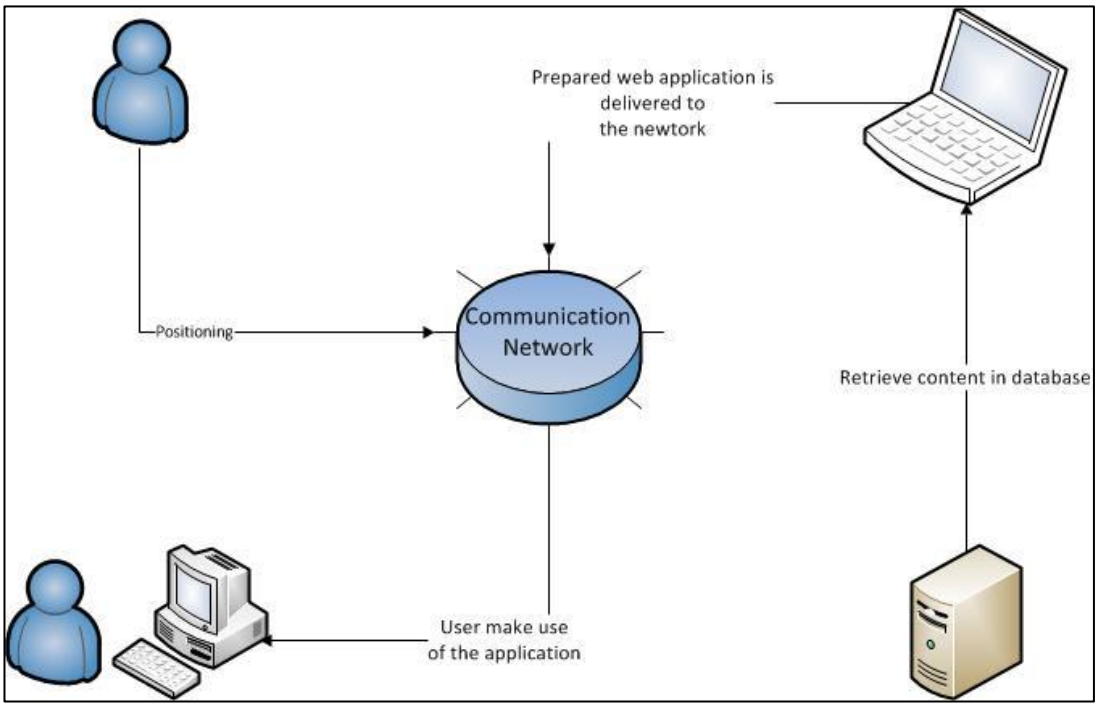


Figure 4 : Basic Location-Based Service components and information flow

3.3 SYSTEM DESIGN

The first goal of E-Waste Collection System design is to let user to view the location information of the entire e-waste collection facilities. Then suggest a route to the selected e-waste collection facilities or second option is to bring user one-click pick up request which allow users request a pick up without filling a form repetitively.

3.3.1 System Core Components

The component that is explained in this section will involve the functions that will be implemented in the proposed project. In Malaysia, there are numerous number e-waste collection centers. In total there are 107 scheduled e-waste collection centers including full and partial recovery. In the system architecture there are few services that can be combine to create the functions explained above. The services are directory services, location utility services, presentation services and routing services. These four services if combined correctly will produce the two main functions in the project which is location nearest e-waste collectors from a particular location and a direction that guide users to the collector. The services will be explained in the section below.

3.3.2 System architecture

The basic architecture of the application is GIS which is one of the elements in LBS. There are two key components to a GIS system. One is the database that contains the geographically referenced information. The other is the set of maps on which the geographical referenced data are presented.

Maps are an important component in GIS systems. Many GIS systems use maps as their user interfaces. Through maps GIS system users obtain a way to work with the geographic data in the GIS system. Also the product of a GIS system most often takes the form of a map (a graphical presentation of the geographically referenced data).

Google Maps offers three types of maps (the standard street map, the satellite map, and the hybrid map) of the world at various resolutions. Also, the Google Maps provides a very interactive user interface – navigation on the map can simply be done by performing “drag and drop” on the map using the mouse.

Being built in the AJAX web application model, Google Maps performs with high responsiveness. Unlike with most of other online mapping applications, Google Maps users do not experience “blank browser” when directing the map to a new area. And for fact, the demanded part of the map always shows on the screen quickly and users still can interact with the application during the loading of the new map. The functionality of the mapping application is based on a number of Javascript modules, which are loaded from the Google’s site then executed on the client side (web browser). The fact that Google Maps functions on the client side makes it even possible for web developers to add in their own map imagery.

Among all the advantages Google Maps has, the most meaningful one for web developers is the application programming interface (API) offered by Google Maps. The Google Maps API [15] library consists of a number of Javascript modules. The API library offers methods which enable web developers to embed a Google map in their own web applications. Also, the Google Maps API supports a set of graphical map overlays. This provides a graphic toolkit for creating visualizations of the external geographic referenced data to be associated with the map. And, even nicer, the Google Maps API is freely available.

Having all the advantages and convenience mentioned in the last paragraph, Google Maps was chosen to be the development platform for the implementation of this thesis project. In order to understand further on the information flow of GIS, Figure 5, 6 and 7 will explain in detail.

3.3.3 Fundamental System Information Flow

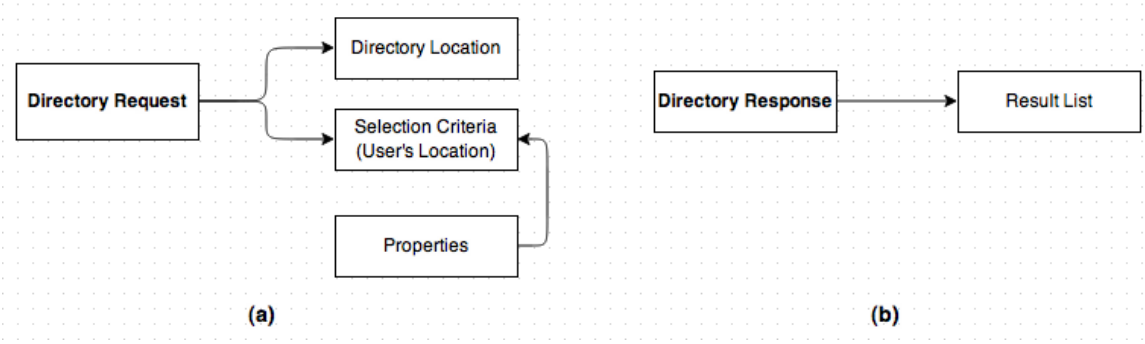


Figure 5: Directory service flow. (a) request; (b) response.

In order to locate user's approximate location, the position will be input by the user or detect using an IP address. The directory type will be specified by the administrator and will be stored in database. As in Figure 5, directory service searches the appropriate directory in database to fulfill the request, finding the nearest and specific place, product or service, depending on search criteria. The service will return one or more query list consists of location and complete descriptions of the place. This all depend on the directory content in database. Existing e-waste collection center is the directory and when user input a location, the function will filter according to the selection criteria. The selection criterion is e-waste collection center that is available around the user's input location.

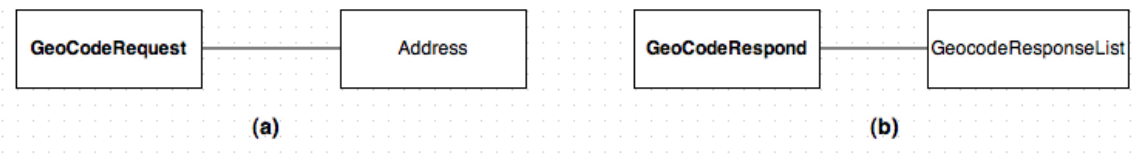


Figure 6: Location-Utility Service (a) request; (b) response.

The second concept is location-utility service performs as a geocoder by determining a geographic position, given a place name, street address or postal code which ahoqa in Figure 6(a). While the return value would be a complete, normalized description of the place which is useful when only partial information known by the user illustrate in Figure 6(b). Geocoding use a process of finding geographic coordinates from other geographic data such as street addresses or zip codes. Using this information, the features can be mapped and entered into Geographic Information System which then

will be presented in a map. This is a process where the location of users and the e-waste collectors' location will be shown on the map.

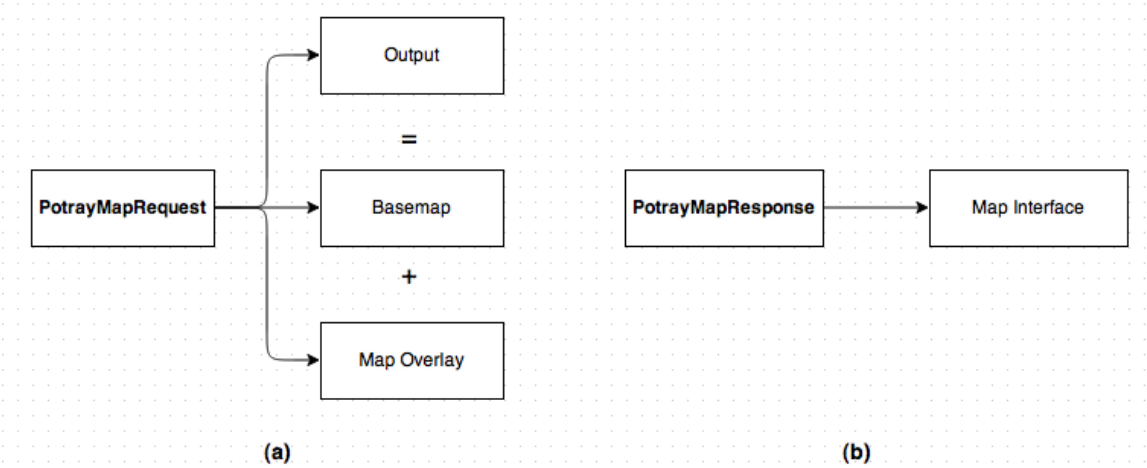


Figure 7 : Presentation service. (a) request; (b) response

A presentation service renders geographic information such as latitude and longitude to display in web terminal. Any OpenLS Application may call upon this service to obtain a map of a desired area, with or without map overlays. The information obtained from directory will be presented using the presentation service. This will ensure the information presented in easy to understand, provided the presentation is in a map layout.

Route service suggests a route for the user. They must indicate the start point and the end point. This is a service that needs to integrate with location-utility service and position service which will help consumer to find an e-waste collection center and at the same time suggesting a route based on user requirement. User will have an option to drop-off their e-waste without thinking how to go to the selected collection center. Using DirectionService class from Google Map API, route will be suggested to the user accordingly.

3.3.4 Basic Design of the Client

Most of the LBS applications have client/server architecture and can be divided into three main parts: Client, Server and Wireless communication which connect Client and Server. Client responsible for sending the user's request and the geographical location to Server and Server is responsible for providing services based in the geographical location provided. Client can make contribution to information acquisition by collecting data in from a selected field area. Server will put the information collected from the

field into database and will provide services for all clients based on the database. In fact, the role definitions of Server and Client are becoming more and more ambiguous. Server can analyze this critical information and put into the database for service which is done by the core system architecture (Open LBS).

3.3.5 Interface Design

Figure 8 shows the example of graphical interface for searching for e-waste collection center and the application will suggest a few locations that mark with red marker on the Google Map.

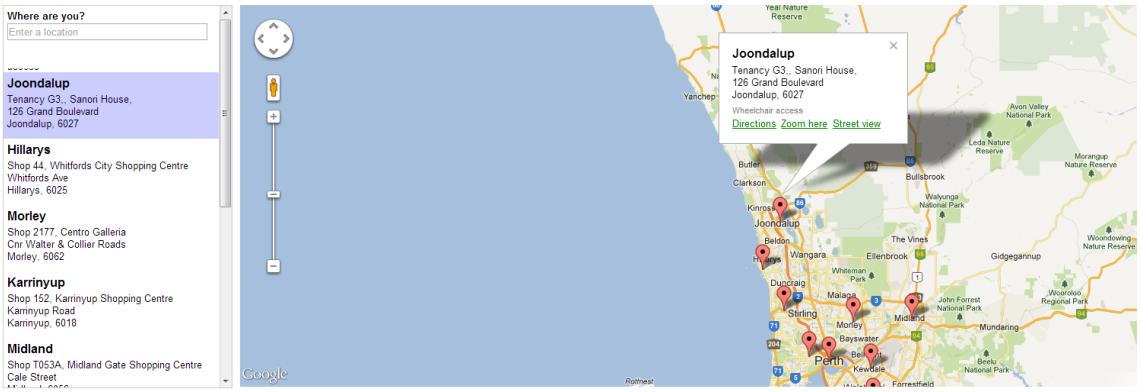


Figure 8 : Finding the nearest location (Location Utility Service, Directory Service and Presentation Service)

Figure 9 illustrate how a route is shown on a map. When user chooses an e-waste recycler, there will be an information window which has a direction option. When user click on direction link, the application will suggest a route from point A (user's location) to point B (e-waste recycler's location).

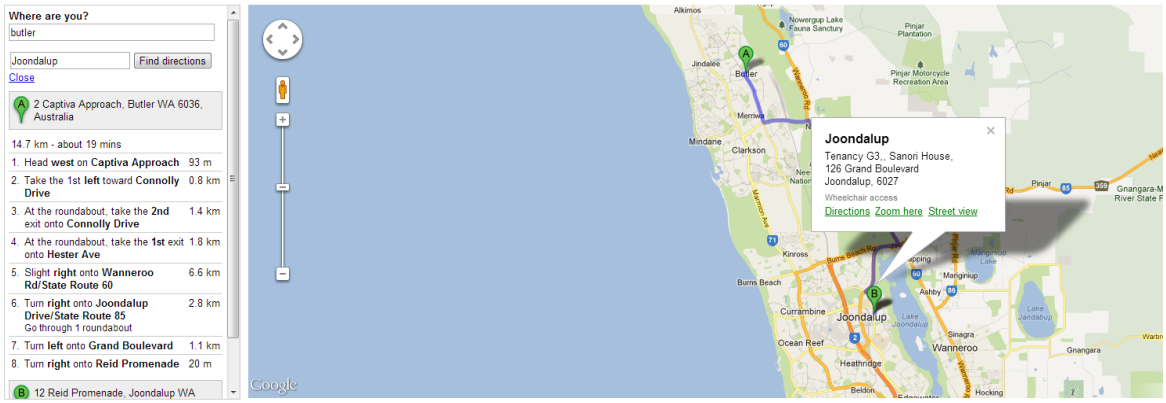


Figure 9 : Show direction from user's location.

3.4 USE CASE DIAGRAM

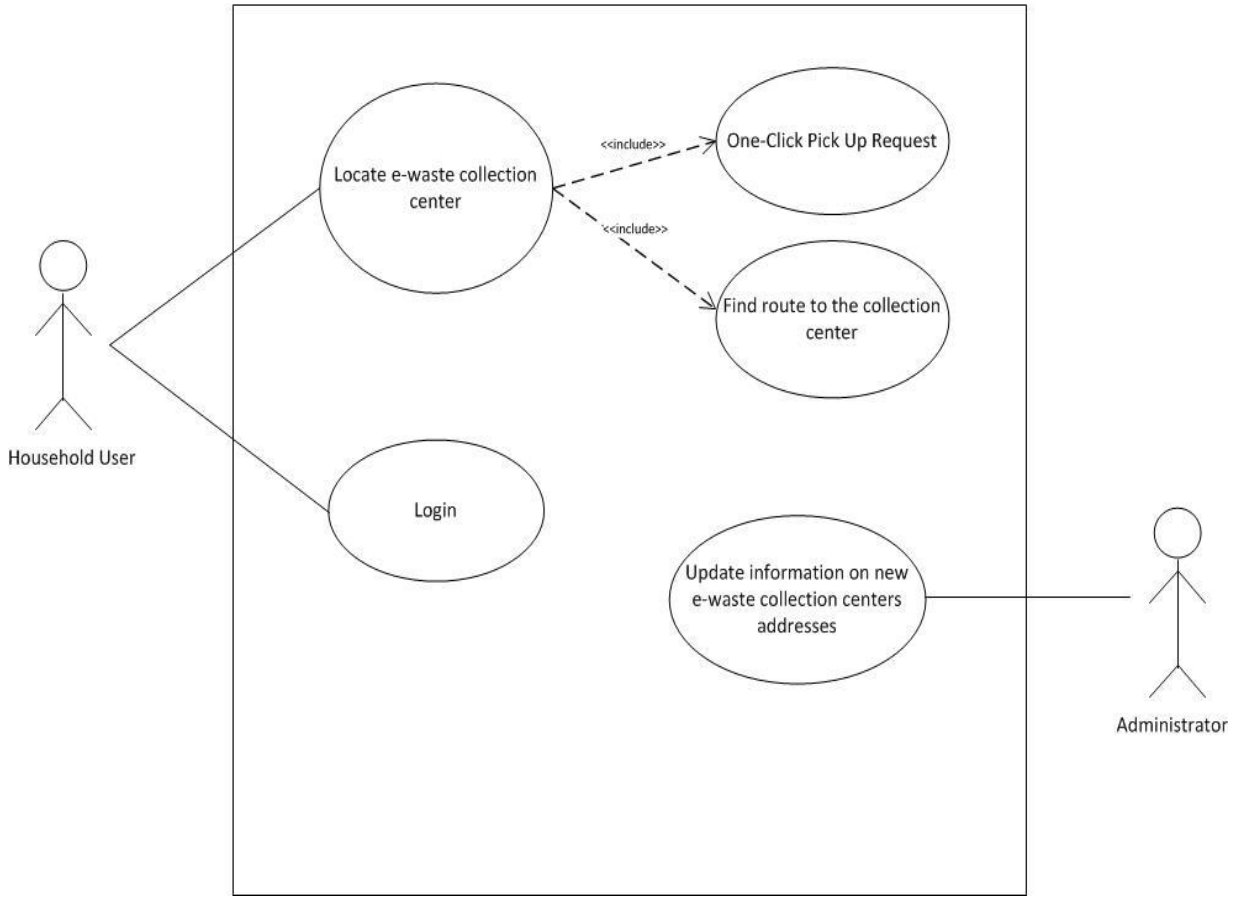


Figure 10 : Use case diagram for e-waste collection system.

3.5 SEQUENCE DIAGRAM

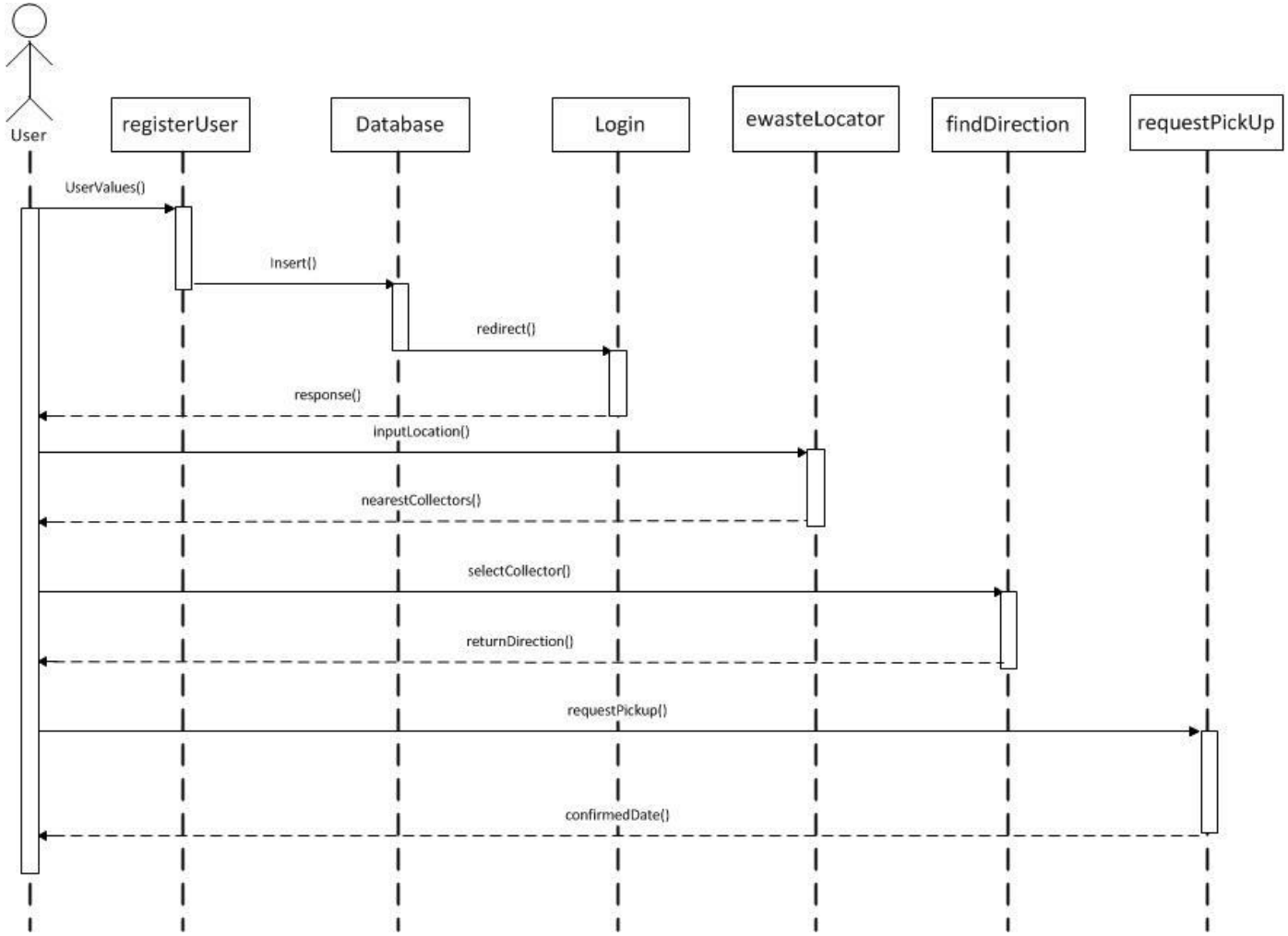


Figure 11 : Sequence diagram for e-waste collection system

3.6 ACTIVITY DIAGRAM

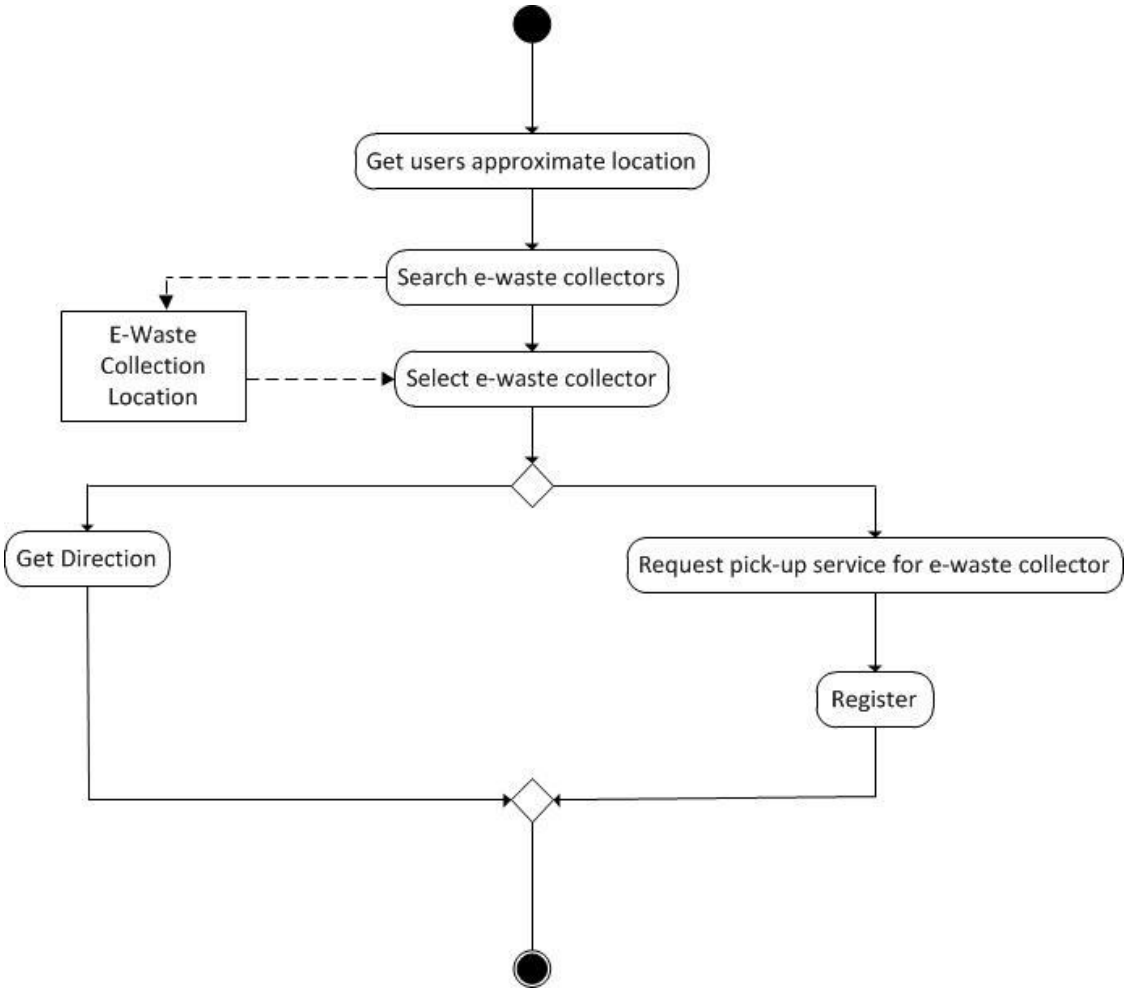
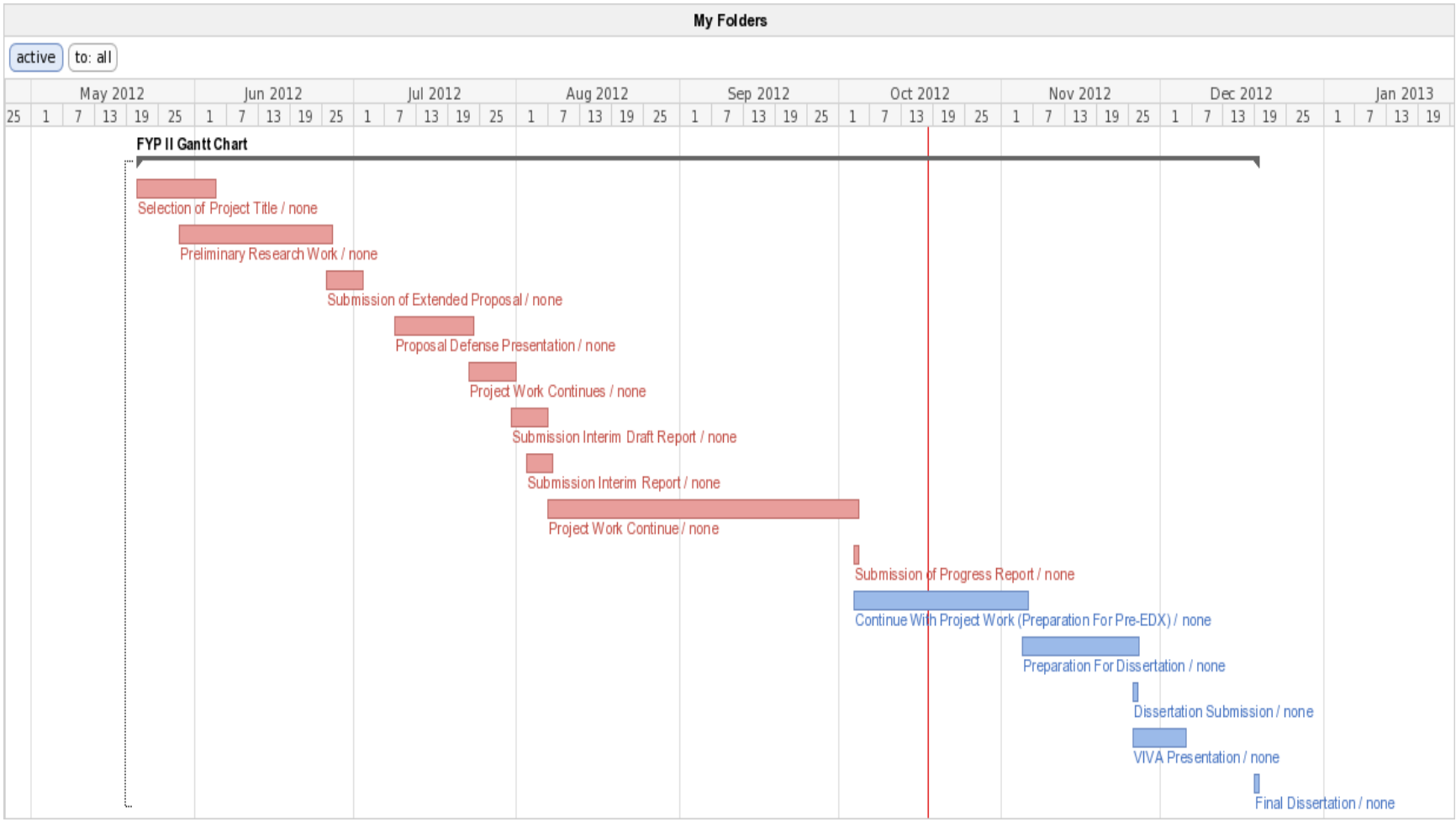


Figure 12: Activity diagram of e-waste collection system

3.6 GANTT CHART



3.7 KEY MILESTONES FOR FYP I & II

Tasks List	Status	Duration	End Date
Final Dissertation	Active	1 day	12/19/12
VIVA Presentation	Active	8 days	12/5/12
Dissertation Submission	Completed	1 day	11/26/12
Preparation For Dissertation	Completed	16 days	11/26/12
Continue With Project Work (Preparation For Pre-EDX)	Completed	23 days	11/5/12
Submission of Progress Report	Completed	1 day	10/4/12
Project Work Continue	Completed	43 days	10/4/12
Submission Interim Report	Completed	3 days	8/7/12
Submission Interim Draft Report	Completed	5 days	8/6/12
Project Work Continues	Completed	7 days	7/31/12
Proposal Defense Presentation	Completed	11 days	7/23/12
Submission of Extended Proposal	Completed	5 days	7/2/12
Preliminary Research Work	Completed	21 days	6/26/12
Preliminary Research Work	Completed	21 days	6/26/12
Selection of Project Title	Completed	11 days	6/4/12

CHAPTER 4

RESULT AND DISCUSSION

4.0 DATA GATHERING ANALYSIS

During the analysis stage of this project, a survey and interview has been made to analyze the effectiveness of current e-waste collection system. The survey and interviews were divided into two groups of people which are e-waste household users and e-waste recyclers. The objective of the survey and interview is to identify the purchasing and usage pattern of electrical and electronic products in general, common way to dispose e-waste and how effective is web-application in helping to increase e-waste recycling rate. The main reason household user is being analyze is because household user is a group e-waste collector does not concentrate on due to difficulty in finding e-waste from them and small amount of e-waste being recycled by this group. Whereas the important factor to analyze e-waste recycler is to know the collectors perspective on the collection method and how effective it is to the users.

4.1 HOUSEHOLD USERS

For the first group which is household users, it was hoped to find 100 respondents to the survey. The target for this category was met with total of 110 answered and completed the questionnaires were returned. The total number of questionnaires being distributed was 200 sets for this group. The questionnaires were received either by e-mails or directly by interviewer during the personal interviews. The interview session was done in Penang. The number of returned questionnaires is considered to be representative of the socioeconomic status and geographical distribution which influence the e-waste generation form the households.

Difficulties encountered in collecting data form the household category are:

i. Individuals were not very concerned with e-waste to make time to fill the form.
ii. Individuals were reluctant to disclose their ownership level of electrical/electronic appliances.

iii. Many people do not keep track of the various electrical/electronic appliances that they dispose and were reluctant to spend time to recall the information.
iv. Lack of interest from the public.

The number of responses that were returned indicated that the questionnaire was reasonably easy to complete. The interviewers also indicated that it was quire easy to obtain the data during the personal interviews and to record it in the questionnaire.

4.2 E-WASTE RECYCLER

The survey and interviews on second group of people consist of e-waste recyclers.
The e-waste recycler were grouped in three subcategories of recyclers, which are the scrap metal collectors, the second-hand or repair shops, and the Department of Environment (DOE) licensed e-waste contractors (collectors, dismantler, processors). Most of the questionnaires returned are obtained from site visit and by e-mail.

The overall number of questionnaire being sent to the target locations are 100 sets. A total of 82 sets of questionnaire were answered and returned in the recyclers category and mainly are form the second-hand shops and repair shops with total of 57 sets (69%), 15 sets (18%) from collectors, 7 sets(9%) from the DOE-licensed processors and 3 sets (4%) from the dismantlers.

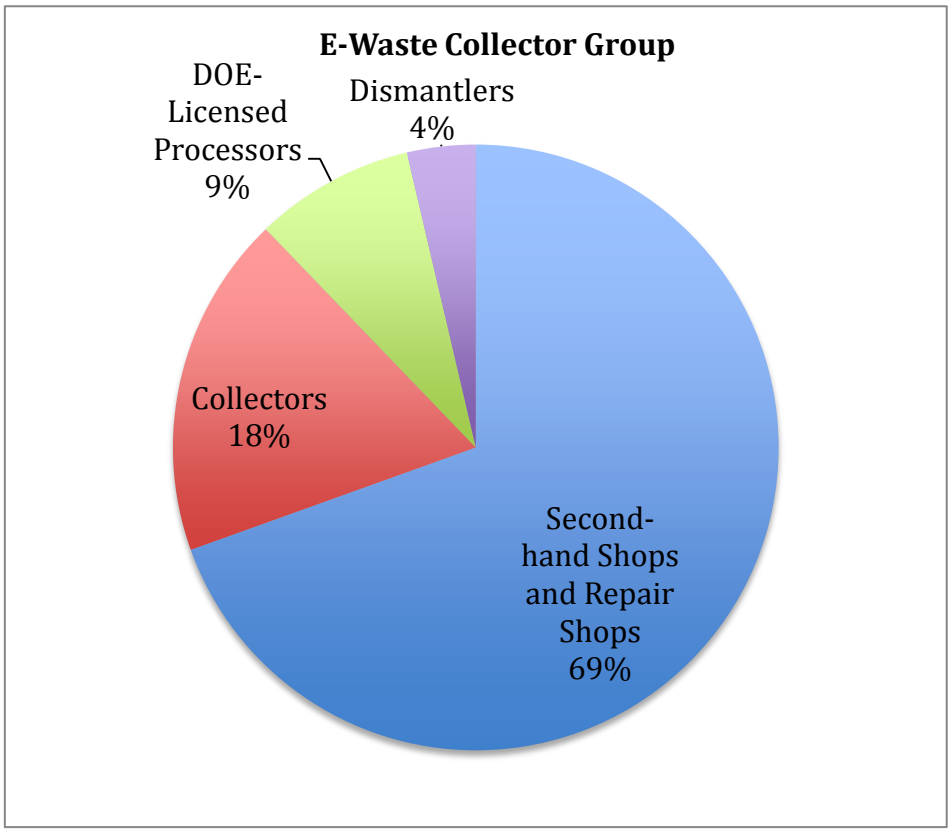


Figure 13 : Percentage of different type of e-waste recyclers who fill up survey form

There are few difficulties encountered in collecting data from recycler category:

i. Most secondhand and repair shops were not willing to participate in the survey and most were not willing to reveal who collects the WEEE from them.

ii. Most of the processors were reluctant to divulge the specific type of e-waste that they collect and the volume collected. It was not possible to alternatively collect the processors data from DOE which is agency responsible for monitoring the processors.

iii. Most if the independent scrap metal collectors interviewed were not willing to participate in the survey.

Thus in total the number of questions being distributed to both of the groups are 193. This includes 110 respondents from household users and 83 respondents from the second group which is e-waste recycler group.

4.3 RESULTS

This section will show the result according to the survey. The result will be presented in two groups which is household users and e-waste recyclers.

4.3.1 Results for Household Users

Purchase and Usage Pattern of Electric and Electronic Product in General		
Item		Number
Way to obtain Electronic product that currently possessed	Bought	93
	Given	12
	Other	5
Ratio of second hand and brand-new products	Brand New	91
	Second-hand	19
Disposal method	Discarded	82
	Currently possessed	28
Could Web-application help in collection method	Yes	101
	No	9

Table 2 : Purchase and Usage Pattern of Electric and Electronic Products General perspective of household users.

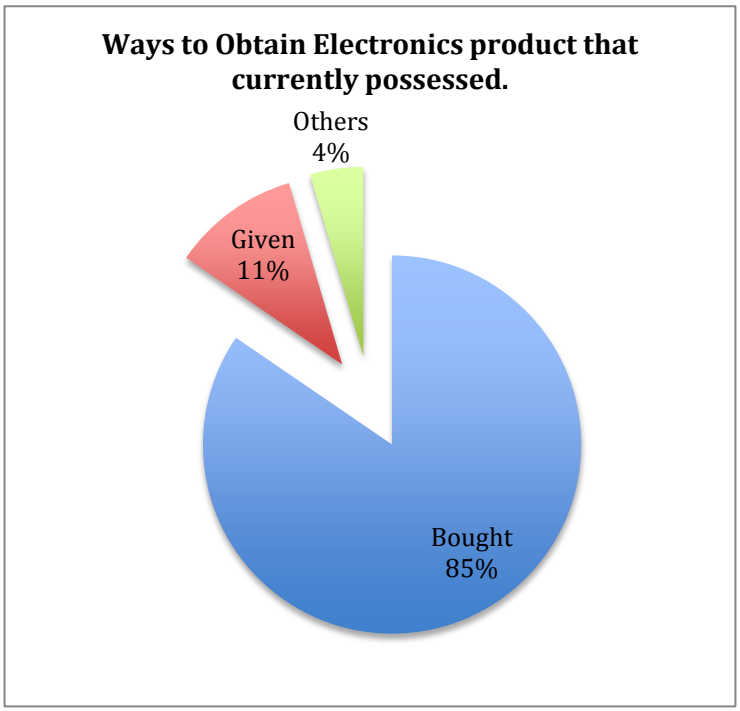


Figure 14: Percentage of ways to obtain Electronic products that currently possessed

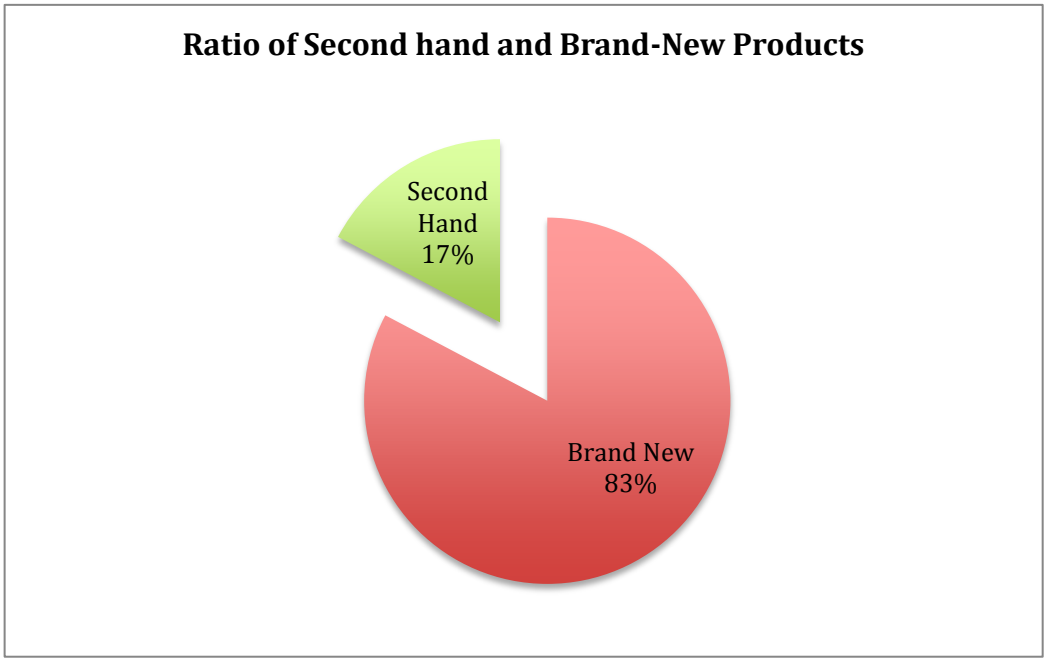


Figure 15: Percentage Ratio of Second hand and Brand New Products

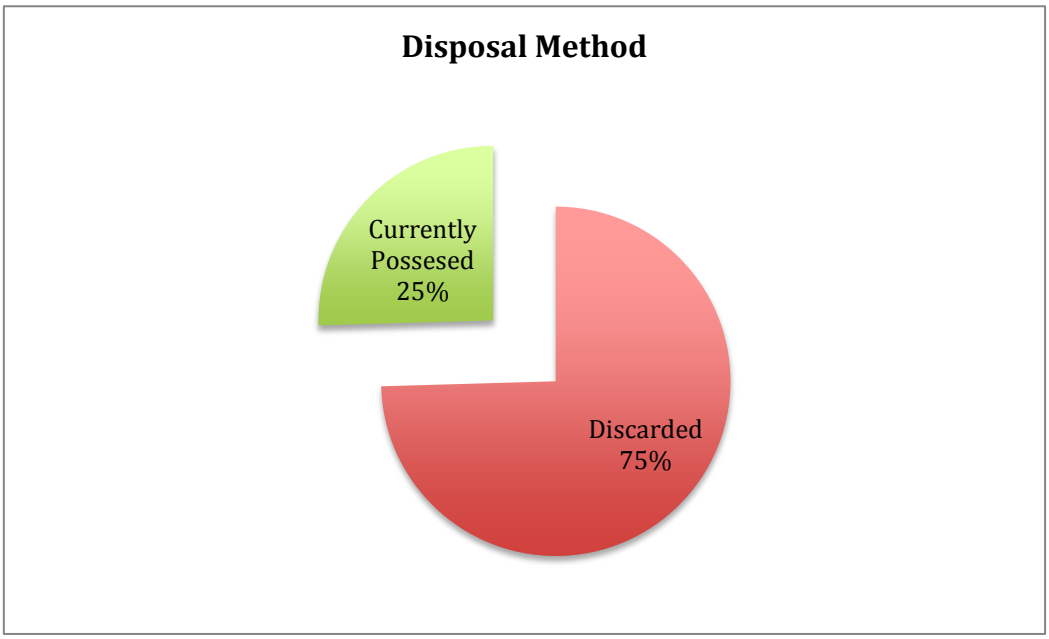


Figure 16: Percentage of people for disposal methods for current electronic items

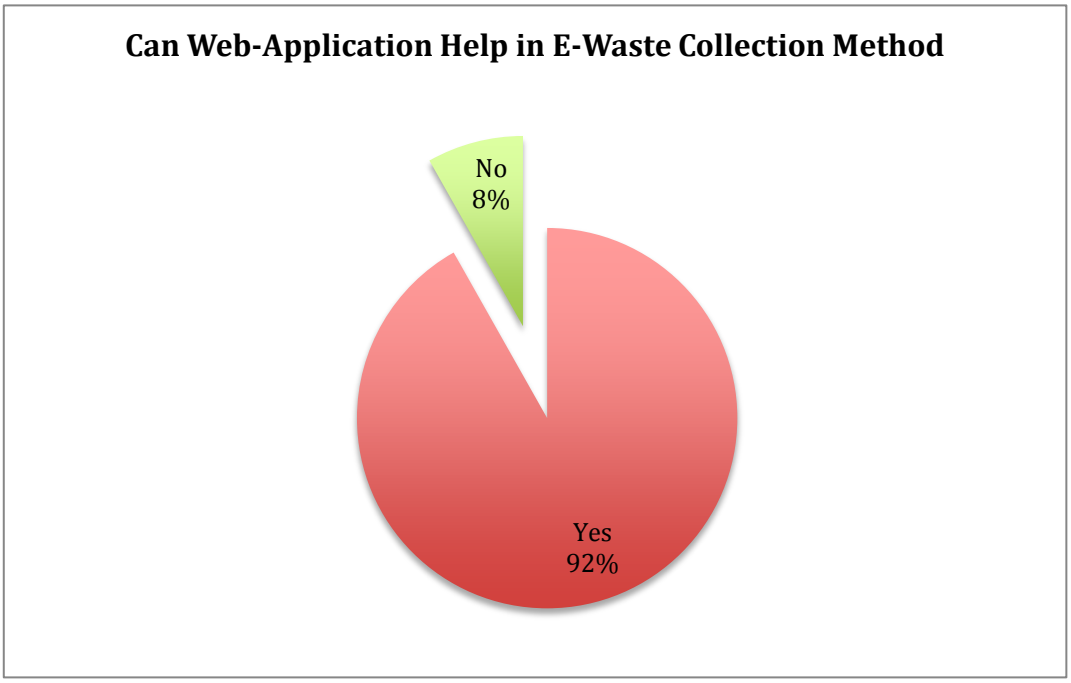


Figure 17: Percentage of people who agree and disagree on web-application can help in e-waste collection method

Generally, the most preferred method to obtain electrical and electronic products by purchase of new items with percentages of 83%. From the data, 75% of the respondents disposed of their WEEE rather than keeping it in their possession. 92% of the respondents agree that having a web application on collecting e-waste will help to encourage user to recycle more e-waste. Some respondent complaints during interview session where the reason e-waste being dispose is because they unable to find a proper place to recycle e-waste around their location. If there is a collector, the location is very far from their houses and hard to contact the collector to request a pick up.

4.3.2 Results for E-Waste Recyclers

According to the survey done with the recycler, most e-waste is collected from leasing company. Household rank second last on the amount of e-waste collected. The reason is, leasing company can easily find collector as they are part of the electric and electronic industry. Yet, collector also will look for leasing company because they can gain more profit by collecting e-waste from them. The amount that leasing company send is in huge amount compared to household. The collector mentioned that, not many household e-waste being sent to them. The reason that have mentioned above, which is user having a hard time to find these collectors. For collector to go and find household e-waste is very costly because they need to have a truck and go around any housing area. The probability of them getting e-waste on the area is very thin. Out of 82 respondents for recycler, 80 people agree that a web-application platform could help them get more household e-waste. While the other two is not confident with the function of web-application as a platform to connect collector with users.

4.4 USABILITY TESTING AND USER ACCEPTANCE TESTING (UAT)

4.4.1 Methodology

Test administrator gathered and recruited participants via random pick among Universiti Teknologi PETRONAS students. Participants did the testing at different time and location. Participants will encounter two type of tests which is Usability Test and User Acceptance Testing (UAT).

Each testing session lasted approximately one hour. During the test session, tester were explained the test session and asked participants to read the task scenarios and test the information on the application.

After the last task was completed, the test administrator asked the participant to rate the website overall by using a 6-point scale (refer Appendix C) to measures:

- Ease of use
- Organization and function of the web application
- Learn ability - how easy it would be for most users to learn to use the web application.
- Information facilitation – how quickly participant could find information
- Look & feel appeal – homepage's content makes me want to explore the site further
- Site content – site's content would keep me coming back
- Site organization

In addition, the test administrator asked the participants the following overall website questions:

- What the participant liked most.
- What the participant liked least.
- Recommendations for improvement.

4.4.2 Participants

All participants are students from Universiti Teknologi PETRONAS raging from first year students until final year students. Fifteen participants were scheduled at different dates starting from 4th November 2012 to 16 November 2012. Among fifteen participants, 4 were female and 11 were male.

Evaluation & Task Scenario

Test participants attempted to complete the following tasks (see Appendix D for complete scenarios and each participant completed):

- Search nearest e-waste recyclers within input area.
- Find recycler's marker display information window/marker.
- Find direction to an e-waste recycler's location.
- Submit registration form to database.
- Successfully send a pick-up request to an e-waste locator.

4.4.3 Results

Participants	Task 1	Task 2	Task 3	Task 4	Task 5
1	√	√	√	√	-
2	√	√	√	√	-
3	√	√	√	√	-
4	√	√	√	√	-
5	√	√	-	√	-
6	√	√	√	√	-
7	√	√	-	√	√
8	√	√	√	√	√
9	√	√	-	√	√
10	√	√	-	√	√
11	√	√	√	√	-
12	√	√	√	√	-
13	√	√	√	√	-
14	√	√	-	√	√
15	√	√	√	√	√
Success	15	15	10	15	6
Completion Rates	100%	100%	67%	100%	40%

Table 3 : Task Completion Rates for User Acceptance Testing

Question	Rate							
		1	2	3	4	5	6	
In relation to other software I have used, I found the E-Waste Collection Center prototype to be:	Very Difficult to use				3	6	6	Very easy to use
In relation to the Viewer, I found the E-Waste Collection Center prototype to be:	Very Difficult to use					5	10	Very easy to use
The menu items were well organized and functions were easy to find.	Strongly disagree			1	1	2	11	Strongly agree
I immediately understood the function of each menu item.	Strongly disagree				2	5	8	Strongly agree
All of the functions I expected to find in the menus were present.	Strongly disagree						15	Strongly agree
The buttons were well organized and easy to find.	Strongly disagree					3	12	Strongly agree
I immediately understood the function of each button.	Strongly disagree					1	14	Strongly agree
All of the functions I expected to find on the button bar were present.	Strongly disagree					2	13	Strongly agree
I found navigating around the E-Waste Collection Center screen to be:	Very difficult		1	1	2	10		Very easy
My overall impression of the E-Waste Collection Center prototype is:	Very difficult					4	11	Very easy

Table 4 : Result for Usability Testing

1.4.4 Recommendations

Change	Justification	Severity
• More interactive and attractive web page design.	Current web application focuses on functionalities and does not emphasize on the graphical design of the web application.	Medium
• Use customizes marker to show uniqueness of the web application.	In order to clearly identify the collection center and create uniqueness of the web application, a customized marker show be used instead default marker by Google.	Medium
• Add more functionality to the web application.	To create attraction and strong reason for user to access the web application, more related functionality should be added.	High

Table 5 : Summary of recommendation for web application

4.4.5 Conclusion

Most of the participants found e-waste collection system to be well-organized, comprehensive, clean and uncluttered, very useful, and easy to use. Having a centralized site to find information is a key to most of the participants. Implementing the recommendations and continuing this project will create a great user-centered website.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Although Malaysia has specific law governing the municipal waste and schedule waste, unfortunately the regulation related to e-waste are not well establish yet. Nevertheless, the awareness of Malaysian citizen towards the e-waste knowledge is growing. Unfortunately, as the elements to create a successful e-waste management system is well align, the collection rate of e-waste is yet not up to the expectation. Thus a proper and easy access collection system should be introduced. This is to help to assist customer in the process of sending e-waste to a collection center effectively.

A collection system that use web as a platform and combine Location-Based Service elements to help customers guide e-waste to an appropriate place. In other word, a web application to help customer to reach and locate middlemen and recycle center efficiently is required. LBS common core web services are proposed to overcome a platform dependency and to enhance web-application functionalities. Due to the web service system architecture, client is not limited to program languages. Thus combination of strict regulation inclusive awareness program and efficient collection system would ensure more e-waste is being recycle thus reduce the impact towards human health and the environment.

Recommendation for future project would be to utilize the Google Map API Store Locator Utility Library that has various features. Among the features that is available and that would be helpful to the user is Street View. The feature allow user to explore a particular location with the help of 360-degree street-level imagery. Utilizing this feature will allow users to explore more e-waste collection centers with clearer navigation and even go inside e-waste collection center through the street view functionality.

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APPENDIX

Appendix A

Questionnaire for Household Users

Electrical and Electronic Equipment in Your House

Q1 How many electric and electronic products have you discarded during past 5 years and how many electric and electronic products do you currently own in your house?

1) Electric and electronic products discarded during 5 years.[__]

2) Electric and electronic products currently in your house [__]

Q2 Please answer the following questions for each electric and electronic products that you discarded during the past five years OR currently have in your house. If you had/have more than two electric and electronic products in total please answer about only two electric and electronic products that you discarded and/or have had for a longer term.

	Question	ELECTRONIC ITEM #1	ELECTRONIC ITEM #2
1	Did you discard the electric and electronic products during the past five years or do currently have it?	1. Currently have 2. Discarded	1. Currently have 2. Discarded
2	What is the electric and electronic products brand name?		
3	How did you get the electric and electronic products?	1. Bought 2. Given 3. Others	1. Bought 2. Given 3. Others
4	Was the electric and electronic products brand new or second hand when you first got it?	1. Brand-new 2. Second-hand	1. Brand-new 2. Second-hand
5	How did you discard the electric and electronic products? Please answer 'Yes' or 'No'	1. Discard together with other wastes for municipal waste collection? 2. Give/sell to the collector (If yes please state the collector's name or location and how do you know about the collector)	

		3. Pay to the collector? (If yes please state the collector's name or location and how do you know about the collector) 4. Give/sell to friends and relatives? 5. Bring to the recycling station/center etc.? (If yes please state the station's name and location and how do you know about the collector) 6. Others [e.g. keep at home]

Appendix B

Questionnaire for E-Waste Collectors

Date		
Interviewer		
Respondent	Name	
	Position	

Company Profile

Name of Organization		
Address		Phone
		Fax
		Email
Annual Sales		Number of Employee

Collection of Used Electrical and Electronic Equipment (EEE)

Type of used EEE	How many units does company collect per month?	Where do they come form? Please indicate the ratio (%) of the units				
		Charity Drive	Household	Office	Leasing Company	Hotel/furnished apartment
Television Set						
Computer						
Mobile Phone						
Air Conditioner						
Washing Machine						

Q1 Please specify the type, quantity, and source of used EEE currently collected by your company.

Q2 Please describe the collection route of used EEE form the original dischargers such as households and office to you company. Who are responsible in the collection and what transportation means do you used?

Q3 Do you think a web platform could help your business collecting more EEE? Why?

Appendix C

Usability Testing

Please indicate the extent to which you agree or disagree with the following statements below:

No.	Question	Rate							
1	In relation to other software I have used, I found the E-Waste Collection Center prototype to be:	Very Difficult to use	1	2	3	4	5	6	Very easy to use
2	In relation to the Viewer, I found the E-Waste Collection Center prototype to be:	Very Difficult to use	1	2	3	4	5	6	Very easy to use
3	The menu items were well organized and functions were easy to find.	Strongly disagree	1	2	3	4	5	6	Strongly agree
4	I immediately understood the function of each menu item.	Strongly disagree	1	2	3	4	5	6	Strongly agree
5	All of the functions I expected to find in the menus were present.	Strongly disagree	1	2	3	4	5	6	Strongly agree
6	The buttons were well organized and easy to find.	Strongly disagree	1	2	3	4	5	6	Strongly agree
7	I immediately understood the function of each button.	Strongly disagree	1	2	3	4	5	6	Strongly agree
8	All of the functions I expected to find on the button bar were present.	Strongly disagree	1	2	3	4	5	6	Strongly agree

9	I found navigating around the E-Waste Collection Center screen to be:	Very difficult	1	2	3	4	5	6	Very easy
10	My overall impression of the E-Waste Collection Center prototype is:	Very difficult	1	2	3	4	5	6	Very easy

Appendix D

User Acceptance Testing (UAT)

Project Name	E-Waste Collector Locator
Objective	Locate the nearest e-waste collection centers and identify directions to the collection centers.

Steps	**Expected Results**	**Met Expectations (Yes/No)**	**Explain Deviation if did not meet expectation**
Input a location into a search box. Click "Search".	Google Map display markers.		
Click on one of the marker.	Display e-waste collector information such as address, phone number.		
Click on link "Search Direction"	Show direction from input location to selected e-waste recycler's location.		
Click the route/blue line on the map.	Info window will show in details the route that need to be taken to the location.		
Click "Zoom In"	The map will zoom in closer to the location/marker selected.		