Ant Colony System: Finding Shortest Path for Fire Fighters

By

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CERTIFICATION OF APPROVAL

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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 in my own except as specified in the references and acknowledgement, and that the original work contained herein have not been undertaken or done by unspecified sources or persons

Shahfiq Nashrah bin Muhammad Ashrah

ABSTRACT

Ant Colony System (ACS) is not a new theory to be discussed among researchers as well in industry. It is proven in optimizing complexity in sense this research area has a lot of technology enhancement towards developing better society. ACS on this research purpose covers the need of fire fighters in finding shortest path to emergency incident. This research will be focusing on Fire and Rescue Department of Malaysia, specifically on Fire Operational & Rescue Division. By using qualitative method in finding requirements, with Rapid Application Development methodology in order to produce a ACS-GPS Map Plotter application that based on Android OS.

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ABBREVIATION AND NOMENCLATURES

ACS : Ant Colony System

FRDM : Fire and Rescue Department of Malaysia

GPS : Global Positioning System

ACO : Ant Colony Optimization

AS : Ant System

STR : State Transition Rule

GUR : Global Updating Rule

LUR : Local Updating Rule

FRD : Fire and Rescue Division

iOS : iPhone Operating System

RAD : Rapid Application Development

SDLC : Software Development Life Cycle

MIT : Massachusetts Institute of Technology

CPRE : Certification Professional Requirement Engineering

IREB : International Requirement Engineering Board

SOP : Standard Operating Procedure

UML : Unified Modelling Diagram

PC : Personal Computer

CDS : Call Dispatcher System

MPS : Map Plotting System

FRT : Fire Response Tender

SIBC : Seri Iskandar Business Centre

API : Application Programming Interface

Lat : Latitude

Long : Longitude

UAT : User Acceptance Test

CHAPTER 1

INTRODUCTION

Ant Colony System (ACS) is an improvised version of ant colony algorithm, introduced by Dorigo and Gambardella in 1997. It has been widely used by researchers in finding approximate solutions to difficult optimization problems. In this paper, the ACS will be focusing mainly on finding shortest path from one point to another. The inspiration of ACS basically comes from ant's colony communication, where the ants communicated through pheromone in finding a good path between the colony and food source in particular place.

On the other part, the research context will be on Fire and Rescue Department of Malaysia. Fire and Rescue Department of Malaysia served their service back in 1883, headed by H.F Bellamy with 15 members. Fire and Rescue Department of Malaysia, is an integrated bodies who reports directly under Ministry of Rural and Regional Development. At the early stage, it does not include with rescuing task, until the cabinet decided in 1997 to add it up. At praise, Fire and Rescue Department of Malaysia has operated more than 100 years and it is good deed to contribute to such achievement.

By means, what the application would do is that by applying ACS inside the work of fire fighters in finding the shortest path, it would help in many ways such as maximizing time usage in finding the destination and giving more opportunity to victim to be saved. In addition, fire fighters also do not acquire an experienced team anymore since by having this application, it will help the team to find the path automatically.

In this chapter, the author will be focusing on the project background, problem statement, objectives and scope of study.

1.1 Project Background

Nowadays, we ought to hear about fire fighters often late to the fire incident place. There are no scientific researches on what are the factors, in sense it presumably accepted the emergency teams arriving late to the scene. However, we cannot put the blame solely on the team, because after all we are all human. But, there are might some solution that can be come out based on nowadays technology available.

Emergency team basically refers to ambulance, fire fighters and most of the government bodies that assigned to keep this country peace and safe. In this paper, the focus will be on Fire and Rescue Department of Malaysia, been choose as scope of study supposedly. This is because; I believe medial emergency team had done in proper way, for time being but it is critical for the Fire and Rescue Department because of the statistics shown quite shocking. Based on the statistics that came out by Fire and Rescue Department of Malaysia, in 2014 there are 431 out of 71958 cases that did not follow the standard procedure, specifically in response time towards rescuing order.

What interest the author in doing this paper is that, generally there are lot of improvement made by some researchers based on evacuation rescue, but barely found any in such, how to get fire fighters arrived to the incident place. Logically, without having fire fighters at the incident place, there are limit chances that the victims can be evacuated and rescued. Therefore, this paper will focusing on essential part of rescuing, which is getting the fire fighters to fire incident place in such faster way of doing.

Besides, in Malaysia there are no specific road ‘named’ upon the road that been made. In such, there are possibilities in rural areas, there are no specific road names for it and therefore would be difficult for the fire fighters decide how to arrive at correct place. With the ACS-GPS application, it could help in a way the GPS tracker will show the exact roads to be taken. Upon completion of this project, it would be a big move for fire fighters in sense we don’t acquire experienced fire fighters for particular place, where we can depend solely on the ACS application.

1.2 Problem Statement

The author critically focus the problems by right, it must be tally with the objective of this research. Findings that had been taken, finds that:-

- Late response time of fire fighters towards the emergency

  Even though it is not scientifically proven that fire fighters having this case, from local news and statistics have shown that this case once happened. During interview with fire fighters in Batu Gajah, they admitted that some of the late cases are still happening, but usually it happen in urbanized and deep rural area.

  Besides that, there is another factor that can cause fire fighters to arrive late at emergency place, for example by receiving insufficient information. This has been a normal case where the emergency reporter doesn't really know where the place is and only give some mark-point for the fire fighters to think where exactly the place.

- Lack of usability and user-friendliness of current GPS

  It is shocked because there is already a GPS system, on a tablet for the fire fighters use in getting them to right location. But then again, the provided system is said that it is not accurate when plotting the path for them to use. In addition, the path showed by the current GPS is wrong because they give the road that is long ago being demolished, thus end up them lost in direction and wasting response time.

  Furthermore, most of the fire fighters are a still senior fireman, which means they are not really good in technology. The senior firemen basically will depend by the old way, where they believed in their experience towards the particular place. The author found that, it is not really about the change they afraid of but the current GPS is not really helping them much because of the complicated procedure and functionality.

Even though there are young firemen, they ought to prefer the current GPS because of the wrong path plotted by the system. Added by them, the current GPS is only a normal GPS used by the people and not suitable for their usage regards the matter of size of vehicles and deep rural areas that they can approach.

- Insufficient of information towards the current emergency happens

When a fire station receives a call from reporter, most of the time the information given is not suffice. Yet, they still try to figure out the things solely by their side by try to interpreting the information. For instance, the exact location is not been informed to them, but with the description of the reporter on the incident place is given. Firemen will try to figure out where exactly the place is and go there.

Sometimes it might true, but we need to bear the risk of wrong interpretation. It is critical to address this problem because there are no standard in taking the report thus it's complicate the information given to make decision for fire fighter's. In addition, in rescuing emergency, the fire fighters don't even know what are they facing, for example is it a wild animal or tame animal. Therefore, it is needed to set a standard of procedure in getting requirement for fire fighters usage.

1.3 Objectives

The following objectives are being set in order to meet goals set up by the author:-

- To produce the application that should help fire fighters in finding shortest path to fire incident.
- To ensure the ACS-GPS application proven to help fire fighters find shorter distance than any GPS application available.
- To investigate theory of ACS and study its implementation on Google Maps

1.4 Scope of study

The scopes of study for this research basically will focus on 2 parts which are technical and context study. This is needed because this research is not mainly focus on the software development solely but also the contribution of the outcome towards the society. The scopes of study that the author looks at are:-

- Development of ACS algorithm into the mobile application ability in order to find the shortest path for fire fighters
- Implementation of ACS in finding shortest path to achieve usability and user requirement
- Focusing on how to apply ACS-GPS map plotter and transfer the records into Google Maps

1.5 Feasibility Study

Focusing on Final Year Project (FYP) I, this research of 12 weeks need to be executed from the idea design thinking towards the first deliverables for this subject which is Interim Report. This time range started from January 2015, to extent there is slightly low number of weeks in getting enough knowledge on algorithm and development phase afterwards. In sense, the time given is short for the author really understands the concept of ACS in embedding with mobile application, especially in Global Positioning System (GPS).

For the FYP II, another 12 weeks are given in order to complete the development as well as testing of the application developed. The time range might change a bit considering there are semester break between FYP I and FYP II, therefore the author approximately consider as 30 weeks needed to complete this project. More or less, the author may prefer additional time as seems, the only thing achieved is the main objective and there are no room for improvement such as decision-making system for fire fighters.

All in all, this research has met its objectives and all the functionalities are working well as it should be.

CHAPTER 2

LITERATURE REVIEW

Nowadays, usage of Ant Colony System (ACS) has been well-known in industry as well in research. ACS is an improvised algorithm that has been introduced by Dorigo and Gabardella in 1997 where it is first major improvement over the original Ant System (AS). Before we discuss further on ACS, a masterpiece that comes before is known as Ant Colony Optimization (ACO). Within ACO, there has been main algorithms that been used such as Ant System (AS), Ant Colony System (ACS) and MAX-MIN ant system. On the par, we can say that ACO is the mother of ACS, AS as well MAX-MIN ant system.

As been defined by Marco Dorigo (2007), Scholarpedia, 2(3):1461. "Ant colony optimization (ACO) is a population-based met heuristic that can be used to find approximate solution to difficult optimization problems." Added by him, ACO is referring to artificial ants as an agent, where it is a set of software that applying search technique in finding good solution to given optimization problem.

In this paper, we will be focusing on one of the main algorithm that been used in ACO, which is the Ant Colony System (ACS). Next, how the ACS differs from current technology that been used in current GPS used by Fire and Rescue Department of Malaysia, as well the advantages and disadvantages of it. Last but not least, this paper also will discuss on the limitation in using ACS in finding shortest path.

2.1 Ant Colony System in finding shortest path

As stated in Daily Express (12 December 2012) quoted on Fire and Rescue Department Sabah Director, Nordin Bin Pauzi said "In 2011, 13 victims bunt to death while 113 victims were killed during rescue efforts. Estimated property losses amounted to RM51, 023,135 up to the month of October, 2011." Besides, Nordin

emphasize that his department faced displeasure in some state authority on over slow response in arriving at fire scenes. Added by him, “The fire engines after such a far distance would probably need maintenance overhaul. Firemen are also human being subject to travelling bodily stresses.”

As recently quotes, this paper try to show there is possibility of firemen facing difficulties in finding shortest path to the fire and rescue incident. Even though we have been living in advanced technology nowadays, there is still a tiny gap in using it for social contribution that doesn’t bring profit in monetary value. As now, paper proposing usage of Ant Colony System (ACS) in order to find the shortest path for fire fighters arrive at fire and rescue incident.

2.1.1 Ant Colony System (ACS)

Ant Colony System (ACS) was introduced by Dorigo and Gabardella (1997) where it is first major improvement over the original ant system. The original ant system is referring to first ACO which also known as Ant System (AS) algorithm that proposed by Dorigo back in 1991. Ant Colony Optimization (ACO) is the base idea of a way how ACS and AS is introduced.

On the insight, ACS differs from AS and ACO in sense of three main aspects that been improvised from previous algorithms which are:

a) State Transition Rule
b) Global Updating Rule
c) Local Pheromone Updating Rule

To make it clear, ACS algorithm is an inspiration from real ants, metaphor on ant colonies. Quoted from Dorigo and Gambardella (1997), “Real ants are capable of finding the shortest path from a food source to their nest, without using visual cues by exploiting pheromone information.” In real terms, pheromone acts as information the whole algorithm, while ants act as an *agent* in this situation. In a way, the more pheromone on particular path, it indicating the shorter the path from their ‘nest’ to

desired destination. Diagram 1 show how the ant colony acts on finding shortest past for them.

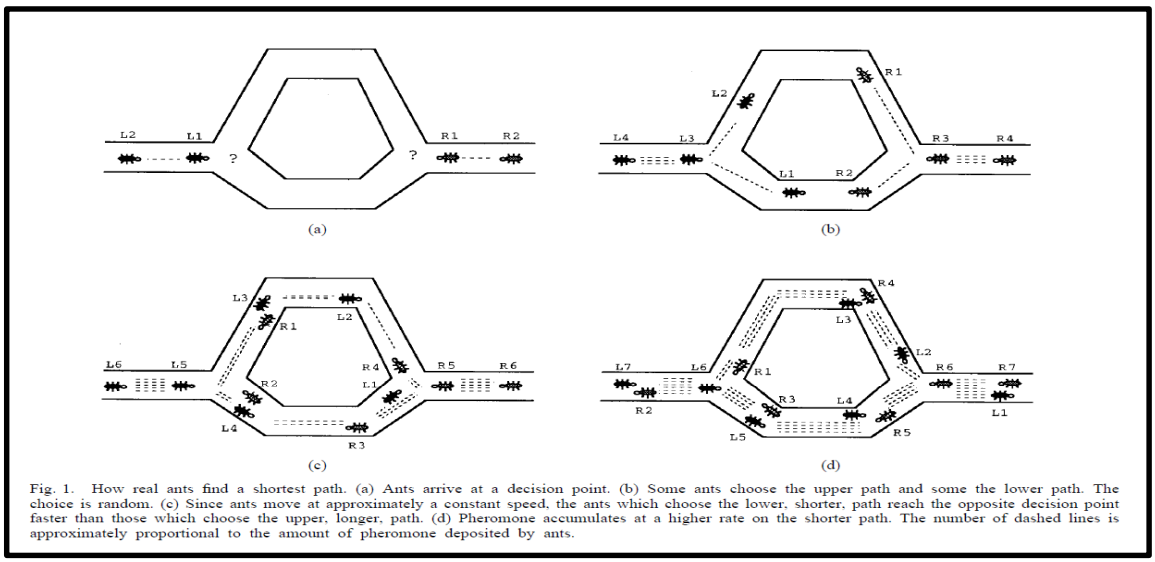


Fig. 1. How real ants find a shortest path. (a) Ants arrive at a decision point. (b) Some ants choose the upper path and some the lower path. The choice is random. (c) Since ants move at approximately a constant speed, the ants which choose the lower, shorter, path reach the opposite decision point faster than those which choose the upper, longer, path. (d) Pheromone accumulates at a higher rate on the shorter path. The number of dashed lines is approximately proportional to the amount of pheromone deposited by ants.

Figure 2.1 ACS metaphor adapted from Dorigo and Gambardella (1997)

2.1.2 Ant Colony System Procedure

As mentioned in previous topic, ACS is capable in finding shortest path for the ants from their shelter towards food. According to Montemanni, Gambardella, Rizolli and Donati (2003),"The main of the algorithm are ants, simple computational agents that individually and iteratively construct solution for the problem." Added by Montemanni et al., mentioned there are two values of combinations to which affects the ACS outcome which are the attractiveness of arc and pheromone level of arc.

This is contrast from what has been proposed by Gomez, Khodr, De Oliveira, Ocque, Yusta, Villasana and Urdaneta (2004) where the two values are (i)a function which is proportional to the amount of pheromone deposited and (ii) a heuristic guide function, also referred to as the incremental cost function and generally defined as the inverse of the distance.

To this extent of this research, the author will preferring Gomez et al., as a main reference for this shortest path distance because the procedure is much more relate

with the current scope of study. Adapted from Zukhairi Zawani (2010), stated by her, the algorithm for ACS is as follow:

- Initialize – ants are placed in initial position and amount of zero τ for initial pheromone
- Tour calculation – distance between the current location and target place directed is calculated
- Model estimation – if the output is not satisfied, agents will move to the next set of path based on meta-heuristic probabilistic transition function and pheromone is converged
- Repeating criterion – procedure continues until the system reaches a satisfactory position

$$p_k(r,s) = \begin{cases} \dfrac{[\tau(r,s)] \cdot [\eta(r,s)]^\beta}{\sum_{u \in J_k(r)} [\tau(r,u)] \cdot [\eta(r,u)]^\beta}, & \text{if } s \in J_k(r) \\ 0, & \text{otherwise} \end{cases}$$

Figure 2.2: ACS algorithm formula adapted from Dorigo et al. (1997)

Based on the formula above, the tau (τ) indicates the pheromone, where $\eta = 1/\delta$ is an inverse of the distance $\delta(r,s)$. Technically, ant *k* is positioned to particular place you are in, and there will be a parameter which determines the relative importance of pheromone (τ) versus distance $\delta(r, s)$.

By this way, as the algorithm executed, it will favour the choice of edges which are shorter and which have a greater amount of pheromone

Added by Dorigo et al. (1997) the ACS algorithm is stated as below:-

```
Initialize

Loop /* at this level each loop is called an iteration */

        Each ant is positioned on a starting node

        Loop /* at this level each loop is called a step */

                Each ant applies a state transition rule to incrementally build a
                solution and a local pheromone updating rule

        Until all ants have built a complete solution

        A global pheromone updating rule is applied

Until End_Condition
```

Figure 2.3: ACS pseudocode

This *pseudocode* basically works in open-end looping structure, following the flow as follow:-

- *k* ants initialize at position, on *n* location according to the rule
- Ants build a tour by applying a stochastic greedy rule or also known as state transition rule
- Next, local updating rule will be taken place where ants modifies amount of pheromone on the visited edges while constructing its tour
- Finally, global updating rule take place where pheromone on edges modified again once all ants have terminated their tour.

2.1.3 Rules in Ant Colony System

As mentioned in previous part, there are three rules that need to follow in order to apply ACS algorithm.

a) State Transition Rule

$$s = \begin{cases} \arg \max_{u \in J_k(r)} \{[\tau(r,u)] \cdot [\eta(r,u)]^{\beta}\}, & \text{if } q \leq q_0 \quad \text{(exploitation)} \\ S, & \text{otherwise} \quad \text{(biased exploration)} \end{cases}$$

Figure 2.4: State Transition Rule Formula

State Transition Rule (STR) follows as ant positioned on particular node, for instance *x* chooses the destination *y* to move by following the formula in figure iv. The STR result is called *pseudo-random-proportional* rule favours transitions toward nodes connected by short edges and with a large amount of pheromone. In other words, ants choose their destination and simultaneously move to the next destination.

b) Global Updating Rule

$$\tau(r,s) \leftarrow (1-\alpha)\cdot\tau(r,s) + \alpha\cdot\Delta\tau(r,s)$$

where

$$\Delta\tau(r,s) = \begin{cases} (L_{gb})^{-1}, & \text{if } (r,s) \in \text{global-best-tour} \\ 0, & \text{otherwise} \end{cases}$$

Figure 2.5: Global Updating Rule Formula

Global Updating Rule (GUR) is one that make ACS differs that any other AS algorithm that has been created. GUR in ACS will only choose globally best ant which construct the shortest tour from the beginning of the trial, allowing them to deposits their pheromone. The purpose of this is to make the search more directed, where the best tour is found to make the current iteration of the algorithm. But then again, GUR will only take place after all ants have completed their tours.

c) Local Updating Rule

$$\tau(r,s) \leftarrow (1-\rho)\cdot\tau(r,s) + \rho\cdot\Delta\tau(r,s)$$

where $0 < r < 1$ is a parameter.

Figure 2.6: Local Updating Rule Formula

In deriving shortest path, ants visit edges and change their pheromone level by applying Local Updating Rule (LUR). LUR is essentially useful because in increase performance level by considering change of pheromone, $\tau(r,s) = 0$ where LUR requires less computation compare to another AS. Besides that, LUR used to shuffle the tours, so that early destination in one ant's tour may

be explored later in other ant's set of destination. This will help in a way it can change the destination dynamically as desired, when each time this algorithm is executed and choose the best tour without needing to start all over computation again.

2.2 Fire and Rescue Department of Malaysia

Figure 2.7: Fire and Rescue Department of Malaysia Logo and Flag

Fire and Rescue Department of Malaysia (FRDM) is a fire service agency in Malaysia, established in 1997 primarily to contribute in volunteer fire services and rescuing in Malaysia. FDRM is constituted under Malaysia Law, Act 341 named Firemen Service Act 1988.

The objective of FRDM as stated in Act 341 Firemen Service Act 1998, covered under Section 5(1) & (2) stated that:-

5. *(1) The duties of the Fire Services Department shall include –*

(a) The taking of lawful measures for –

i. Extinguishing, fighting, preventing, and controlling fires;

ii. Protecting life and property in the event of a fire;

iii. Securing the provision, maintenance, and proper regulation of fire-escapes; and

iv. Securing the provision of adequate means of exit in the event of fire from all designated premises

(b) The making of investigations into the cause, origin, and circumstances of fires; and

(c) Performing humanitarian services, including the protection of life and property in any calamity.

(2) The Fire Services Department may, in addition to its duties under subsection (1), perform such other duties as may be imposed on it by law or as the Minister may direct it to perform

In FRDM Operation and Rescue procedure, it is divided into 10 operation divisions and 2 units who are:-

A. Operation
    a. Fire Operational and Rescue Division
    b. Fire Safety Division
    c. Training Division
    d. Fire Investigation Division
    e. Air Division
    f. Development Division
    g. Planning and Research Division
    h. Corporate Management Division
    i. Management Division
    j. Engineering Division
B. Unit
    a. Discipline Unit
    b. Legal Unit

In this research, the author will mainly focus in one of the operation division which is Fire Operational and Rescue Division, to extent this division is primarily will be the front-people involve in the operation.

2.2.1 Current SOP for Fire Operational and Rescue Division

In Fire and Rescue Division, the task is to draft, organize and implement strategies to provide quality fire-fighting operations to protect life, property and the environment. In order to do that, Fire and Rescue Division (FRD) need to ensure the professionalism in what they doing, to extent providing quality fire and rescue operation services. Besides that, they need to provide a service that effective and efficient thus systematic approach can be taken to protect life and destruction according to law.

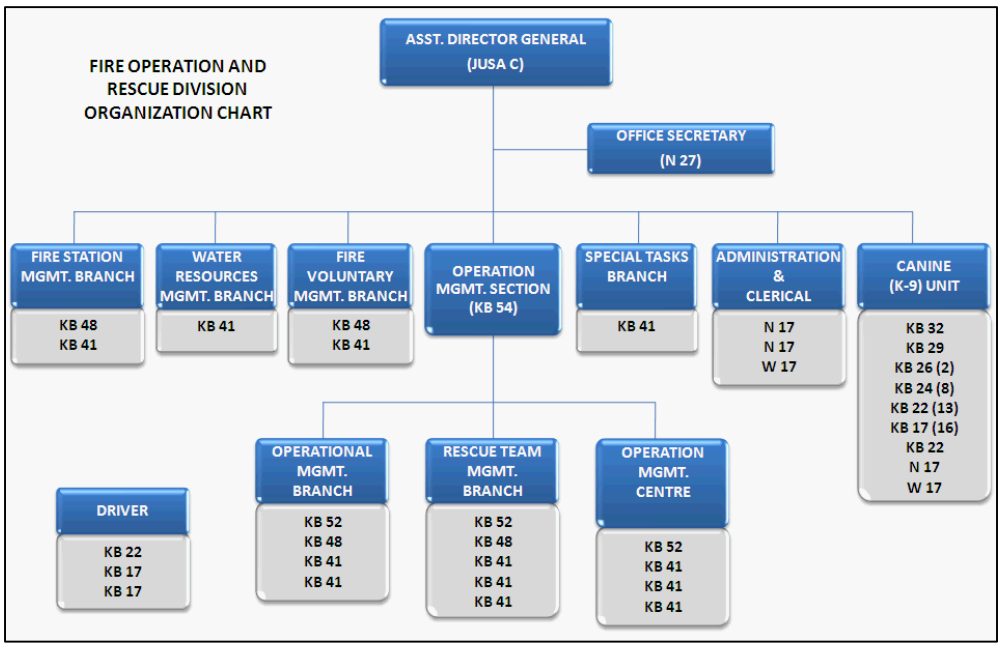


Figure 2.8: Fire and Rescue Division Organizational Structure

Referring to figure above, FRD consist of six main branches and five support units. The branches are described as follows:-

a) <u>Operation Management Section</u>
    a. Consist of three main branches which are
        i. Fire Operation Management Branch
        ii. Operation Management Centre Branch
        iii. Rescue Team Management Brach
    b. The tasks covered are

i. Manage the implementation of major operations and disaster management
ii. Create a policy and SOP to monitor effectiveness of implementation

b) Fire Station Management Branch
    a. Manage all the fire station around Malaysia
    b. Review and monitor the effectiveness of each fire station
    c. Manage and control the daily routine and work

c) Special Task Branch
    a. Provide special task implementation policy
    b. Manage the implementation taken

d) Water Resource Management Branch
    a. Plan new installation as required
    b. Review the suitable water resources for extinguish

e) Fire Voluntary Management Branch
    a. Provide voluntary policy implementation
    b. Application for voluntary fire officers and fire auxiliary officer
    c. Manage on equipment needs to the brigade

f) Canine (K-9) Unit
    a. Focus it task on canine operation
    b. Conduct investigation root of course based on petroleum materials
    c. Rescue victims trapped in collapsed buildings, soul structure and related work
    d. To train dog and officer accordance with the discipline and expertise

The Standard Operation Procedure (SOP) shown in flow chart placed in Appendix I.

2.3 GPS Technology

Global Positioning System (GPS) invented by Masumoto in 1992. According to Masumoto (1992) defined GPS as "A global positioning system for positioning a mobile object such as an automobile in a global geometrical region includes a GPS receiver for receiving radio waves." Added by him, "An altimeter detects a relative

altitude of the mobile object and outputs relative altitude data indicative of the detected relative altitude."

In other words, GPS provides functionality in positioning a moving object in global geometrical region, by receiving radio waves from a number of satellites. Right then, the waves output either two-dimensional position data indicates present position or three-dimensional position data indicative of present position of it.

2.4 Constraints of ACS in finding shortest path

In such, there are lot of application that used GPS based system enhanced the living of society in real life. For instance, Waze Application that based in real-time update of its user, offering number of application such as traffic jam indicator and optimized path to destination.

To extent of ACS-GPS application, it is almost impossible to create an optimized path for the user. For example, ACS-GPS does not indicate if the shortest path is in traffic condition or not. In addition, ACS-GPS is not a real-time update system, make it not really reliable if there are new roads add up, or new development areas build. In sense, it really depending on GPS itself to intervals updates their system so that ACS can be used in much longer time.

In comparison, the current GPS application taken to be compared is Waze application. Waze was founded by Uri Levine, Ehid Shabtai and Amir Shinar who is Israelian in 2008.What make Waze differs from others is because of the community-driven information that feeds the application so that even tiny information can be derived without any algorithm involved.

Table below shows the comparative study between GPS Application and ACS-GPS Application in order to show the advantages and disadvantages of ACS-GPS Application

TABLE 2.1: Comparative studies on Waze Application and ACS-GPS Application

Variables	GPS Application (Waze Application)	ACS-GPS Application
Type of update	Community-driven information feeding	Ant Colony System algorithm calculation based on node from one destination to another.
Reliability	Depending the GPS satellite and internet/mobile data connection	Possibility to work offline after the GPS map and navigation built in
Usability	High usability because of number of quality functionalities provided	Low usability because of only one functionality provided
Safety and security risk	Concern on drivers privacy, risk in robbery or self-protection	High privacy and low in risk

2.4.1 Waze Application

Waze application is a free GPS application that can be downloaded by most of smartphones users, regardless iOS, Android, Windows Mobile and even Blackberry. In 2012, number of users of this application has approximately 36 million users worldwide, and 1.5 million local users in Malaysia.

According to Mirzaee A.,"Globall, Malaysia is in the top five for the highest number of users and in the top three for share of population, meaning the number of users compared to the country population.". Added by the Global Head of Business Development for Waze, Malaysia is a biggest market in Asia for them in 2015, followed by Indonesia and the Philippines.

The advantage for the user of Waze in Malaysia is that, Waze users in here have been granted self-management from Waze HQ. Therefore, it means that the local user can

dedicate their time to translate as well as personalize this application to fit their local communities, thus increase the usability and reliability of this application.

But then again, we need to aware that Waze application is a real-time application update which means the user need to update it regularly so that the path and direction given is precise and reliable. Past few months ago, Malaysia had changed nine road names in Kuala Lumpur, and the response time for this to happen inside Waze to update this information is 24 hours. This is still a drawback for Waze user to response in such manner of time.

All in all, Waze application has a unique ahead from ACS-GPS application that being develop by the author, which is real-time traffic alerts which is not build in inside ACS-GPS application. In addition, Waze also known as a pioneer in traffic services in such of optimizing time and duration of users inside their car or motorcycle while travelling, thus fulfill one of the objective of this research.

2.4.2 Google Maps

Google Maps comes after successful build of Google Earth back in 2005. At that time, Google Maps only can be used in desktop application, seems the smartphones and tablets technology not yet famously used that time. Later then, in 2007 Google has extended the Google Maps by adding Google Live Traffic, which is the visualization of traffic information in real-time.

In addition, Google Maps also comprises with floating car data (FCD) which it is data positioning that been used by Google, where it is feed from Android OS smartphones. The result from this is Google significantly improve mapping of traffic flow much faster. In other words, the generation of traffic information is in real-time update rather like Waze on community-driven information update.

In terms of usability, Google offers much more comprehensive than Waze application. For instance, Google Maps cover the route planner for user who wants to

(a)Drive (b)Public transport (c)Walking and (d)Bicycling. Not only that, Google has introduced Google Maps API for the users/developers who wish to integrate Google Maps into their website. Therefore, it means that Google Maps can be used anywhere in any platform that the user wish to have.

Relating Google Maps with ACS-GPS application, Google Maps seems more advanced in terms of usability, reliability and quality. But, take a look on ACS-GPS which only focus to fire fighters is all this research need to focus. If the ACS-GPS application been used by community i.e. the community as a whole using ACS-GPS, it will make the route that fire fighters should use been dominated by the local people.

All in all, it is not in denial to say Google Maps has provided most of the research objective in sense that ACS-GPS is not in need for this. But, take a look in context of emergency response time and usability is need to be taken into account. We well advised most of the fire fighters do not really good in technology usage, thus ACS-GPS application will focus on the user friendliness of this application too. Besides that, it is potentially being integrate with the current system been used by the fire fighters which is Call Dispatcher System (CDS).

As cited by Svennerberg, G.,"… but the most popular one is Google Maps. In fact, according to Programmableweb.com, it's the most popular API on the Internet." Therefore, the author chooses to pick Google Maps as a API selection to be mash up with the ACS-GPS application.

In addition, Google Maps is not a new thing to learn, as it may seem complex from the front, it is actually just HTML, CSS and JavaScript that are working together. As mentioned by Syennerberg, G.,"The API itself basically consists of JavaScript files that contain classes with methods and properties that you can use to tell the map how to behave."

CHAPTER 3

METHODOLOGY

This chapter will bring up the information regarding the software development methodology used which is Rapid Application Development. Besides that, the discussion in requirement analysis, in focus group for this project which is Fireman. Moving ahead, there will be a description of Project Deliverables and finally Tools and Gantt chart at the end of this chapter.

3.1 Software Development Methodology

In this research, author has changed the development methodology from Agile Development to Rapid Application Development. This is because; Agile Development requires the user and developer to work together from time to time, in this case weekly goals needed to be achieved. Due to non-fixed schedule of fire fighters, the author changed the methodology to Rapid Application Development (RAD).

Previously, there are two applications that proposed in order to meet the requirement elicited, but as per agreed with the user scope, we simplify the solution to on ACS-GPS application alone. Thus, it is more suitable for user to meet the objective by using RAD rather than Agile Methodology.

RAD is a complete methodology that covers system development from business requirements to ongoing development. In other words, for each functional requirement identified, development will take place simultaneously as it supposed. In addition, RAD focuses on radical changes of goals, in this case the author find difficulties in developing the GPS application with Ant Colony System (ACS) algorithm. Therefore, RAD can be relying on because it requires fast development phase and much more important is, low cost.

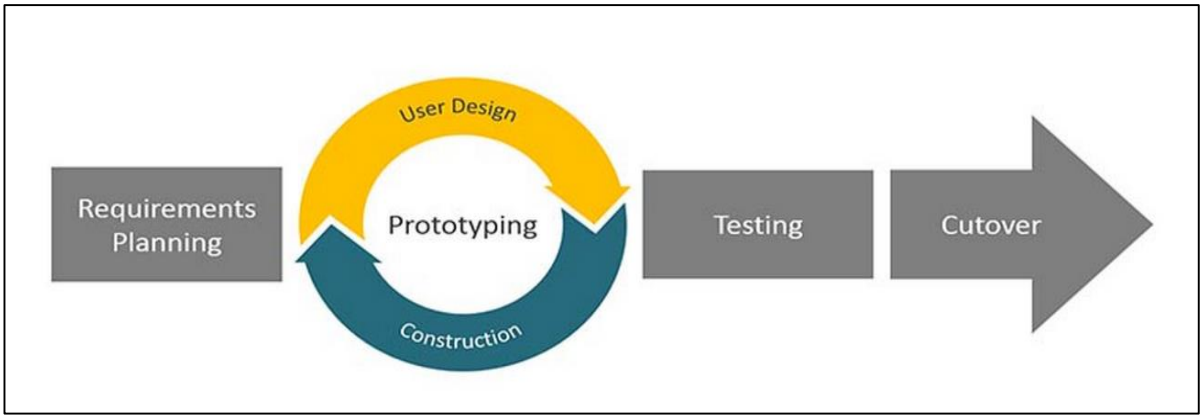


Figure 3.1: Rapid Application Development Methodology

Source from: Free Stock Illustration, Retrieved 12th July 2015, from http://free-stock-illustration.com/rapid+application+development+(rad)

Based on the diagram, RAD consists of 4 phases which are:-

a) Requirement Planning Phase
   i. Covers Planning and Analysis Phase from System Development Life Cycle (SDLC).
   ii. Author needs to conduct qualitative method and requirement elicitation technique in gather user requirement
   iii. During FYP I, author still using Agile Development Methodology, specifically Extreme Programming Model. Based on that model, author met Mr.Hamadan, Deputy Chief of Batu Gajah Fire Station in order to solidify the **storyline** of the application so that the application would not miss out the functionalities required

b) User Design Phase
   i. Development of prototype using Android Studio and run in mobile application through Asus Zenfone 5
   ii. Continuous interactive process between user and developer. For each functional need to ensure it meets user requirement
   iii. During FYP I, author using MIT App Inventor in order to design the User Interface. At prototype level, there is some functionality that has been removed after the target user feel it would not be necessary.

iv. Diagram below shows the pre-prototype phase that has been proposed to Mr. Hamadan.

i. Login Page

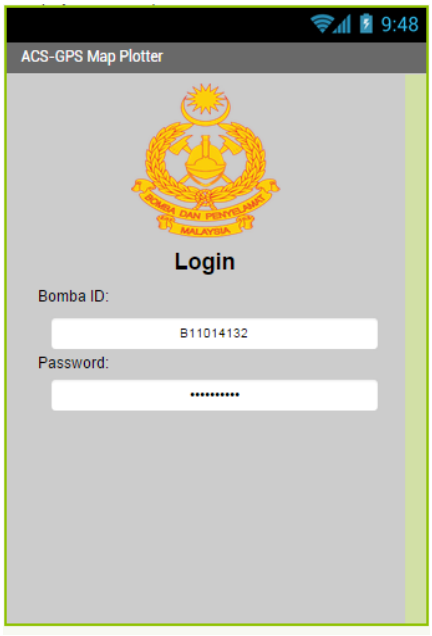


Figure 3.1.1: Login Page

As showed in figure above, shows the login page for fire fighters. This is to ensure the security of this system from being misuse by any party. As from interview taken, there has been a case that previous GPS used by these fire station missing, thus login page is needed in order to enhance the effectiveness of this application.

ii. Map Plotting

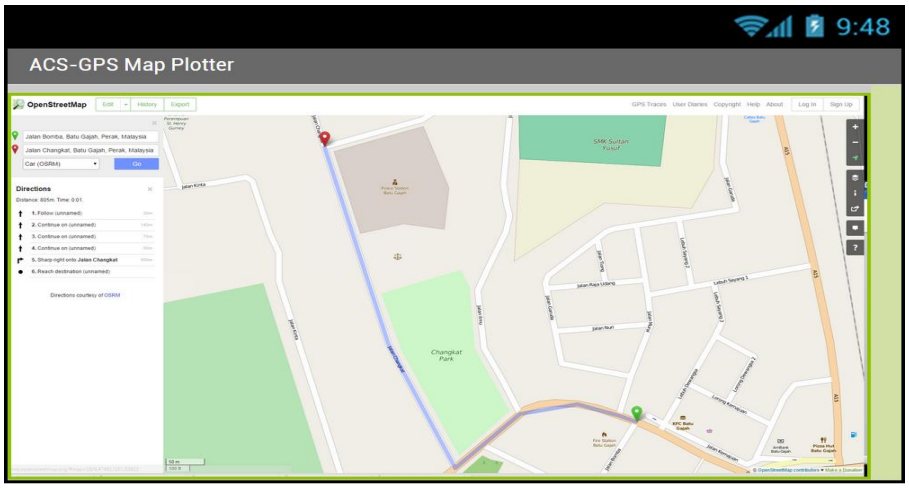


Figure 3.1.2: Map Plotting Page

From the screen, it shows the path is already plotted from Batu Gajah Fire Station to random located destination to indicate the plotting process of this application. The plotter used is OpenStreetMap, an open source GPS web-based application to as indicator of actual application that will be developed.

In this process, the ACS algorithm will be embedded inside this open source code so that the plotting process will be enhanced by the ACS algorithm. Previously, the OpenStreetMap GPS is used in order to plan for ACS-GPS embedded application. Then, after going through some readings and research, author decided to use Google Maps API as the source code is already available and only need to MashUp rather than developing raw code.

iii. Display Information

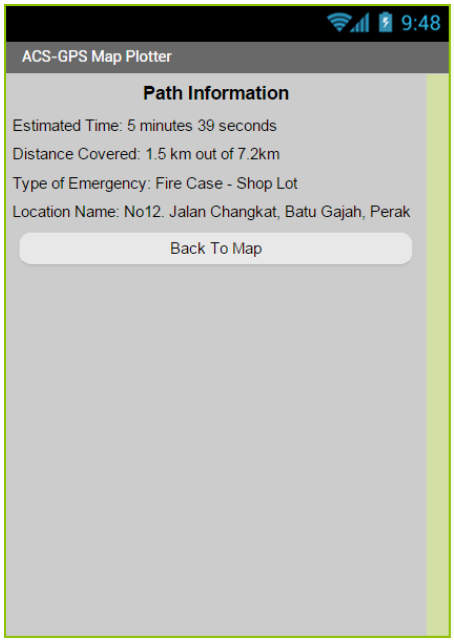


Figure 3.1.3: Display Information Page

As showed in the screen, this page displays information regarding the plotted path, and showing useful information for the fire fighters. This information is derived based on GPS application system that included in this application.

After Google Maps API has been used, author personally thinks that this interface is no longer needed because Google Maps has offer the same functionality. Therefore, this function has been dissolved.

c) Construction Phase
    i. Focus on application development and in this research, this phase is not much differs with user design process because the functionalities is not much to develop
    ii. Perform functionality testing as well as user acceptance testing
d) Cutover Phase
    i. Same phase refer to SDLC, where in this research it focus on user training rather than system replacement

3.2 Research Methodology (Qualitative Method)

In qualitative method, it is a type of scientific research. In other words, in consist set of investigation which:-

- Interpretation of question into an answer
- Used set of procedures to answer the question
- Collecting prove or evidence
- Produce a finding that is beyond boundaries of scope set up.

In this research, the author mainly focuses on two of the options inside qualitative method which are interview and observation.

3.2.1 Interview

Author seeks to use interview with the focus group which is the firemen. The purpose of the interview conducted is mainly purpose in sense that to gather information that is real happening, comparing to his idea of proposal, and all his assumptions. The information elicited using the requirement engineering method that has been studied based on Certification Professional Requirement Engineering (CPRE) Training that held in Universiti Teknologi PETRONAS (UTP) on past semester. The materials are approved by International Requirement Engineering

Board (IREB) which means it is certified a proper method of doing requirement elicitation.

Some of the elicitation techniques used in the interview is:-

- Survey Technique (Referral to interview technique)
    - Elicitation is precise and unbiased statements as possible from stakeholders
    - Respondent is capable of explicitly expressing his or her knowledge
- Change of Perspective Technique
    - It is adoption of extreme standpoints where it requires the interviewer to give situation and expecting a respondent to correct the situation whether it is true or not. One of the sub-techniques is Analogy technique.

3.2.2 Observation

After interviewing, author will seek for confirmation from the surroundings so that he can interpret his findings whether it is reliable information or not. Furthermore, observation technique is a compliment to interview, as regards the matter of risk in mistakes of answering and answer reliability on open question given.

Some of the techniques used for observation are:-

- Field observation – take an instant observe on current standard operation procedure (SOP) of current target location, in this case is fire station in how they manage their operation on daily basis.
- Apprenticing – author must involve in one of the operation in order to seek for information at the bottom level. In other words, author must experiencing the journey from beginning the fire station receiving call until the firemen arrive to incident location

3.3 Project Activities

Throughout the requirement gathering and elicitation, the analysis is being blue-printed in Unified Modelling Diagram (UML) in order to show the functionalities

from user and technical perspective. The diagram involves are use-case diagram and activity diagram.

The purpose of deriving use-case diagram is to show the application usage from user perspective. This is needed because of there are involvement of more than one user. Besides that, use-case also will describe the functionalities that will be create for the application

On the other hand, activities diagram purposely to show on technical perspective of this application. The flow of activity that proposed in this ACS-GPS application describes inside the diagram, showing both usage of ACS-GPS application as well as the Google Maps.

3.3.1 Use Case Diagram

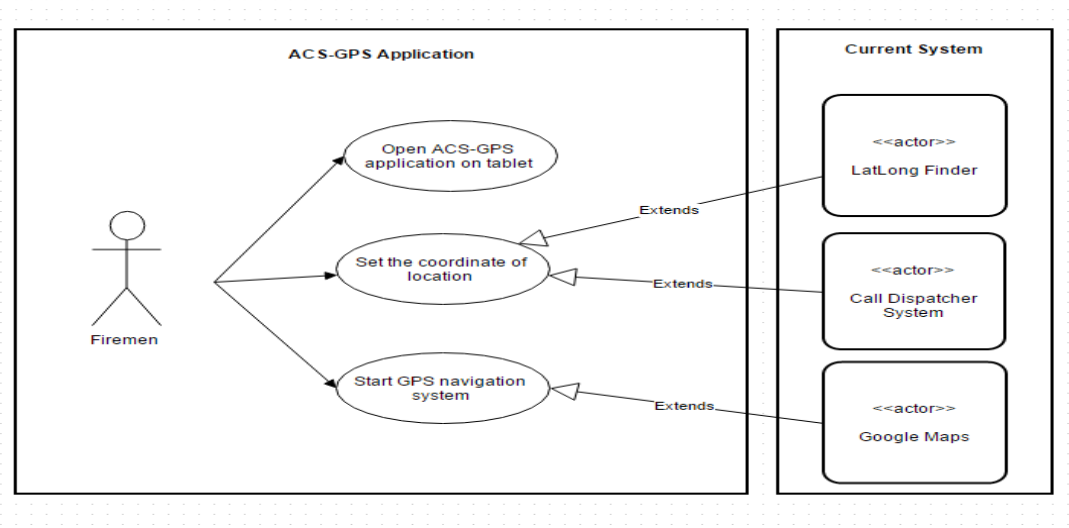


Figure 3.2: Use-case Diagram for ACS-GPS Application

Use-case diagram is an UML tool in order to describe the application based on user perspective. From the diagram below it describes Firemen as the user, which he/she will open the application. Then, the fire fighter need to set the coordinate at the user interface and update the current location of them.

There are some rare cases where if coordinate is not retrieved, there are two available system that can help them to do so which are Call Dispatcher System and

LatLong Finder. After the coordinate has been plotted, they can start the GPS navigation system, in this case Google Maps.

3.3.2 Activity Diagram

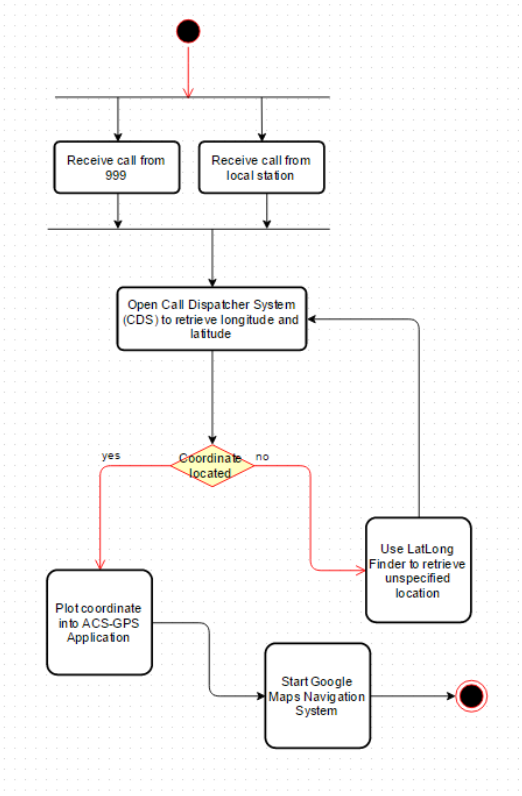


Figure 3.3: Activity Diagram for ACS-GPS Application

Activity Diagram is one of UML tools to represents the workflow of activities, from the beginning of process until the end. From the diagram above, it shows the overall storyline on how ACS-GPS application being used. At the beginning, fire station will receive a phone call either from 999 or local area communities. After the call, 999 will send the latitude and longitude of the location that reported, but if the call is made from the local, there are probabilities of fire fighters do not receive latitude and longitude due to unspecified location reported. Therefore, they need to do an effort to find the coordinate first before they can use ACS-GPS application. After the coordinate retrieved, they need to key in inside CDS and take the records then key in into ACS-GPS application.

3.3. Application Architecture

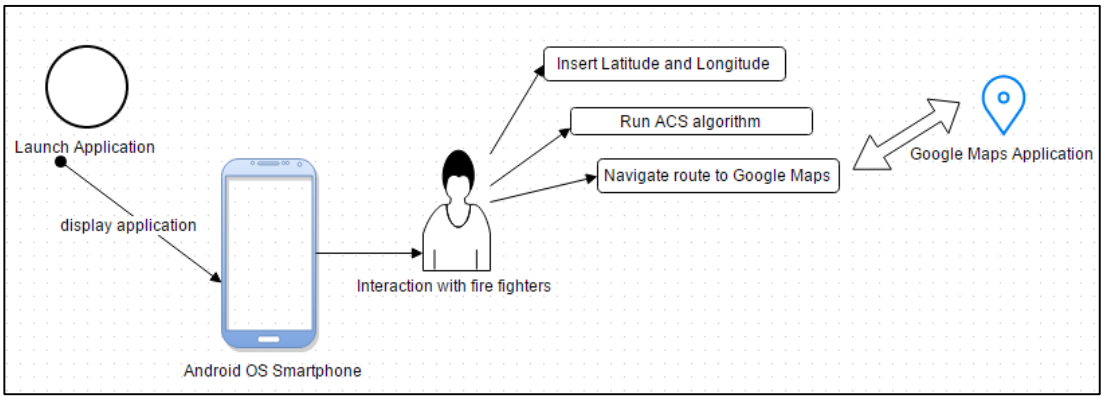


Figure 3.4: ACS-GPS Application Architecture

The purpose of elicitation of the application architecture is to define the behaviour and flow of the system. Referring to diagram above shows how ACS-GPS application works as well as components that directly involve in order to meet the objective of this research. At first, the application will launch and open in Android OS Smartphone. After that, fire fighters will interact with the application through the functionalities as listed on the diagram. After the fire fighters plotted the route, the navigation system will run on Google Maps Application.

3.4 Project Deliverables

The outcome of this project will consist of different parts of development. The primary outcome supposed to be a mobile application that will adapt Android Development. The mobile application will serve a functionality of showing shortest path to the fire incident place.

Besides, the application wills having a GPS navigation functionality, which by right it will navigate the fire-fighters in a way just like a normal GPS we are using right now. What it differs from other is that, the algorithm of ACS will be apply instead of GPS functionality. But then again, to mention that it will be GPS-ACS embedded software in order for the GPS to navigate the fire fighters in shortest path using ACS algorithm.

3.5 Tools and Equipment Required

TABLE 3.1: Tools and Equipment Required

Elements	Specifications
Hardware	• Personal Computer (PC) o Use to develop ACS-GPS application

	• Android OS smartphone
	  o Use to test and run the application
	  o Model used is Asus Zenfone 5

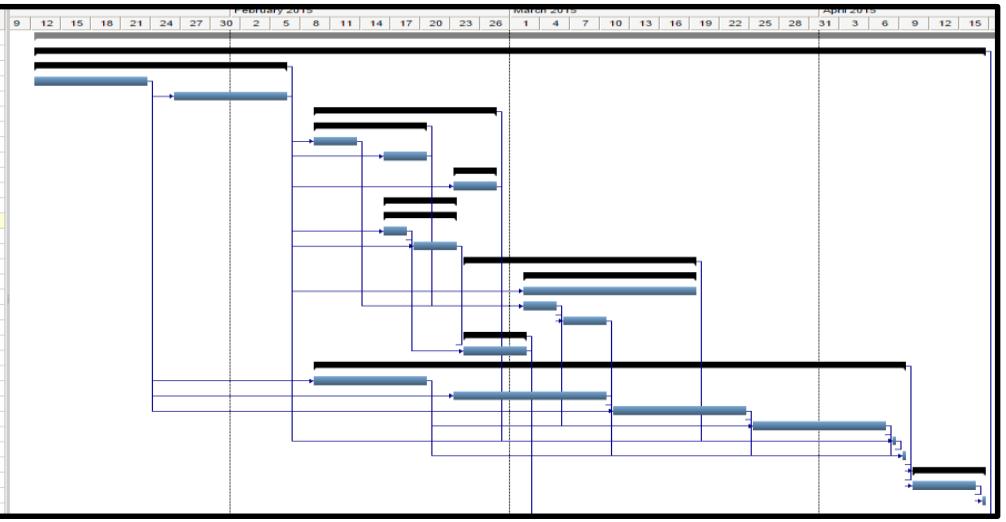
	• USB Cable
	  o To connect smartphone with PC
	  o This is to update any changes made inside code and test it from time to time

	• Tablet Holder o To hold the tablet for fire fighters
Software	• Google Maps o This software purposely use for navigation system
	• Android Studio o This software is used to develop the ACS-GPS application
	• Java Eclipse o This software is used to run the open source Ant Colony System algorithm
	• Gantter for Google Drive o This software is used to track this research timeline
	• Draw .io o This software is used to design UML modelling for this research

3.6 Gantt Chart and Milestones

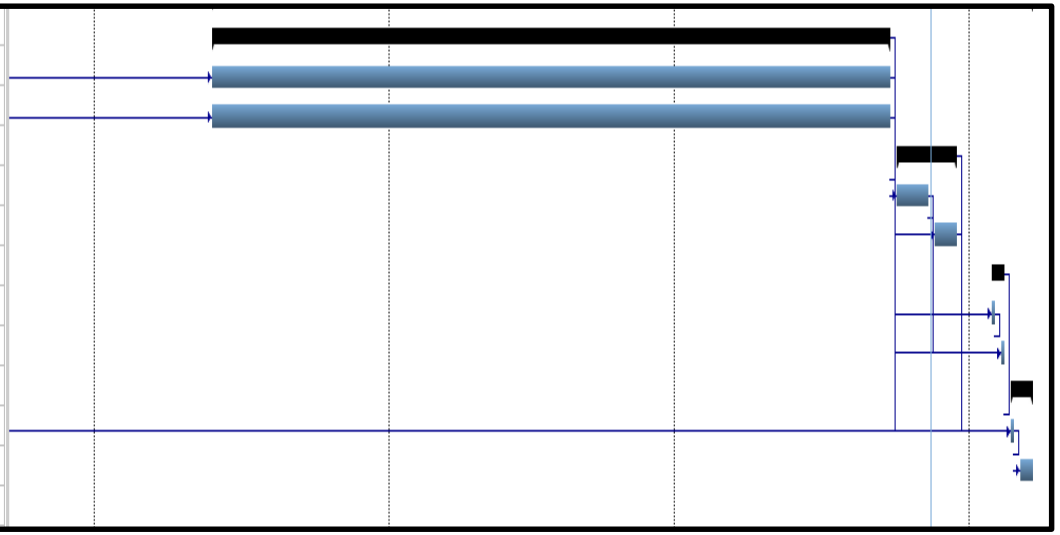
FYP I

	WBS	Name	Duration	Start	Finish	Predecessors	Resources
0	0	FYP TL	150d?	01/12/2015	08/07/2015		
1	1	Final Year Project (FYP) Phase 1	70d?	01/12/2015	04/17/2015		
2	1.1	Pre-initiation	20d	01/12/2015	02/06/2015		
3	1.1.1	Selection of Project Topic	10d	01/12/2015	01/23/2015		
4	1.1.2	Identify the requirement and problem	10d	01/26/2015	02/06/2015	3	
5	1.2	Exploration Phase	15d	02/09/2015	02/27/2015		
6	1.2.1	Requirement gathering	10d	02/09/2015	02/20/2015		
7	1.2.1.1	Identifying Stakeholder	5d	02/09/2015	02/13/2015	4	
8	1.2.1.2	Preparing interview question	5d	02/16/2015	02/20/2015	4,7	
9	1.2.2	Develop System Architecture	5d	02/23/2015	02/27/2015		
10	1.2.2.1	System Boundries	5d	02/23/2015	02/27/2015	4,6	
11	1.2.3	Develop Conceptual Framework	6d	02/16/2015	02/23/2015		
12	1.2.3.1	Designing UML Diagram	6d	02/16/2015	02/23/2015		
13	1.2.3.1.1	Use-Case Diagram	3d	02/16/2015	02/18/2015	4,7	
14	1.2.3.1.2	Activity Diagram	3d	02/19/2015	02/23/2015	4,7,13	
15	1.3	Planning Phase	18d	02/24/2015	03/19/2015		
16	1.3.1	Elicitation of Root Cause	14d	03/02/2015	03/19/2015		
17	1.3.1.1	Enhancement on storylines	14d	03/02/2015	03/19/2015	4,8,10	
18	1.3.1.2	Conduct Interview	4d	03/02/2015	03/05/2015	7,8,10,14	
19	1.3.1.3	Conduct Observation	3d	03/06/2015	03/10/2015	18	
20	1.3.2	Documentation	5d	02/24/2015	03/02/2015		
21	1.3.2.1	Develop User Interface	5d	02/24/2015	03/02/2015	13,14	
22	1.4	Prepare Interim Report	44d?	02/09/2015	04/09/2015		
23	1.4.1	Introduction	10d	02/09/2015	02/20/2015	3,4	
24	1.4.2	Literature Review	12d	02/23/2015	03/10/2015	3,4,23	
25	1.4.3	Methodology	10d	03/11/2015	03/24/2015	3,4,23,24	
26	1.4.4	Result and Discussion	10d	03/25/2015	04/07/2015	18,19,21,23,24,2	
27	1.4.5	Conclusion and Recomendation	1d	04/08/2015	04/08/2015	2,5,15,23,24,25,2	
28	1.4.6	APA Formatting, Listing and TOC	1d?	04/09/2015	04/09/2015	23,24,25,26,27	
29	1.5	Proposal Defense	6d	04/10/2015	04/17/2015	22	
30	1.5.1	Prepare slides	5d	04/10/2015	04/16/2015	22	
31	1.5.2	Presentation	1d	04/17/2015	04/17/2015	30	



FYP II

32	2	Final Year Project (FYP) Phase 2	63d?	05/13/2015	08/07/2015		
33	2.1	Software Development	52d?	05/13/2015	07/23/2015		
34	2.1.1	Code Development	52d?	05/13/2015	07/23/2015	21	
35	2.1.2	User Interface Development	52d?	05/13/2015	07/23/2015	20	
36	2.2	Iteration	5d?	07/24/2015	07/30/2015		
37	2.2.1	IT Testing (Debug)	2d?	07/24/2015	07/27/2015	33	
38	2.2.2	User Acceptance Test (UAT)	3d?	07/28/2015	07/30/2015	33,37	
39	2.3	Productionizing Phase	2d?	08/03/2015	08/04/2015		
40	2.3.1	User Approval	1d?	08/03/2015	08/03/2015	34,35,37,38	
41	2.3.2	Product Release	1d?	08/04/2015	08/04/2015	34,35,37,38,40	
42	2.4	Prepare Final Report	3d?	08/05/2015	08/07/2015		
43	2.4.1	Viva	1d?	08/05/2015	08/05/2015	1,33,36,39	
44	2.4.2	Project Submission	2d?	08/06/2015	08/07/2015	43	



CHAPTER 4

RESULTS AND DISCUSSION

4.1 Findings

Based on qualitative method, using interview and observation as a medium of findings, the author has seen some flaw in current SOP taken by the fire fighters. The first interview take place in Sri Iskandar Fire Station and another one is in Batu Gajah Fire Station, both located in Middle Perak Darul Ridzuan, Malaysia.

4.1.1 Sri Iskandar Fire Station

Figure 4.1: Sri Iskandar Fire Station

Based on Appendix II, attached the interview script between the author and Deputy Chief Officer of the fire station, Mr Amat at his office in 17th March 2015. In summary, I can say that some of the problem raised and the relation of ACS-GPS application towards the requirement elicited.

A. Current GPS system is unreliable and not functioning

   Mentioned by Mr Amat, his team already given a GPS from the management, but then again due to some circumstances they won't be able to keep it for a long time. This is due to security of the station, plus the GPS tablet is not

been used all the times. Added by him, the given GPS is not really functioning well when they try to use it, for example there are times when the path plotted by the GPS showed is not really correct.

B. Firemen tend to rely on experience in getting to emergency place

In Sri Iskandar Fire Station, most of the staffs are seniors, and has been lived in Sri Iskandar area for a long time. Due to that, some of the firemen really know the shortcut and each route in Sri Iskandar area. Because of that, they tend to rely solely on the person experience in getting them to correct place.

To extent of getting late to specified area, it depends on the situation itself. For instance, there are case a reporter giving insufficient information to them, and fireman need to find a way based on landmark given and visual sense, specifically any thick smoke in particular area.

All in all, the author can conclude that due to current situation, the ACS-GPS application will potentially help this situation, because the result of current doing is not absolute-perfect way of doing.

4.1.2 Batu Gajah Fire Station

Figure 4.2: Batu Gajah Fire Station

On the other hand, different story found in this interview with Mr Hamadan, the Deputy Chief Officer of this fire station. In fact, I found that the Fire Response Tender (FRT) used by them has placed with tablet holder, showing the FRDM

committed in using technology inside their operation, as showed in appendix III. The interview takes place in 18th March 2015. Some of the related information from this interview:-

A. Use of Call Dispatcher System (CDS), an application for 999 emergency cases.

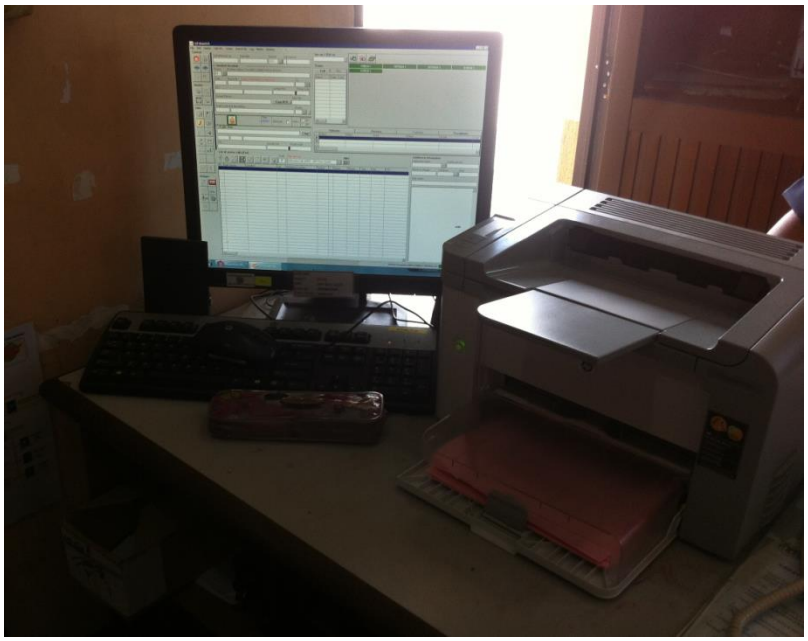


Figure 4.3: Call Dispatcher System in the control room

Apparently, there is a system used in this fire station, CDS purposely to elicit information from 999 order call that directed to local station. This application will basically display the information on a screen and they don't need to follow up to 999 for any further information needed. This process will basically compose in 1 minute upon 999 getting the emergency call.

Added by Mr Hamadan, CDS really useful to them because previously without CDS, they need to call 999 after control room receive any emergency report. Therefore, CDS is a big move for this station to move more effective and efficiently.

B. Upcoming Map Plotting System (MPS), fire pipe locator application.

Mentioned by Mr Hamadan, in this upcoming May 2015 their station will be receiving a MPS application, where it will be used to locate the fire pipe nearby the fire incident location. This is critical for them, as he may say

water source becoming part of the factor in operation achieving Key Performance Index (KPI). Besides that, he would suggest that this ACS-GPS application would probably can be used at that time too, because he looking forward to improve their operation using this application.

4.2PreliminaryPrototype

In this section, there will be explanations on three prototypes designed, showing the user interface of the ACS-GPS Map Plotter application. As mentioned in methodology, the map will plot the route based on ACS algorithm, then transfer the record from the ACS-GPS application to Google Maps. For readers' information, the author named this application as 'AntColony'.

Main Page

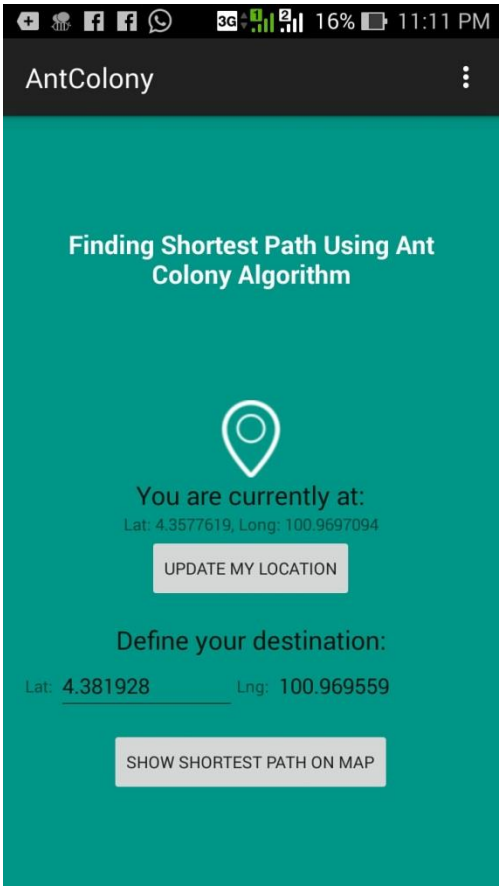


Figure 4.4: Main Page

As showed in figure above, shows the main page for the application. First of all, the fire fighters need to press ‘UPDATE MY LOCATION’ button in order to plot their current location. After that, a pop-out will come out and prompt that the location has been changed. Fire fighters need to insert the coordinate location, the latitude and longitude of the destination. Finally, fire fighters can press ‘SHOW SHORTEST PATH ON MAP’ and wait for a moment for the output.

Map Plotting

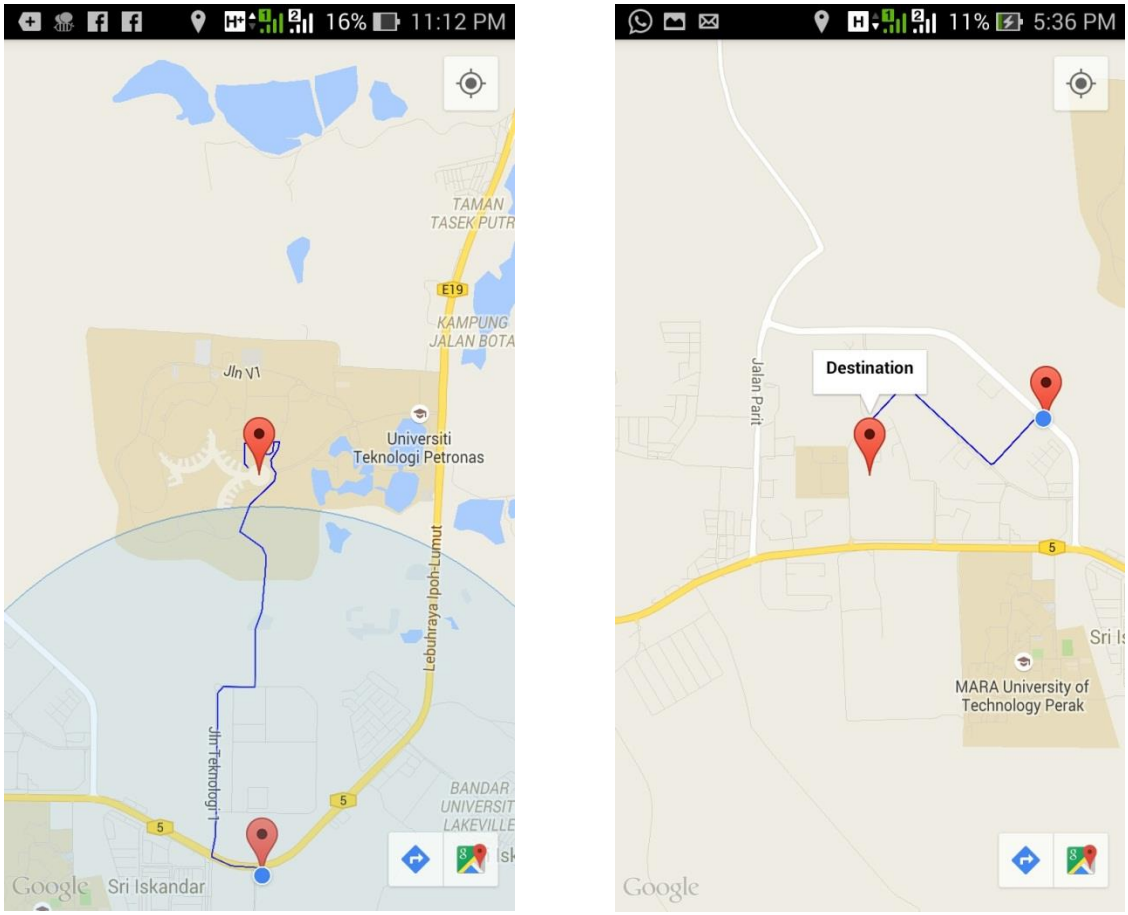


Figure 4.5: Map Plotting Page

From the screen, it shows the path is already plotted from Seri Iskandar Business Centre (SIBC) to Chancellor Hall, UTP to indicate the plotting process of this application. The plotter used is Google Maps API, an open source GPS and as you can see from the right bottom of application, there are a navigation button that will divert this records to Google Maps.

In this process, the ACS algorithm will be embedded inside the GPS application code so that the plotting process will be enhanced by the ACS algorithm

Display Information

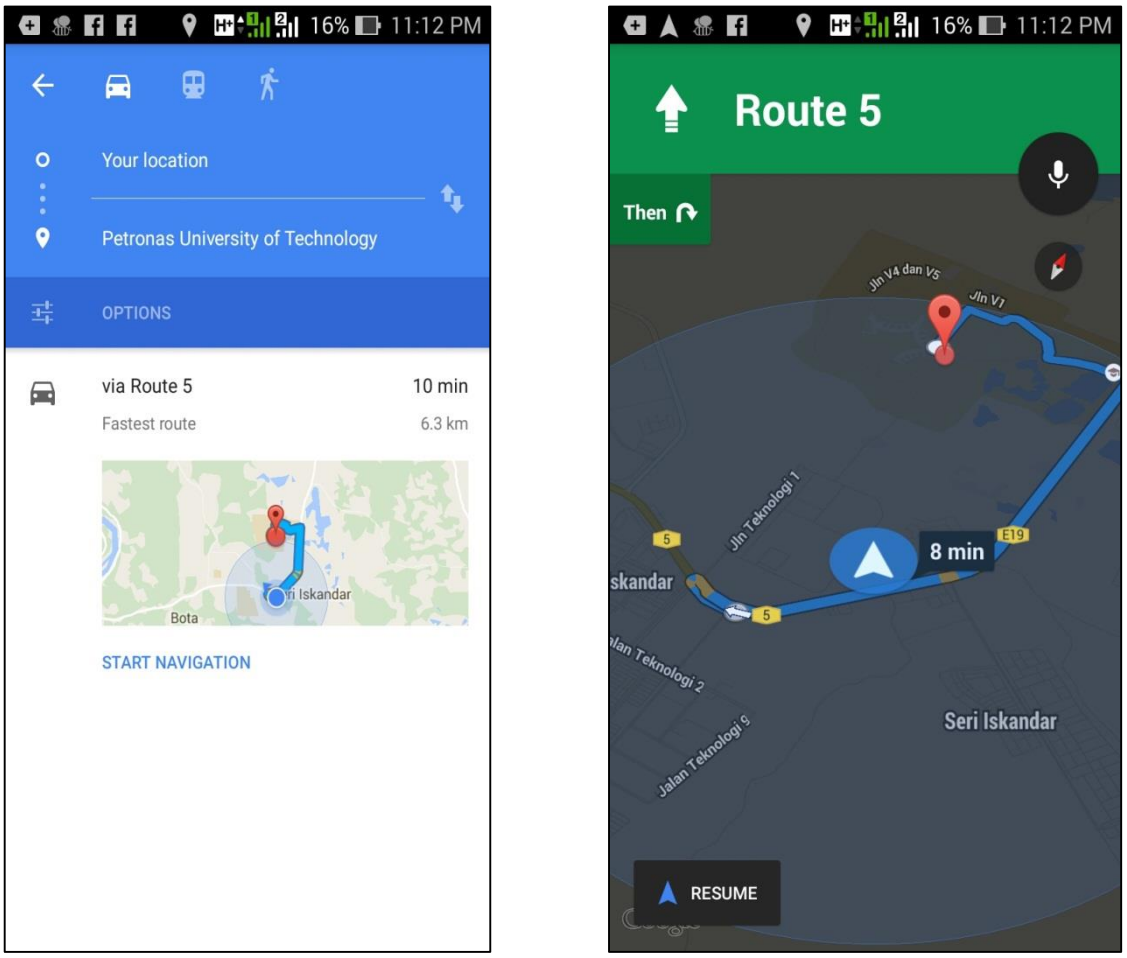


Figure 4.6: Location Information Page

As showed in the screen, this page displays information regarding the plotted path, and showing useful information for the fire fighters. This information is derived based on AntColony application and now fire fighters can click 'START NAVIGATION' and the navigation system will start afterwards.

4.3 Experimental Result and Discussion

The development has been completed as right as requirement should be measure. The functionality testing has successfully taken by starts at Seri Iskandar Fire Station

heading to 5 different locations that pre-defined in this test. The results are as follow:-

TABLE 4.1: Experiment Result on functionality testing

No	Destination	Lat and Long	Google Maps distance	ACS-GPS distance
1	UTP – Chancellor Hall	4.381834,100.969557	7.1km	6.3km
2	House area in Taman Maju	4.366814,100.969471	3.1km	2.9km
3	Kolej Profesional MARA Seri Iskandar	4.369373,100.947078	2.1km	2.0km
4	Seri Iskandar Industrial Zone	4.351135,100.971720	3.6km	3.2km
5	UiTM Seri Iskandar – Faculty of IT and Science	4.355967,100.954944	2.4km	2.3km

From the result, it is proven that the ACS-GPS application would really help the fire fighters to find their destination in more reliable way. Even tough, this application will not take account the traffic system, it is logical in fire fighters perspective as such that they are an emergency vehicles that can ring their bells and move forward to their way without concern much about traffic.

But, this ACS-GPS application will be dependent on Google Maps application as such that, when the fire fighters want to navigate to desired location, it will be internet independent as since Google Maps depends solely on internet in getting their route and direction precise. In conjunction, it would not be a big problem for mobile

application user, because generally for who possess mobile application they should have working internet connection as well.

The reason why Google Maps is being included is that in designing GPS application, there are too much API that need to be included as such thing delay more on development phase. After Google Maps is being "mash-up" with ACS-GPS application, I can save more time to develop and Google Maps can be said as reliable and quality application to be rely of.

After testing take place, I liaise with Fire and Rescue department of Malaysia, specifically in Batu Gajah Fire Station to ensure my application is accepted to be used by their side or not. After careful approach on functionality are being discussed and argued, we come to an agreement where this application is possibly can solve an issue in urban area.

Added by Mr. Hamadan, this application is one that already been wait by their operation because regardless of experience in particular place, even a fresh fire fighters can rely on this application in order to find optimized path for their time. In 2016, there are expected 30 more new fire station will be open in entire Malaysia, thus he encourage this application perhaps can help the fire fighters to use this application.

In order to test the ACS functionality; the algorithm AntColonyOptimization.java, author has included the LogCat tansaction during its running time. The transactions are as follow:

```
07-29 02:36:10.065  13935-13935/com.antcolony I/System.out:  Agent returned with new best distance of: 0.09264883908797833
07-29 02:36:10.345  13935-14870/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3939K, 22% free 15564K/19792K, paused 15ms, total 15ms
07-29 02:36:10.705  13935-14871/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3952K, 22% free 15550K/19792K, paused 14ms, total 14ms
07-29 02:36:11.045  13935-14869/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3954K, 22% free 15544K/19792K, paused 24ms, total 24ms
07-29 02:36:11.065  13935-13935/com.antcolony I/System.out:  Waiting for 3 agents to finish their random walk!
07-29 02:36:11.125  13935-13935/com.antcolony I/System.out:  Agent returned with new best distance of: 0.09233003954713398
07-29 02:36:11.135  13935-13935/com.antcolony D/route 0::  0.09233003954713398
07-29 02:36:11.135  13935-13935/com.antcolony D/shortest::  0.09233003954713398 route: 0
07-29 02:36:11.425  13935-14905/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3892K, 21% free 15820K/19792K, paused 19ms, total 19ms
07-29 02:36:11.465  13935-13935/com.antcolony I/System.out:  Agent returned with new best distance of: 0.10635588082356881
07-29 02:36:11.475  13935-13935/com.antcolony I/System.out:  Agent returned with new best distance of: 0.10036592884263526
07-29 02:36:11.715  13935-14903/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3180K, 22% free 15842K/20120K, paused 15ms, total 15ms
07-29 02:36:11.985  13935-14902/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3216K, 22% free 15834K/20148K, paused 14ms, total 14ms
07-29 02:36:12.245  13935-14902/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3199K, 22% free 15854K/20148K, paused 16ms, total 16ms
07-29 02:36:12.515  13935-14904/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3223K, 22% free 15846K/20164K, paused 15ms, total 15ms
07-29 02:36:12.835  13935-14904/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3234K, 22% free 15834K/20164K, paused 19ms, total 19ms
07-29 02:36:13.215  13935-14905/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3242K, 22% free 15826K/20164K, paused 24ms, total 24ms
07-29 02:36:13.505  13935-14903/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3212K, 22% free 15854K/20164K, paused 18ms, total 19ms
07-29 02:36:13.875  13935-14905/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3220K, 22% free 15844K/20164K, paused 17ms, total 17ms
07-29 02:36:14.165  13935-14904/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3228K, 22% free 15838K/20164K, paused 14ms, total 14ms
07-29 02:36:14.295  13935-13935/com.antcolony I/System.out:  Agent returned with new best distance of: 0.09768609652457562
07-29 02:36:14.435  13935-14904/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3234K, 22% free 15834K/20164K, paused 14ms, total 14ms
07-29 02:36:14.715  13935-14902/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3240K, 22% free 15826K/20164K, paused 14ms, total 14ms
07-29 02:36:14.965  13935-13935/com.antcolony I/System.out:  Waiting for 3 agents to finish their random walk!
07-29 02:36:14.975  13935-14903/com.antcolony D/dalvikvm:  GC_FOR_ALLOC freed 3247K, 22% free 15819K/20164K, paused 14ms, total 14ms
07-29 02:36:15.025  13935-13935/com.antcolony D/route 1::  0.09768609652457562
07-29 02:36:15.025  13935-13935/com.antcolony D/shortest::  0.09233003954713398 route: 0
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38195, 100.97431
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38233, 100.97432
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38236, 100.97432
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38236, 100.97432
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38239, 100.97416
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38246, 100.97401
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38251, 100.97394
07-29 02:36:15.025  13935-13935/com.antcolony D/point::  4.38268, 100.97376
```

i. Red box

   a. In the transaction, *Agent* represents the ants that are moving on the map, like in its colony – travelling on the road route and wherever the most route been travelled by most of the ants, the more pheromone level on it.

   b. Based on ACS Set of Rules Theory, **the transaction proved** State Transition Rule (STR) is used in the open source code retrieved.

ii. Brown box

   a. In the transaction, it proves that the *Agents,* travel in all directions provided; the route and therefore, transaction proves the ACS theory of Global Updating Rule (GUR).

   b. In addition, GUR is a unique rule of ACS which by it means, GUR only choose globally best ant travelled which construct shortest tour.

iii. Purple line

   a. Purple line proves that after the shortest path routed, the GPSTracker Class functions is to plot the direction on Google Maps using GoogleMapsAPI.

   b. Therefore, it proves the ACS-GPS functionality to plot the shortest path on map.

iv. Green line

   a. On the transaction, the *Agents* are performing "random walk' throughout the route. This type of behavior reflects ACS theory, Local Updating Rule (LUR).

   b. In LUR, the purpose of ant behavior to perform it is purposely to derive shortest path. It also reduces the computation in ACS compare to other AS, because of LUR will consider the change of pheromone on routes.

v. Grey line

   a. When echoes set are finish (In AntColony application has been set to150 echoes), the most last ant among the 150 *Agents* will travel on the shortest path among all the previous 149 ants has travelled.

   b. Therefore, when route=1, it will be consider as shortest path to be plotted on Google Maps

vi. Blue line

a. Blue indicates the shortest route array, waiting for the shortest route before the loop transfer the record (lat, long) to Google Maps Navigation to plot the route and start navigation

4.3.1 Functionality testing

The purpose of the system testing is to check the fulfilment of functionalities based on the requirement. Table 1 shows the data of each functions of AntColony.

TABLE 4.2: System Functional Testing for mobile application

Functions	Expected Outcome	Testing Frequency	Testing Result		Remark
			Success	Failure	
Open the 'Ant Colony' application	The application is successfully opened	5	5	0	
"Update Location" button	The prompt/outcome showed "Location changed!"	5	4	1	Poor internet connection can cause such crash
Longitude text box	Insert longitude value inside text box and successfully inserted	5	5	0	
Latitude text box	Insert latitude value inside text box and successfully inserted	5	5	0	
"Show shortest path on map" button	Successfully divert to Google Maps application and Ant Colony Optimization take place. The blue route will be plotted	5	4	1	Poor internet connection can cause such crash
Selection 'Destination' pin point	Navigate button will pop out	5	5	0	
"Navigate" button	It will divert to Google Maps application	5	5	0	
"Start Navigation" button	The map will start navigate, and display estimated	5	5	0	

	time and distance travelled				
Close the application	Application closed	5	5	0	

4.3.2 User Acceptance Test (UAT)

User acceptance test take place in Batu Gajah Fire Station, involving 5 fire fighters. There are 2 important criteria that the author really emphasizes on which are:-

a) Do fire fighters understand the application flow?

The questionnaires are passed to 5 fire fighters (Refer Appendix 7) and they need to answer all the questions. From what the author can conclude that, 3 out of 5 respondent's rate 'Very understand' and the rest rated 'Slightly understand'. From the responds, the author can assure that all the 5 respondents are eligible to use this application no matter what is your demographic information. To strengthen author perspective, he conducted post-discussion after the testing and found that AntColony interfaces are understandable and useable.

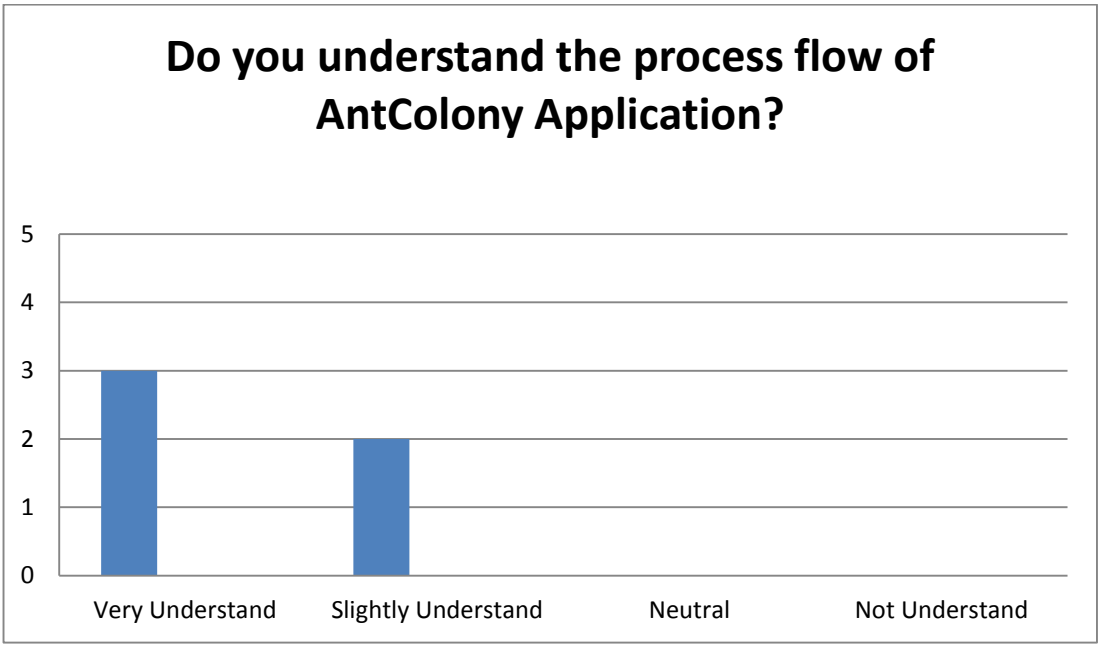


CHART 4.1: UAT Question I

One of feedback after test post-discussion - **To what extend do you understand the process flow of AntColony Application?**

"The application is simple as it should be. I don't expect to have a variety of functionalities and this is straight-forward and most of fire fighters are trained to find optimized solution for each tasks that given on them."

Mr. Fikri, KB17 Batu Gajah Fire Station

Figure 4.7: Feedback on Question I

b) Does the application meet your level of expectation?

The procedure is just the same like previous question, and the result is out of 5 respondents, 4 has selected 'Most expected' and another one respondents selected 'Slightly expected'

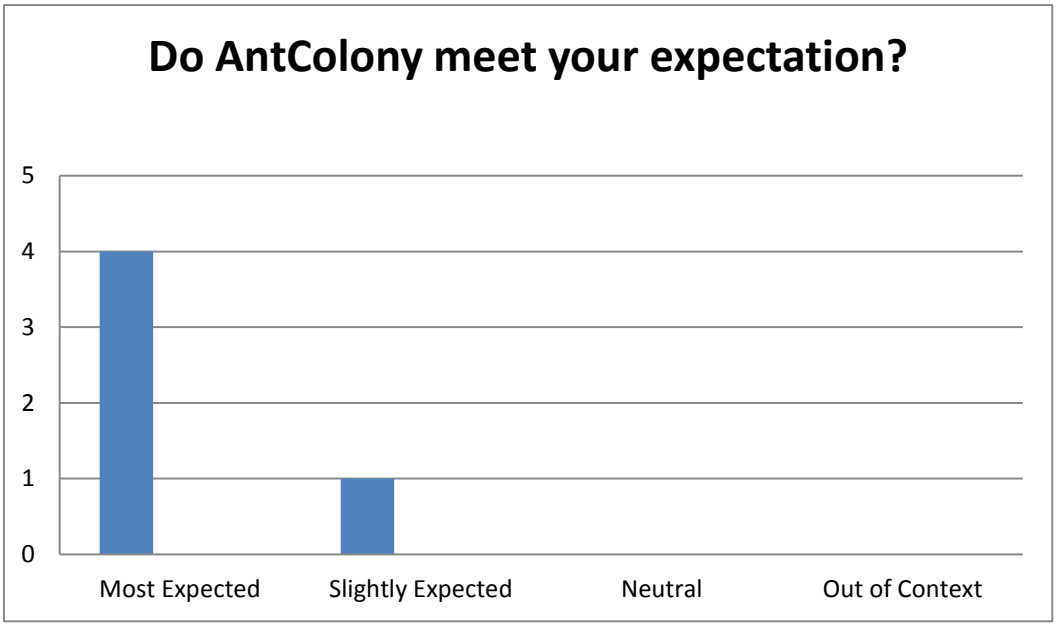


CHART 4.2: UAT Question II

From the outcome, the author found 1 respondent have a suggestion that can help the fire fighters I much better way. The feedback received cited as follow:-

"It is good to have latitude and longitude prompt, but once again we need to face any possibilities in case of emergency, the CDS also not functioning and there are no internet connections. What should we supposed to do?

Mr. Hamadan, KB48 Batu Gajah Fire Station

Figure 4.8: Feedback in Question II

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Relevancy of objective

First of all, this project focuses its interest in finding shortest path for fire fighters, which the outcome to solve this is AntColony application. The application is significant on finding the solution, which it will plot the route on Google Maps using the ACS algorithm and finally the plot routed on Google Maps Navigation.

Secondly, the AntColony application is capable to prove the theory of finding shortest path on map, is a best way to travel in a shorter distance compare to any other GPS application that available to be used. From the application screenshot (Refer Appendix 9), there are comparison between the Route plotted by AntColony and route plotted by Google Maps. From what the author can observe, the route given by AntColony is much shorter than Google Maps route.

Last but not least, the author has proved the theory of ACS inside the rationale of using it on map. From previous chapter, there are explanations that aligned with the ACS Set of Rules, which consist of STR, LUR and GUR

Suggested future work

The AntColony application can be enhance in a way that, it can trace the coordinate from 999 call and catch the information straight through from the voice recognizing feature. With advancement of technology, it is essential to secure this function from been passed to wrong hand. Therefore, the author personally emphasize on security to be implement to this GPS so that we can ensure the quality of the application.

In this first phase of idea dissertation process, the author can conclude that ACS-GPS application is an essential improvement in helping the emergency team to solve the problem in these millennial days. With the embrace of technology in one of our important elements in saving people lives, it can help to contribute good values in developing this nation.

In other words, author emphasize in user requirement is important at such without the qualitative method performed, it would be a waste in effort finding what is supposed to be achieve for this research project. Added by author, with this application produced it can increase the standard and bar in achieving efficient emergency team. Though, it can be seen in bigger picture of broaden usage in ambulance and police gear.

In contrast, there are still big gaps in this application. To recommend, it is good to enhance the current idea with finding optimized path, in such free from traffic jam risk and any factor that can lead to delay the shortest path advantages.

All in all, the ACS-GPS Map Plotter is potentially can transform the old method of doing to be much effective and efficient in future ahead.

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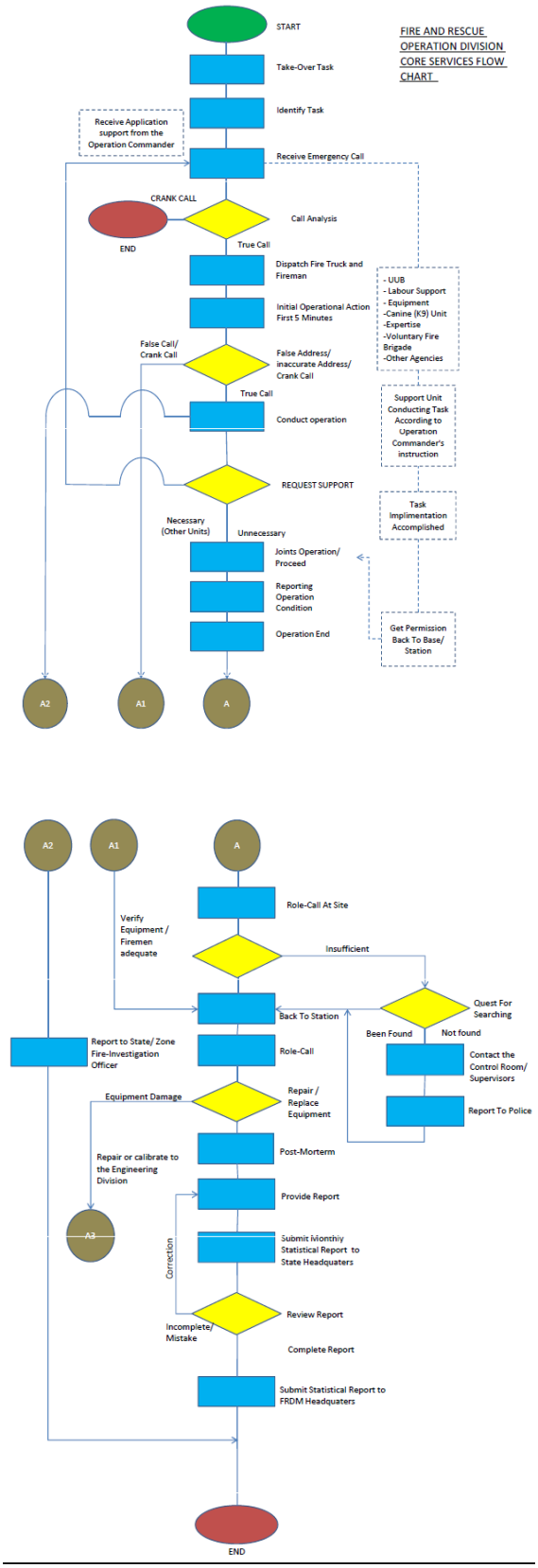
APPENDIX



Appendix 1: The process flow in FRDM Fire Operation and Rescue Division

Appendix 2: Picture after interview session with Mr Hamadan, Deputy Chief of Batu Gajah

Fire Station

Appendix 3: The Fire Rescue Tender (FRT) used by Fire Fighters in their operations

Appendix 4: The tablet holder inside FRT installed

Appendix 5: Interview Report at Sri Iskandar Fire Station

The interview conducted with Mr. Amat, Deputy Chief Fire Station of Sri Iskandar at his office, 17th March 2015. I try to elicit the requirement needed from their side, on view how the ACS usage on GPS can help them in finding the solution.

Basically, the question asked more focusing on open statement on what is current situation and what is his opinion towards the statements. Some of the points upraised are:-

a) **What is your opinion on my research outcome, a navigation system in finding shortest path for fire fighters usage?**

   Generally, there are that kind of solution given from the Asset Management in Fire and Rescue Department of Malaysia (FRDM). Each vehicles provided, comes with a portable tablet that basically will display a map for the usage in finding the path to pointed location. But, the problem is that the fire engine driver doesn't used it because they really know the path given is not correctly plotted, in sense there are alternative way they can use that is more faster compare to displayed path. Besides that, there is information confusion from the complainant, where the information given is partial, and they need to ask from the local to wait outside of their house/premise so that

they can detect where the exact location is. Speak of path; the driver is basically someone who has experience on the local area, the shortcut and size of the road they head.

b) If in that case, are you managing to arrive at fire incident at time even without the GPS?

At norm, we used to get complaint on this issue where when it comes to emergency, we always being blame to be late. But the thing is, the information given from the complainant sometimes not suffice for them to interpret the information. The complaint will be received to control room, by one of the fire fighter. Then, he will interpret the message and ring the emergency bell. In 60 seconds, they need to make sure they already out for the fire station and head to the particular location.

Within the 60 seconds, no one else except the one who received call knows what type of emergency they faced and just takes suitable vehicles; consider the one who receive call decided which suitable need to be used. In emergency operation, they only had 2 possibilities which are fire incident or rescuing incident. To which I'm certain, if it is fire incident, we will be using the Fire Rescue Tender (FRT) follows by the Emergency Medical & Rescue Service (EMRS). Regards the rescuing operation, it depends on the situation whether it is serious or normal. Regardless all, EMRS is one that will be used no matter what emergency type they received.

Nevertheless, in Malaysian climate and culture, not being punctual is normal and what it takes a best for them to do; they will try to maximize the opportunity as much as they could.

c) In the current GPS, what it takes to ensure the direction or path is directed correctly regards the situation?

Sadly, the GPS is not with us anymore. It is due to misuse of the tablet, and until now it is hard for us to retrieve where it is. But since that application is here, there is not much the technology can help because the plot is not really

correct. The driver found that there is another better way of getting there, but then again we can see the direction is not getting any good after a while.

d) **Do you think shortest path is needed in FRDM usage in increasing effectiveness of your operation?**

Personally I think it will help, in a way there is no dependency on experienced fireman and because of current issue faced in FRDM, we are losing experienced people nowadays. This is due to dangerous tasks lately, and most of the senior fireman fall sick and some resigned due to physical abilities. Right now, we are recruiting new fireman and in fact, we had opened our own state training place at Tronoh, Perak. This is to encourage more new and fresh fireman that can help the country and contribute to the nation.

After all, most of the youngsters nowadays have more knowledge towards technology compare to their ancestors. Therefore, I really sure if this thing can be implement, most of the fireman will love to use it, in spite you need to unsure it is user-friendly and functionally working well

Appendix 6: Interview Report at Batu Gajah Fire Station

a) **Speak of Seri Iskandar Fire Station, they already been introduced with GPS technology in getting them to emergency response, how about here?**

That is so sudden because we still waiting for that kind of technology to be distribute here. Perhaps, Seri Iskandar is a new fire station, and no wonder the technology is applied there is better than here. In fact, the area covered in Seri Iskandar is bigger compare to here in Batu Gajah.

Until now, we still wait for the first GPS application for our usage in finding water pipe that nearby the fire incident place. This has been a big factor lately and dilemma for us, in finding water sources for our use in getting the fire off

b) **To confirm, even without that such technology is there are flaw met inside your Key Performance Index?**

To adhere, in perfection there is still a gap that might happen for such situation. But then again, to mention basically the issue in arriving late to

emergency response is still a rare case. Basically the issue when arriving late is because of insufficient information that been reported directly to here rather than 999 emergency team response. All in all, I found that most of the ordinary case we arrive on time, and sometimes even well than the standard set.

To explain, there are 3 zones of time set up by the top management, which are Zone A, Zone B and Zone C. For Zone A, we supposed to arrive in 10 minutes, where the area coverage of 10km. For Zone B, it is between 10km – 20km, with par of less than 20 minutes to arrive, there goes for Zone C that is more than 20 km and above. In other words, for each kilometre we cover it supposed to done in 1 minute.

Here are different from other big fire station, such as Ipoh and KL. In there, the KPI is quite tough for them to achieve, especially in peak hours. It took several minutes due on general, when it comes to peak time. Perhaps, there is solution for them to find path that is not in traffic jam condition rather than shortest path.

c) Is the vehicles play a big factor in determining the response time following the standard set?

There are yes and no in this case. It is yes condition when it comes to narrow road or rural area, which is not really known by the KB17 (Driver grade in FRDM) in sense there are coverage in deep rural areas. In addition, FRT is a big gear for us to handle, plus with unsuitable road condition. But then again, we still manage to get there on time because of after all there are still road that can be used by the fire fighters. What I am trying to say is, even though there are many obstacles we faced, we will try our best to get there in time no matter what. That is our motto in operation.

d) Personally, do you think that this ACS-GPS application would help much in your operation?

Frankly said, I don't even know how to say it because after your explanation I still don't get the picture. But then again, I do believe if this application can be done, it will help us a lot in sense that we don't need to depend on experienced KB17 and we can take shift in driving the gear. In addition, it is

also will be good improvement to newly place fire station opened, because it can save time in getting to know the particular place inside out.

Appendix 7: User acceptance questionnaires

Final Year Project – Ant Colony System: Finding Shortest Path for Fire Fighters

User Acceptance Questionnaire

Please answer all questions.

Personal Information

1. Name : _____
2. Age : _____
3. Grade : _____
4. Do you have smartphone? ○ Yes ○ No

Application Review

1. Do you understand the application process flow of AntColony application?
   ○ Very understand
   ○ Very understand
   ○ Neutral
   ○ Very understand

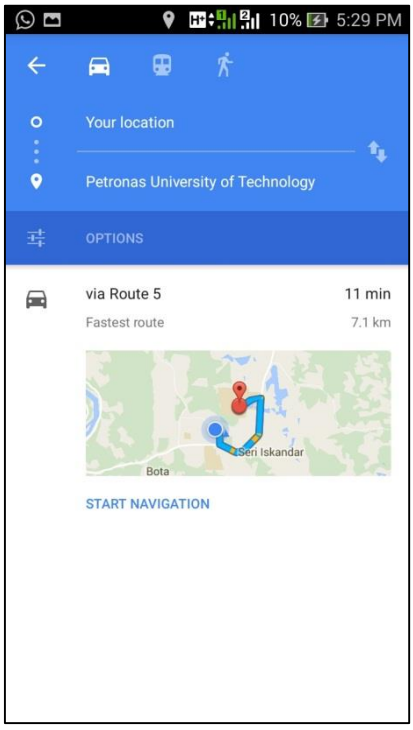
2. Do AntColony meet your expectation? If not please gives explaination?
   ○ Most expected
   ○ Slightly expected
   ○ Neutral
   ○ Out of context
   Explaination : _____

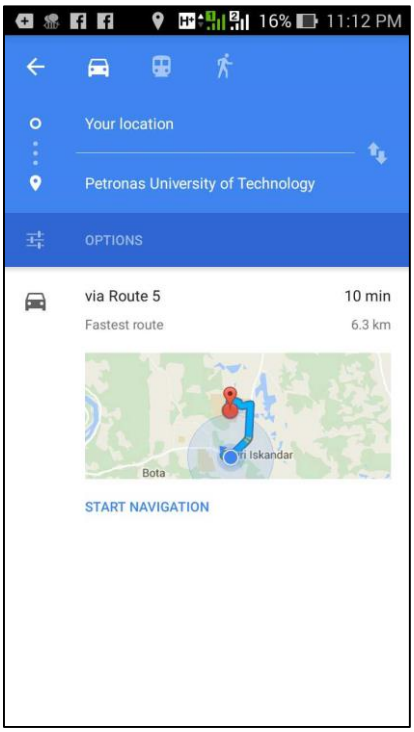
   Thank you.

Appendix 8: The author during functionality testing

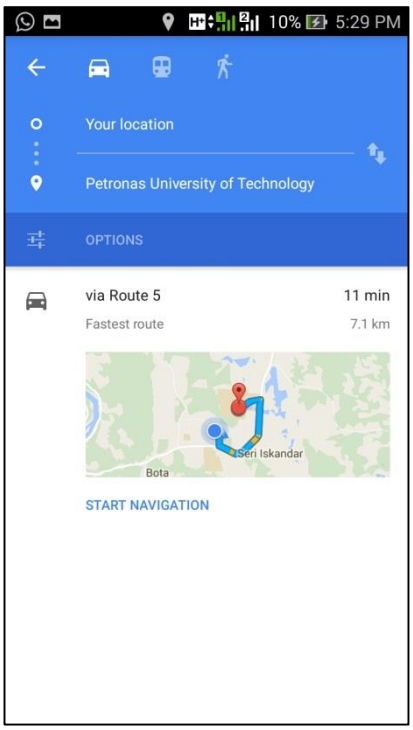
Appendix 9: Application screenshot

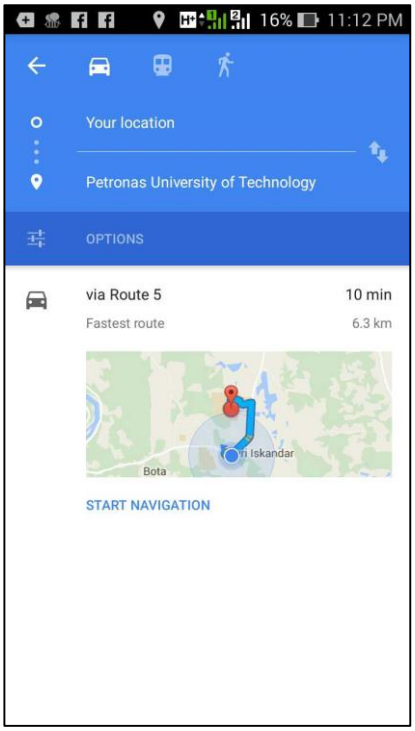
1) UTP – Chancellor Hall



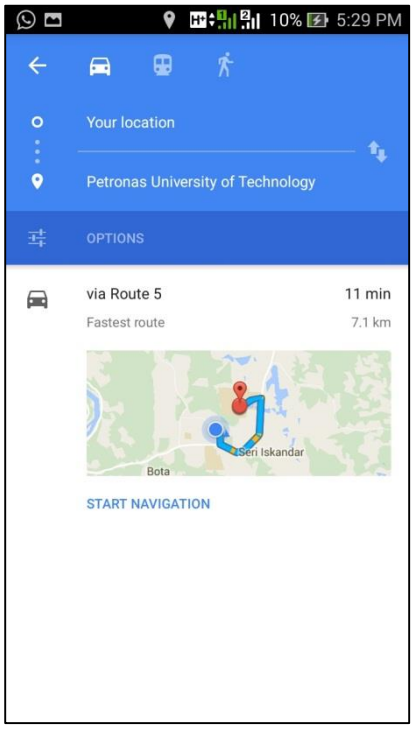


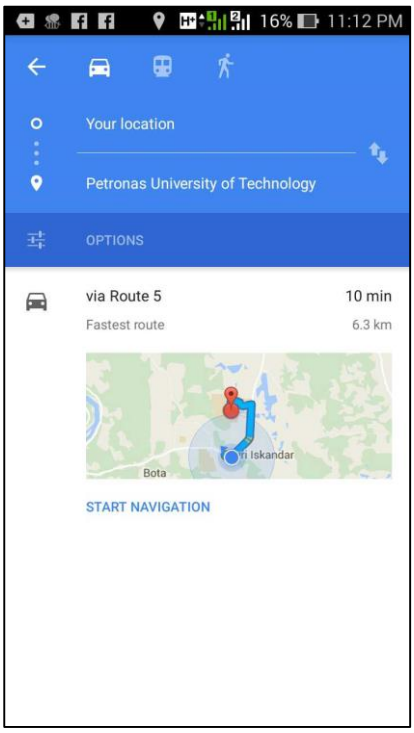
2) House area in Taman Maju



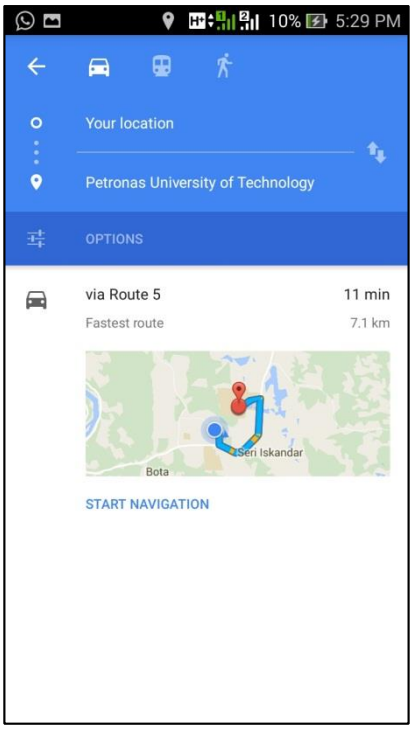


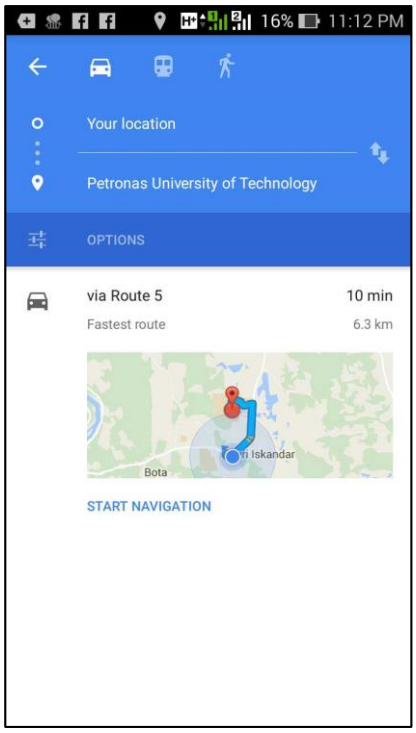
3) Kolej Professional MARA Seri Iskandar





4) Seri Iskandar Industrial Zone





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