EMERGENCY TRAFFIC SYSTEM (ETS)

By

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FINAL YEAR RESEARCH PROJECT REPORT

Submitted to the Business Information System Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Computer Science (Hons)
(Business Information System)

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CERTIFICATION OF APPROVAL

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Business Information System Programme
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Approved:

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Project Supervisor

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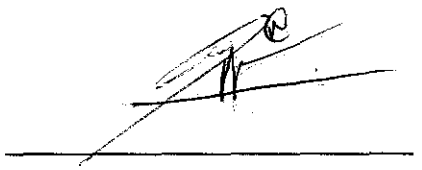
CERTIFICATION OF ORIGINALITY

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.



Abdul Qayyum Bin Haja Mohideen

ABSTRACT

Communication has been growing very rapidly where almost every one on earth is connected despite their geographic location. This is due to various improvements in the telecommunication industry. There have been various researches done to apply communication medium into car where it is called Vehicular Ad Hoc Network (VANET). This dissertation focuses on the design of a simulation application which establishes communication between two 802.11 nodes. One of the nodes is a mobile node which resembles an ambulance and another static node resembles a road side unit. The mobile node will be able to instruct traffic light to react upon its path request. To prove this concept, experiment on VANET was done on NS 2 to simulate a moving mobile node communication with a static node.

The system has been resourced on android platform for the mobile node application as android is the most widely used operating system for smart phones. Visual Basic is used to simulate the traffic light condition as it receives input from mobile node via ad hoc network. The application developed would be able to reduce ambulance time spend on road due to bad traffic condition while increasing chance of saving patients life.

ACKNOWLEDGEMENTS

All credits are due to Al-Qayyum the all mighty that have make everything happen at the very precise moment. I also need to thank myself for being able to complete this project within much fuss.

I would also take this opportunity to thank my FYP supervisor, Mr Low Tan Jung for his undivided support in helping to complete this project.

Sergey Brin and Larry Page have significantly contributed to the success of my project whereby without the efficiency of Google, it would slowdown the progress of my project. The abundance of resource available especially on Google Scholar and Google Search has helped a lot and redefine my research activity.

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Not to forget fellow friends Adam, Anief, Anwar, Ilhami, Fauzan, and other unmentioned but always remembered friends which have been very supportive in discussing various matter with regards to this projects.

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LIST OF ABBREVIATIONS

AODV	**Ad Hoc On Demand**
MANET	**Mobile Ad Hoc Network**
OBU	**On Board Unit**
NS	**Network Simulator**
RREQ	**Routing Request**
RREP	**Routing Reply**
RSU	**Road Side Unit**
t	**Time**
s	**Seconds**
UAT	**User Acceptance Test**
VANET	**Vehicular Ad Hoc Network**

CHAPTER 1
INTRODUCTION

1.1 Background of Study

In a case of emergency, a vehicle equipped with siren would travel to the place of accident in a state of urgency. Among vehicles that respond to emergencies are ambulance, fire trucks, and police cars. In a situation where lives need to be transferred from an accident place to hospital, an ambulance needs to be prioritized but that's not usually the case. In an intersection road, vehicles from other side won't know exactly the location of the ambulance. Time wasted on the road due to inefficient road traffic system would lead to loss of life. There are also cases of road accident often occur at intersections involving emergency vehicles due to confusion, impaired hearing and overly-aggressive drivers who meant to give way to the emergency vehicle [Gross, 2001].

In this paper, we focus on the implementation of a VANET (Vehicular Ad-Hoc Network) based traffic light system for emergency vehicle in a three way intersection. A corresponding simulation will be done to replicate the implementation of the system at the end of this study.

VANET is part of Mobile Ad Hoc Network (MANET) which creates a communication medium in car-to-car without a need of infrastructure. Research on this are have been very extensive as it is believe to be the future automobile technology. This paper would like to implement VANET technology into ambulance to communicate with traffic light. Message sent to the traffic light will instruct the traffic light to behave according to the need of the ambulance direction. This is because the direction of the emergency varies for every accident scenario.

Based on figure 1, assuming the traffic light on the lane which the ambulance is on, is red, the ambulance will send a path request message to the traffic light via RSU.

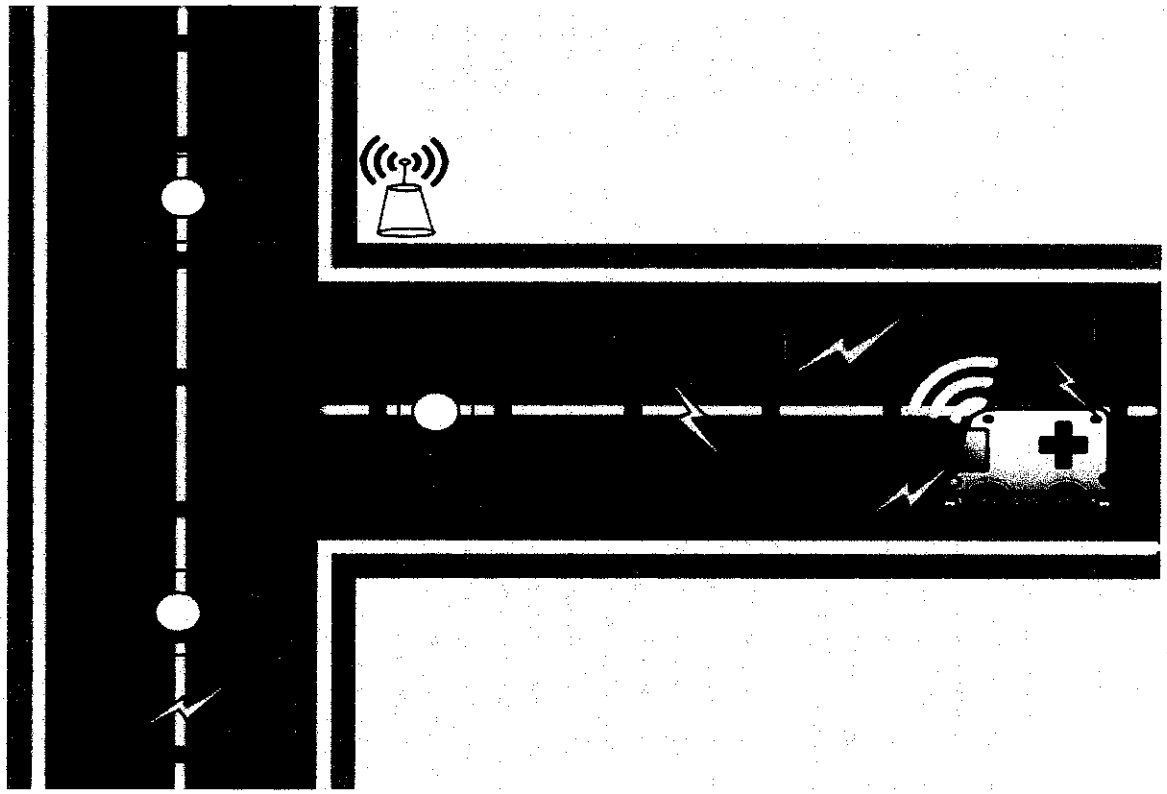

Figure 1: Road traffic visualization

Finally, a simulated traffic system which would respond to emergency vehicle using ad hoc network will be develop.

1.2 Problem Statement

When ambulance is stuck in a traffic jam and the traffic flow depends on traffic light, it causes ambulance having a hard time to get through. In a 3 way street, when the traffic light turns red on the ambulance side and its green on either one of other side the front most vehicle will have problem to navigate away from the road because they poses high danger as it have a high tendency of getting hit by vehicles moving on the flowing street as vehicles move on average at 60km/h on a normal traffic flow. Even though the ambulance siren is on, vehicles on the other side of road would have a hard time to determine which side of the street is the ambulance located. This whole situation put patient's life that is meant to be transported on ambulance at stake.

1.3 Objectives

The main objective of this project is to establish communication system between ambulance (mobile node) and traffic light via a road side unit (static node) through ad hoc network and to simulate traffic light activity when given input via ad hoc network. This communication would enable ambulance driver to control the traffic light to be in favor of their intended route to reduce its time on road due to bad traffic. Several other objectives are as follow

1. Design user interface, and system architecture for mobile node.
2. Design a traffic light simulation resembling a road junction.
3. Develop a system that interacts between mobile node and static node which responds to the traffic light simulation.

1.4 Scope of Study

The scope of this project is to prove ad hoc network using AODV routing protocol between two nodes on NS 2. Mobile node application is developed on Android platform while a three way junction traffic simulation is developed on Visual Basic.

1.5 Pre-requisite

- ✓ Basic knowledge on OSI layers.
- ✓ Knowledge on socket programming.

1.6 Tools

- ✓ Microsoft Visual Studio 2010
- ✓ Eclipse with Android SDK
- ✓ NS 2

CHAPTER 2
LITERATURE REVIEW AND / THEORY

2. 1 Overview of MANET

An ad hoc network is a collection of wireless mobile nodes (or routers) dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration [Sarkar et al.,2007]. Mobile ad hoc network (MANET) is ad hoc network with the ability to change location and reconfigure itself. Ad hoc network originate since the early 70's when in conjunction with ALOHA (Areal Location of Hazardous Atmosphere) and CSMA (Carrier Sense Medium Access) were used to provide networking capabilities in combat environment on a trial basis. Communication could be establish in any situation within few hours as it doesn't need any infrastructure and it is deployable within 802.11 protocol. All nodes connected in an ad-hoc network can communicate with each other. Each of these nodes is a wireless transceiver that transmits and receives at a single frequency which is common to all nodes. [Khoury and Rachid,2007]. Ad hoc networking brings features like easy connection to access networks, dynamic multihop network structures, and direct peer-to-peer communication [Sarkar et al.,2007].

2.2 Overview of VANET

VANET is a subset of MANET which turns every vehicle with wireless transceiver to be a node. Cars within certain range of could communicate within each other and the circle of cars interconnected could grow. According to Zeadally et al [2010] for communication to happen, vehicles must be equipped with radio interface or On Board Unit (OBU). It is further explained by Qian and Moayeri [2008] that VANET is a self-organized communications between vehicles and RSU (Road Side Unit) in which network application and services could be provided to vehicle including internet access.

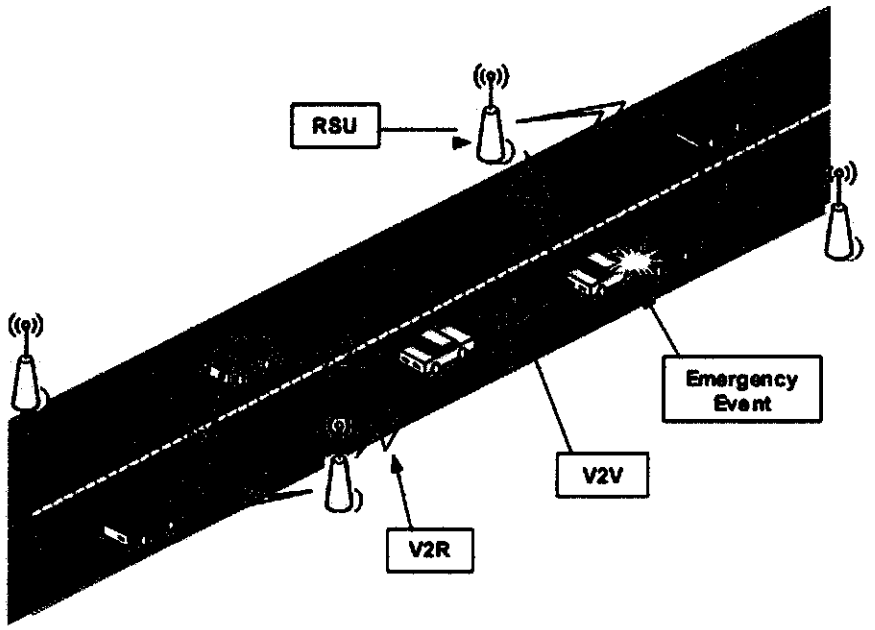

Figure 2: VANET Communication [Qian and Moayeri, 2008]

2.3 Architecture Selection & Unicast Routing Protocol

In mobile ad hoc network there are three main process which the first is during information gathering. They are divided into three parts which are proactive, reactive and hybrid routing. In proactive routing, routes are being calculated before it is needed. Proactive routing protocol maintains regular and up to date routing information about each node in the network by propagating route updating at fixed time intervals throughout the network, when there is a change in network topology. As the routing information is usually maintained in tables, so these protocols are also called table-driven protocols i.e. Ad hoc On Demand distance Vector protocol (AODV), Dynamic Source Routing (DSR), Admission Control enabled On-demand Routing (ACOR) and Associativity Based Routing (ABR). [Qasim et al, 2009]. Reactive routing on the other hand establishes routes on demand by flooding a query. Many reactive protocols have been proposed based on such on-demand philosophy, such as dynamic source routing (DSR), signal stability-based adaptive routing (SSA), ad hoc on-demand distance vector routing (AODV) , and temporally ordered routing algorithm (TORA)[Tseng et. al., 2007]. When a source wants to

send to a destination, it uses the route discovery mechanisms to find the path to the destinations by initiating route request. When a route is established, then route remains valid till the destination is reachable or when the route is expired [Qasim, 2007]. Hybrid protocol is a class in Unicast protocol which combines the proactive and reactive protocol which brings together the advantage of both protocols. Proactive and reactive algorithms are used by the node to route packets within and outside the zone, respectively [Sarkar et al, 2007].

2.3.1 Reactive Routing Protocol

Reactive is also known as "on demand" protocol [Sarkar, 2007, Lee, 2008, Qasim et al, 2007, Baumann, 2004]. Throughout the path taken by the emergency vehicle, traffic lights would appear only in certain location. Sarkar et al. [2007] mention that reactive routing protocol, search for routing path only when needed. Routes are discovered and maintained for only those nodes that are currently being used to send data packets from source to destination [Mustafa and Raja, 2010]. How route discovery is done in reactive routing: when a route is demanded, the requesting node will send RREQ (route request) and waits for RREP (route reply). If it does not receive any RREP within a given time period, source node assumes that either route is not available or route expired. When RREQ reaches the particular destination and if source node receives RREP then by using unicasting, information is forwarded to the source node in order to ensure that route is available for communication [Mustafa and Raja, 2010, Andreas 2004, Baumann, 2004]. Sarkar et al. [2007] further explained that active route may be disconnected due to node mobility and therefore suggested route maintenance as an important operation of reactive routing protocol. Zeadally et al [2010] said "Communication among vehicles will only use a very limited number of routes, and therefore reactive routing is particularly suitable for this application scenario."

2.3.2 Ad Hoc On-Demand Distance Vector (AODV)

AODV is a reactive protocol and uses a table driven routing framework, distance sequence numbers for routing packets to destination mobile nodes and has location independent algorithm [Qasim, 2008]. AODV is a pure algorithm for ad hoc

networks [Sarkar et al., 2007 and Mustafa and Raja, 2010]. It sends messages only when demanded and it has bi-directional route from the source and destination [Qasim, 2008]]. AODV uses an efficient method of routing that reduces network load by broadcasting route discovery mechanism and by dynamically updating routing information at each intermediate node [Mustafa and Raja, 2010].

2.3.3 Route discovery

Path discovery is a process initiated when two node needs to communicate without any routing information in its table [Sarkar et al., 2007] and its makes the most important part in any protocol in wireless communication [Mustafa and Raja, 2010]. AODV nodes use four types of messages to communicate among each other. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance [Lim, 2004]. When a source node needs to communicate with a node, the network is flooded with RREQ message. A node which receives the RREQ, replies with RREP if the conditions are met or it continue to broadcast to its neighbor and increase the hop count (hop_cnt). The RREP generated by the end note is sent on the reverse path it arrives to the source node [Lim, 2004, Mustafa and Raja, 2010, Sarkar et al., 2007].

2.3.4 Route Table

Routing table management in AODV is needed to avoid those entries of nodes that do not exist in the route from source to destination [Mustafa and Raja, 2010]. According to Sarkar et al. [2007], each route table entry consists of following information:

- Destination
- Next hop
- Number of hop (metrics)
- Sequence number for the destination

- Active neighbors for this route
- Expiration time for the route table entry

Clifton's flow chart simplifies the whole process:

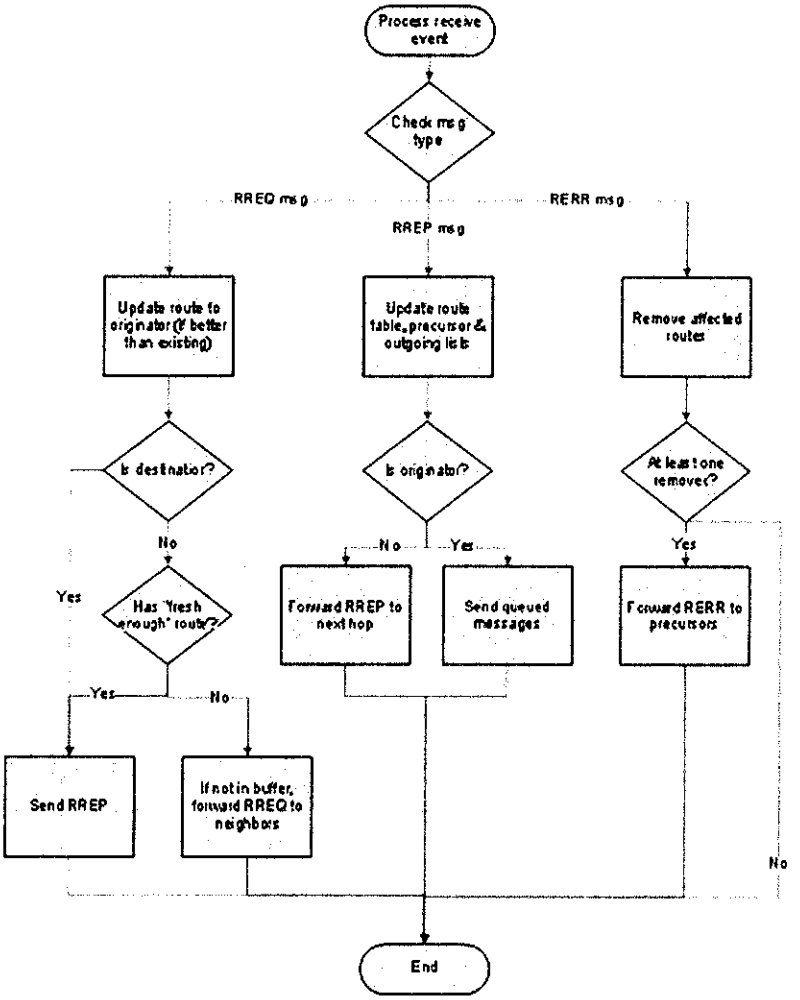

Figure 3.1: Route Table flow chart

2.4 Traffic Flow

The numbers of cars on road have increased significantly. Traffic lights were created to control traffic flows in intersection so that the traffic flow would be smooth and it would avoid inter vehicle accident from happening. There are two types of traffic light: pre-timed and traffic actuated [Paulson, 2002]. The signal control of the congestion length in a two-way urban road network means that the three signal control parameters are controlled systematically and sequentially so as to minimize the performance criterion of the urban road network under such a coming that the

sum of the green time, yellow time and offset at each signalized intersection in a closed link equal to n times of the common cycle length [Shimizu et al., 2004]. According to Hall, [1992], the items which interest the traffic flow are rates of flow, speed, and travel time over known length of road, road occupancy, density, time headway between vehicles, distance per vehicle, concentration.

2.5 Intelligent traffic

In modeling a traffic simulation, there are two models that need to be look into. Macroscopic traffic models are based on gas-kinetic models and use equations relating traffic density to velocity [Lighthill and Whitham, 1955, Helbing et al., 2002]. This model is less flexible and offers no optimizing function. On the other hand, Microscopic model offers the availability to evaluate driver's behavior in relation with the traffic condition individually. Communicating between road user and traffic condition has been done traditionally through dynamic road signs, messages and even twitter. Research done by Emmerink et al [1996] road users are most likely to react upon the message they receive in order to get a better alternative to get to their final destination. According to Rizvi et al [2007] green light at intersection can reduce driver confusion, reduce conflicts, and improve emergency response time.

2.6 VANET Application

VANET technology have very much related with the research of Intelligent Transport System (ITS) therefore it have contributed in the creation of ITS application which improve the whole idea of transport. There are various that contributes to the development of a VANET application such as bandwidth allocation, security, delay and many communication method such as one to many, many to many, many to one and one to one. According to Qian and Moayeri [2008] for a warning dissemination application, allowable latency requirement should be an important aspect that been looked into during development. It is important for an application to have a low latency level in order to transmit efficiently. There also have been concern on security and tempering on message disseminated via VANET. Several solutions that available are through certificate authority (CA), and specific

IP communication. Specific IP with CA would increase the security for a low level application as the message flooded is only for a specific IP whereby it only will send a RREQ when it connects to a specific IP. It would than need a second layer handshake through CA to confirm the connection before the real message is being disseminated.

CHAPTER 3
METHODOLOGY

ETS consists of 3 main stages which consist of 7 phases which are:

- Planning Phase
- Design Phase
- Implement Phase
- Test Phase
- Evaluate Phase
- Deployment Phase

The procedure for each phase above will be discussed below. Figure 2 shows the overall methodology of the project.

3.1 Research Methodology

Agile Methodology

This project uses agile methodology to develop the system. Agile software development is a group of software development methodologies based on iterative and incremental development, where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams, Udayan *(2009)*.Figure 2 below demonstrate the stages/phases in the methodology that been used. It is important to perform all the stages to make sure all the things that been planned could be accomplish according to the schedule.

Having a methodology before embarking on a project is very essential as it act to guide throughout the development of the project

For early stages of the project, it is important to understand the entire concept that involve in the project. In a way to provide better understanding, an appropriate

method will be used besides using the manual method. And for that, it will reduce lesser time to complete the project.

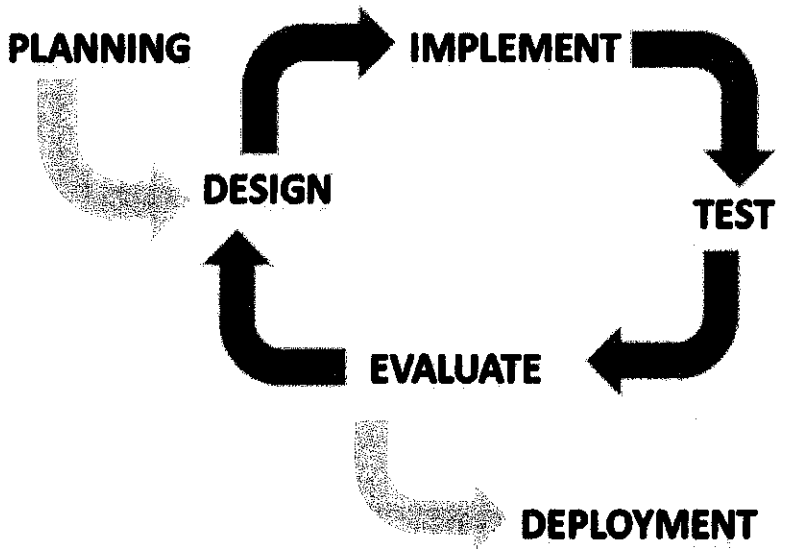

Figure 3.2: Agile methodology

3.1.1 Planning Phase

During this stage, requirement gathering was done. The subject of ad hoc network and traffic light system need to be fully understood its application is being analysed. This phase was done during FYP 1 and most information was gathered by reading journals, conference paper and related books. After doing the feasibility study, extended proposal and defense proposal was submitted and approved by the supervisor.

3.1.2 Development Phase

During the development phase, there are 4 main processes which are done repetitively until a satisfactory system is achieved. The 4 processes are (i) design (ii) implement (iii) test (iv) evaluate. During the first process, flowchart of the planned system, and system architecture of the project is designed. Then it is translated into codes whereby in for this system three platforms were used. NS 2 was used to simulate AODV VANET simulation whereby TCL language was used. Java is used to develop android app as an interface for the mobile node and Visual Basic was

used to simulate a three junction traffic light. The system is the tested and evaluated. Usually there are elements that were failed to be met thus the development phase is being repeated with improvement.

3.1.3 Deployment Phase

This is the final stage of the whole system development. During this phase the whole system is finalized and is in a ready state where it is ready to be used by end user. This will include testing done by potential customers and user where there will give feedback and the system will be available for them to use.

3.2 Gantt chart

No.	Detail	Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Title Selection / Proposal													
2	Confirmation of Proposed Title			X										
3	Preparation of Extended Proposal													
4	Extended Proposal Submission						X							
5	Preparation for Proposal Defense													
6	Proposal Defense and Progress Evaluation									X				
7	Preparation of Interim Report													
8	Interim Report Submission											X		
9	Technical Report													
10	Final Submission													X

Figure 3.3 Gantt chart

Legend:

Progress

X Project Milestone

CHAPTER 4
RESULT AND DISCUSSION

4.1 Requirements Gathering

A survey was done among ambulance driver to understand the need to have a system that would be able to control traffic light in order for them to get to the final destination faster.

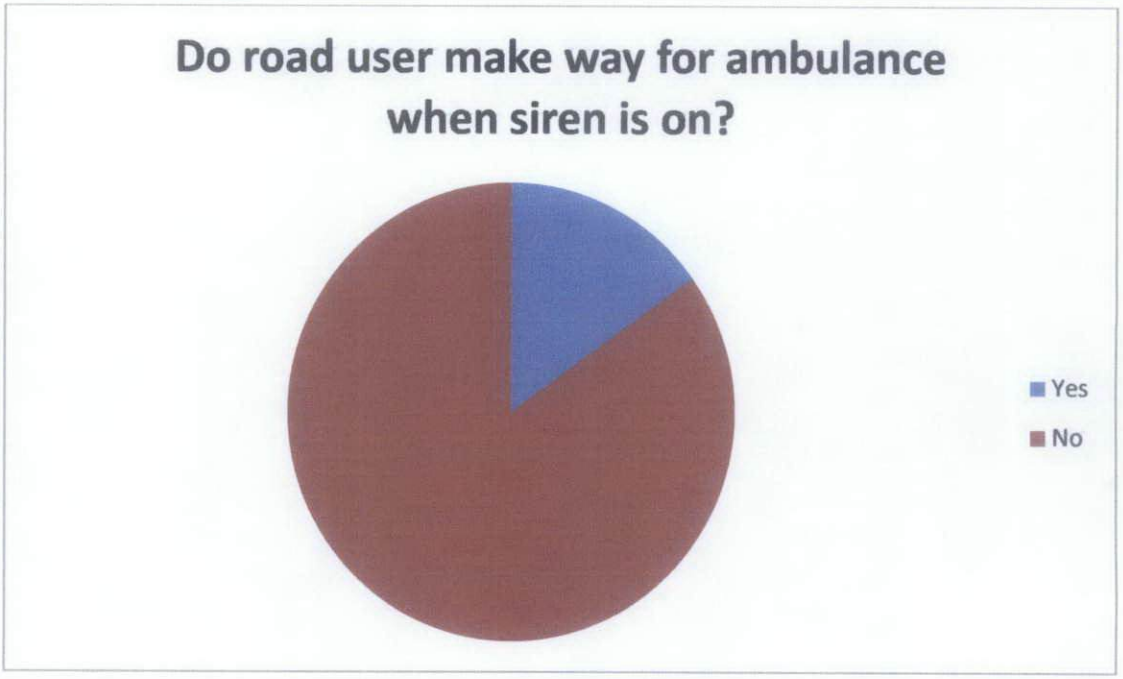

Figure 4.1 – Survey response 1

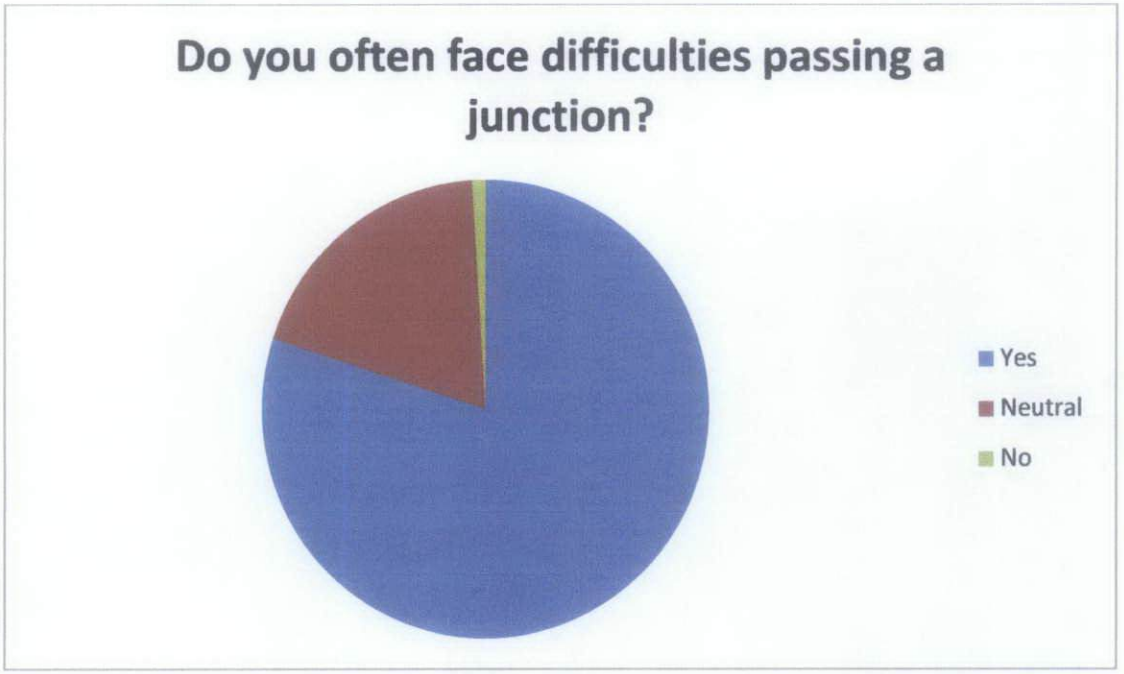

Figure 4.2 – Survey response 2

Figure 4.3 – Survey response 3

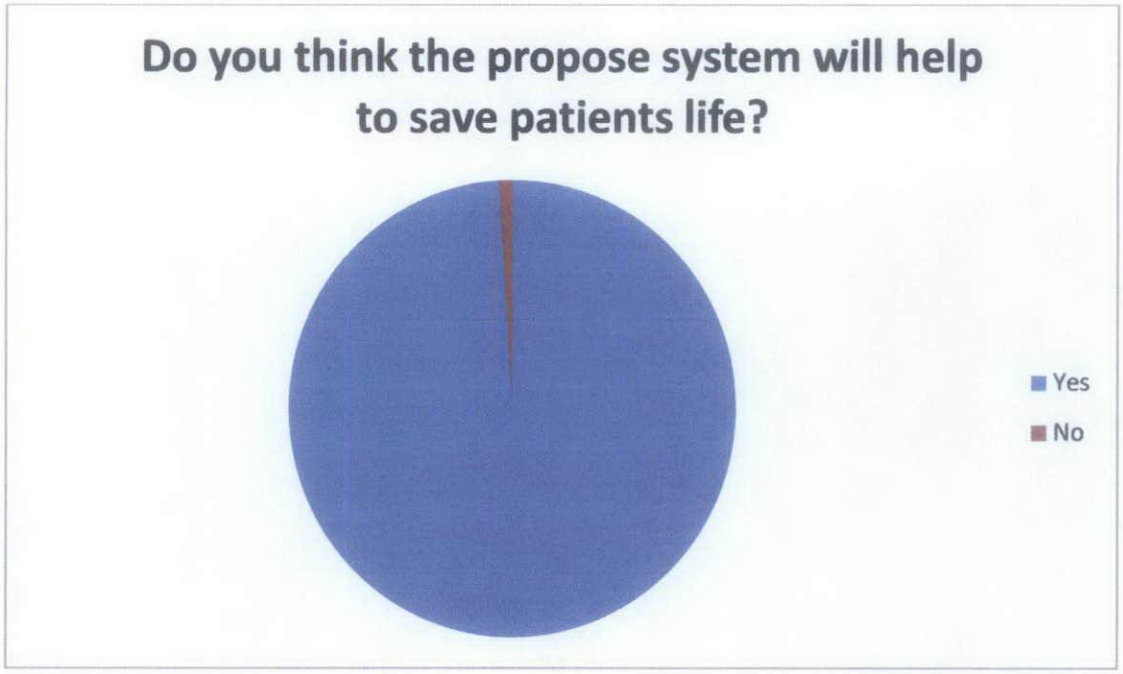

Figure 4.4 – Survey response 4

80% of ambulance driver agreed that they face difficulties in passing through junction especially when their ambulance is located at far back on the path which is red light. There are two reason why the front most car doesn't make way so that ambulance could pass through is because they don't actually know the location of the ambulance and they are scared that the will collide with other vehicles moving on other direction.

89% of the respondent also would like to have a system that would be able for them to control the traffic as it would make them travel faster. They also prefer if the system could navigate their ambulance to the final destination as some patient location are not familiar to them.

Majority of the drivers which constitutes to 99% agree that by having a system that could reduce their travel time would be able to increase the chances to save a patient's life. Though some of them are skeptical of the system as they believe that what will be will be. As per their experience, though traffic was clear there were still cases where patients were unable to be saved before they reach the hospital.

4.2 System Architecture

The following figure would explain the architecture.

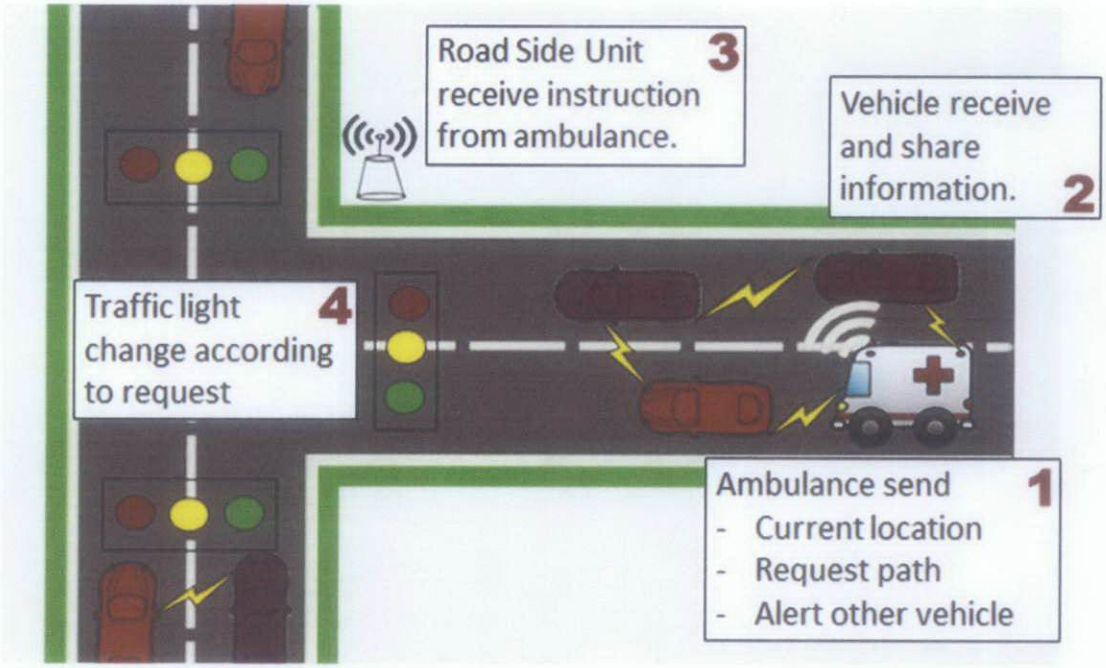

Figure 4.5 – System Architecture

1. Ambulance will first establish communication with the road side unit as the android system on the ambulance is connected with RSU. Ambulance will send a RREQ message and RSU will reply with a RREP message for a handshake to establish. Ambulance will then report its current location from the traffic light, and also input its intended path.
2. Besides for multihop purpose, vehicles will also receive the alert message broadcast by the ambulance.
3. RSU will then translate the request from ambulance to act according to current traffic condition.
4. Traffic light would then change in favor of the request from the ambulance.

4.3 Prototype

Mobile node application is developed for Android based smart phone as the SDK is readily available besides its open source. The mobile node app was developed using Java language on Eclipse platform. The app will be able to connect to the road side unit, update its current location and request its intended path. This app was later run on a Android Emulator which resemble a real Android based smart phone.

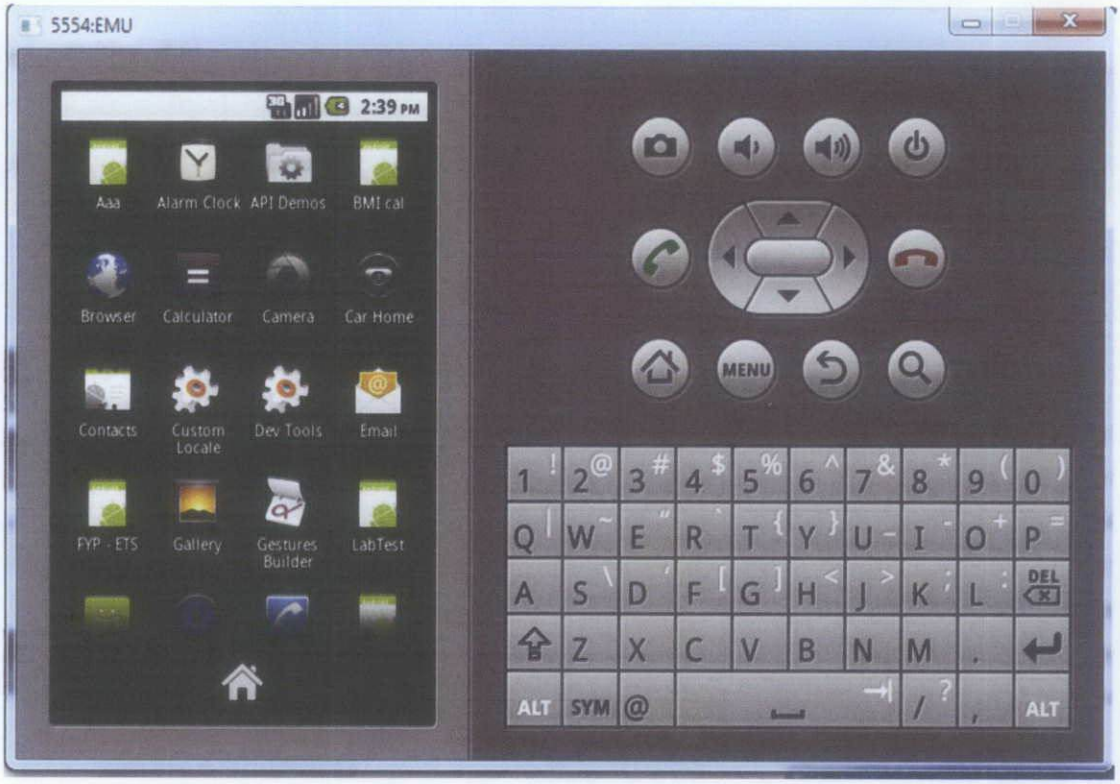

Figure 4.6 – Android main menu

Figure 4.7 – Application interface

The press button will connect the smart phone to a road side network. The current location of the ambulance should be input. This location is where there are from the traffic light as shown in figure 4.10.

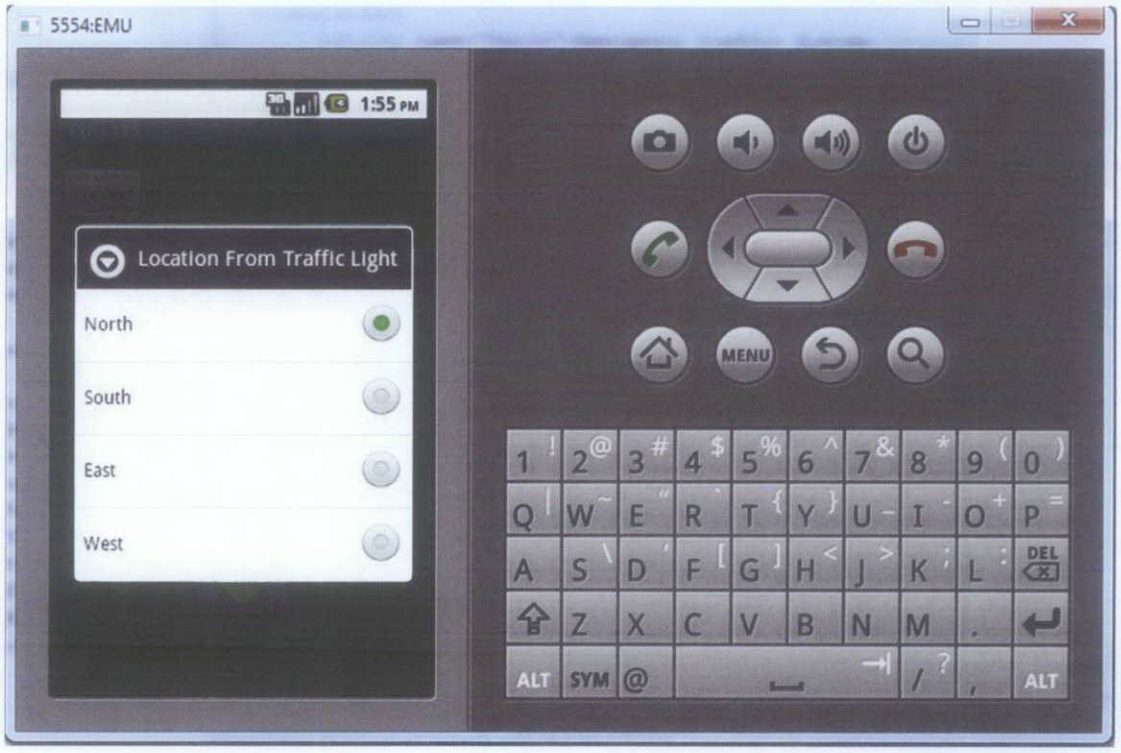

Figure 4.8 – Location from traffic light

User than should press the path they intended to travel on represented by the green button on Figure 4.11. This will trigger the traffic light to react according to their request. The architecture is simplified in figure 4.11.

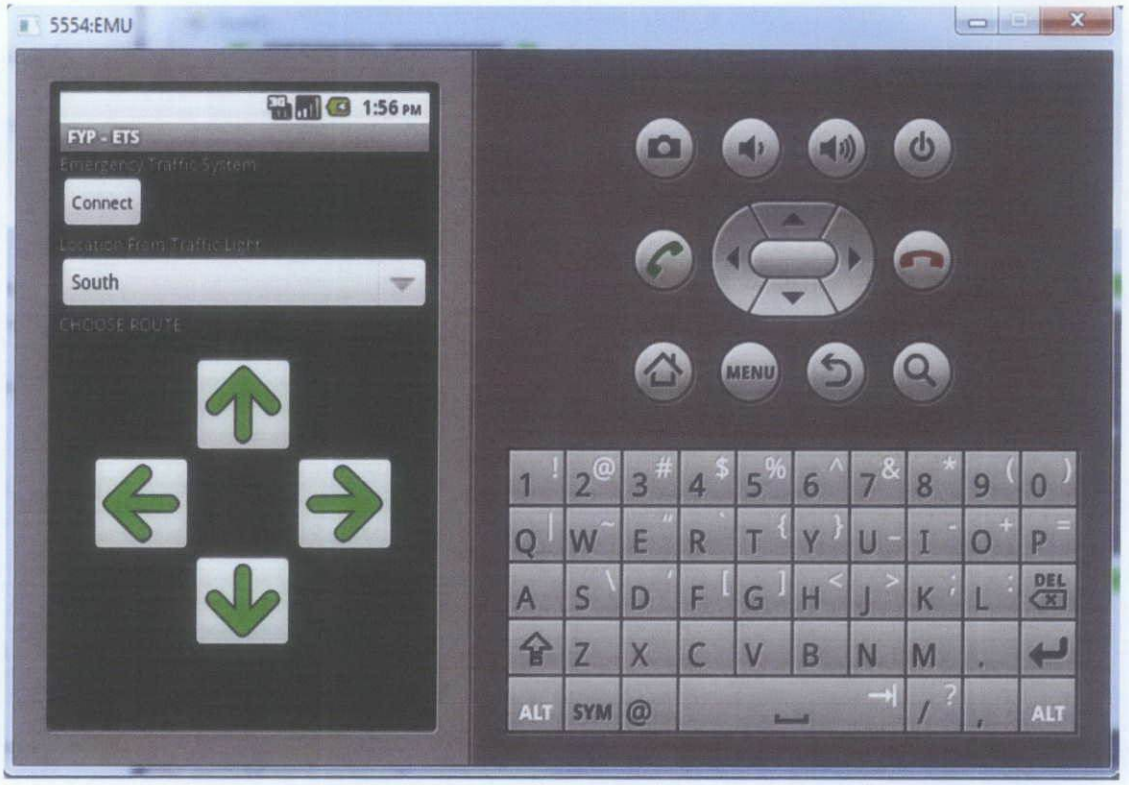

Figure 4.9 – Path selection

4.4 Traffic simulation

Three ways junction road model was developed using visual basic. The simulation resembles a normal traffic light cycle with only one traffic light will be green per time while the rest were red. The simulator is able to react upon receiving instruction from the mobile node. The mobile node will update its current location and the path it intends to take, and the simulator will then change accordingly to allow the emergency vehicle to past. By using timer for the traffic light, once the message is received, the path intended by the emergency vehicle is t+10s. The traffic light than will reconfigure itself to form a normal cycle where each lane will get its turn to be green. Figure 4.10 shows the rudimentary traffic light simulation developed. This communication is established through ad hoc network connected between the two

nodes. This two nodes than communicate using socket programming. This cycle is further explained in figure 4.12.

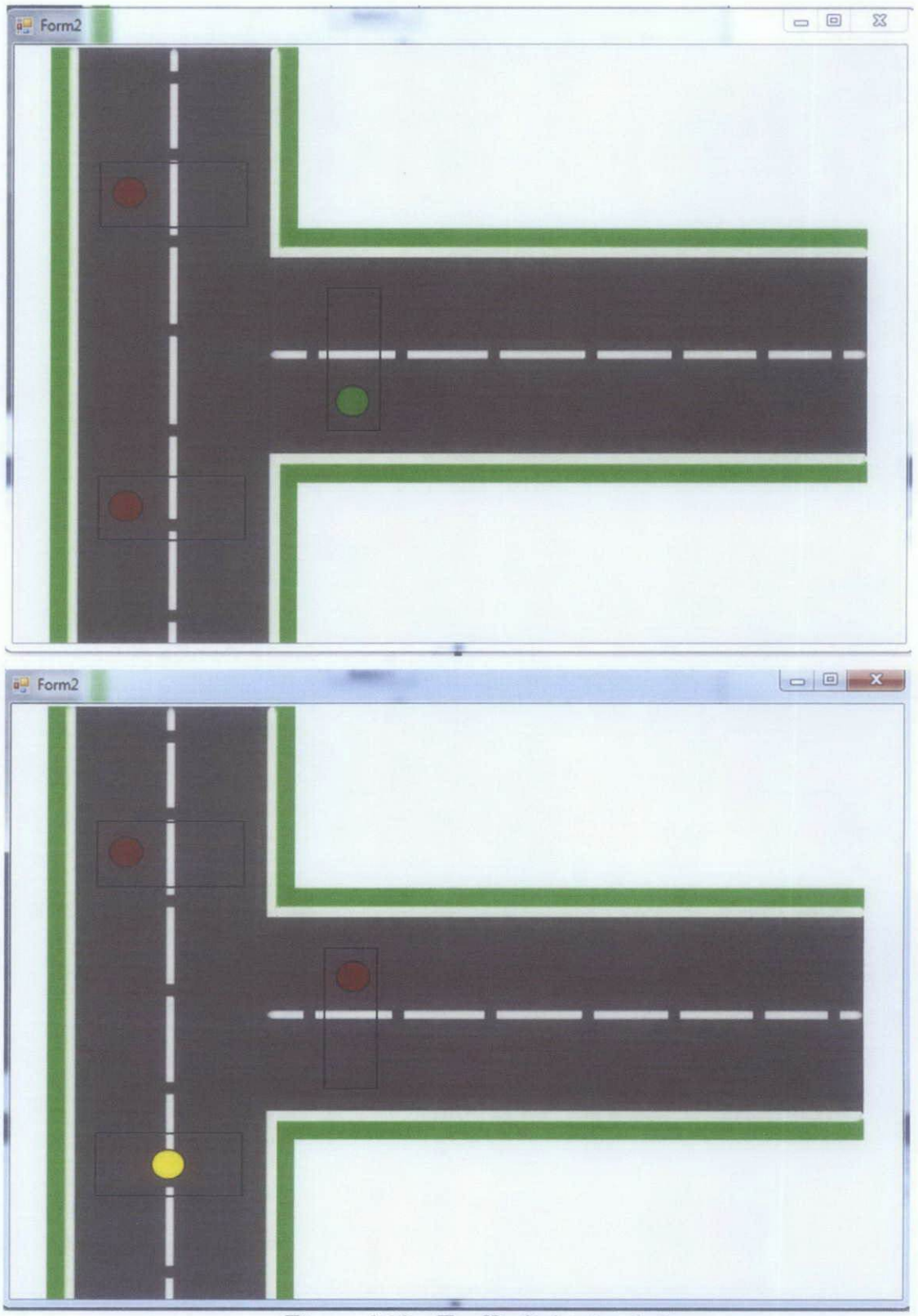

Figure 4.10 – Traffic light simulation

4.5 System Algorithm

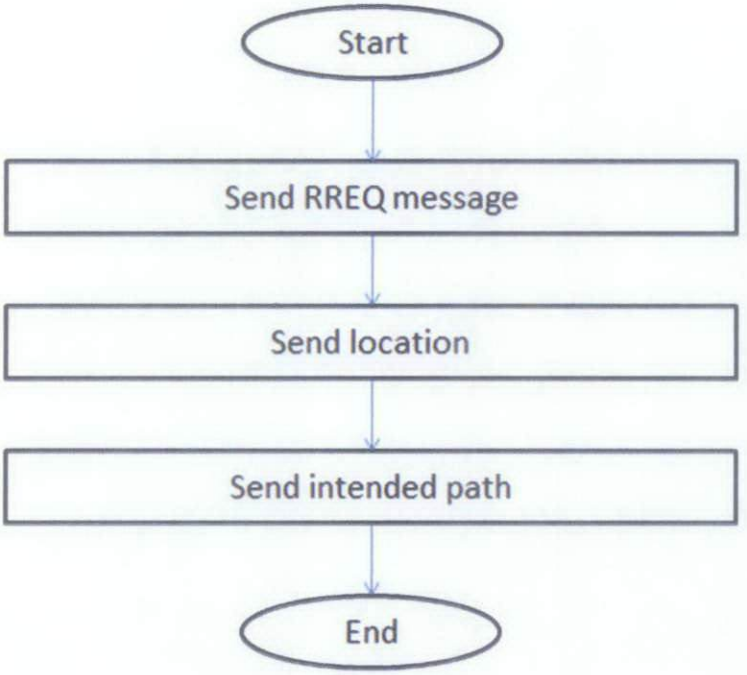

Figure 4.11 – Mobile node flowchart

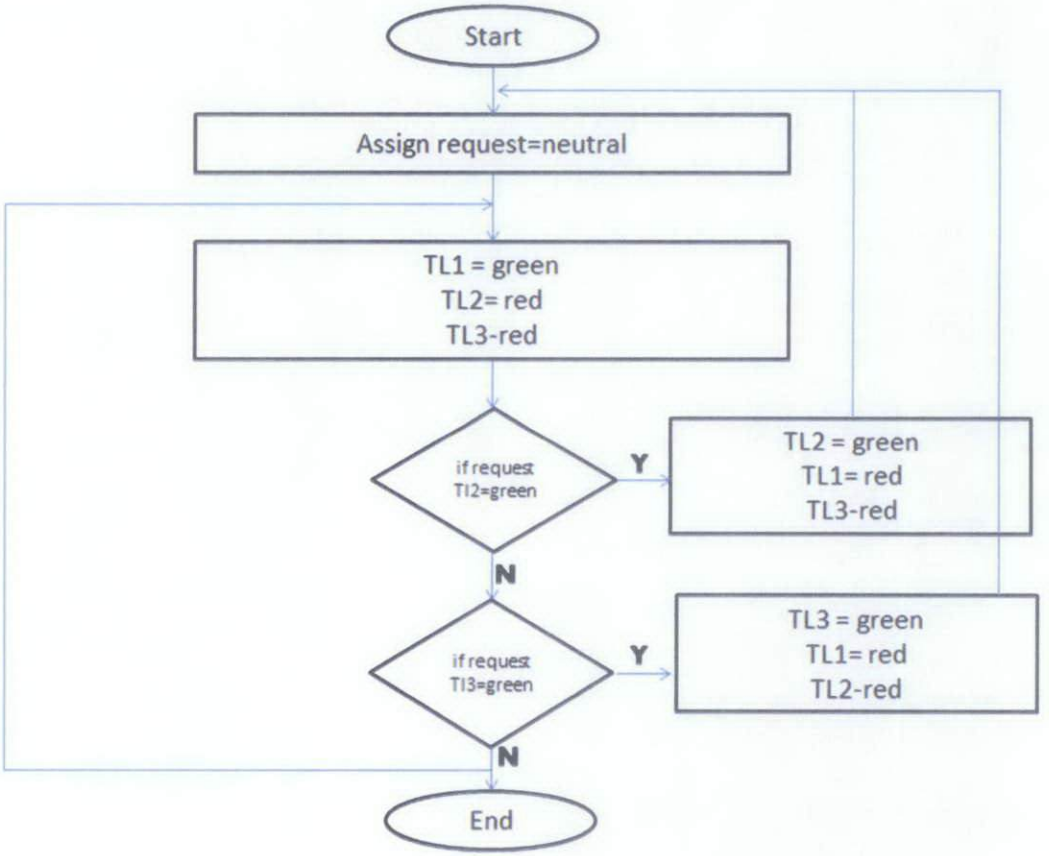

Figure 4.12 – Traffic light flowchart

4.6 User Acceptance Test

The objective of conduction the user acceptance test is to measure the system usefulness. 20 people were selected to act as potential user to test the system. After testing the system, they were asked to complete a feedback form with following questions:

1. I understand the purpose of the mobile application
2. It is difficult for me to perform a desired action
3. The mobile application is hard to learn
4. I think the system is confusing
5. The system able to achieve my objective
6. The system behaves differently from my expectation
7. I think I need the system manual
8. I find the system helpful

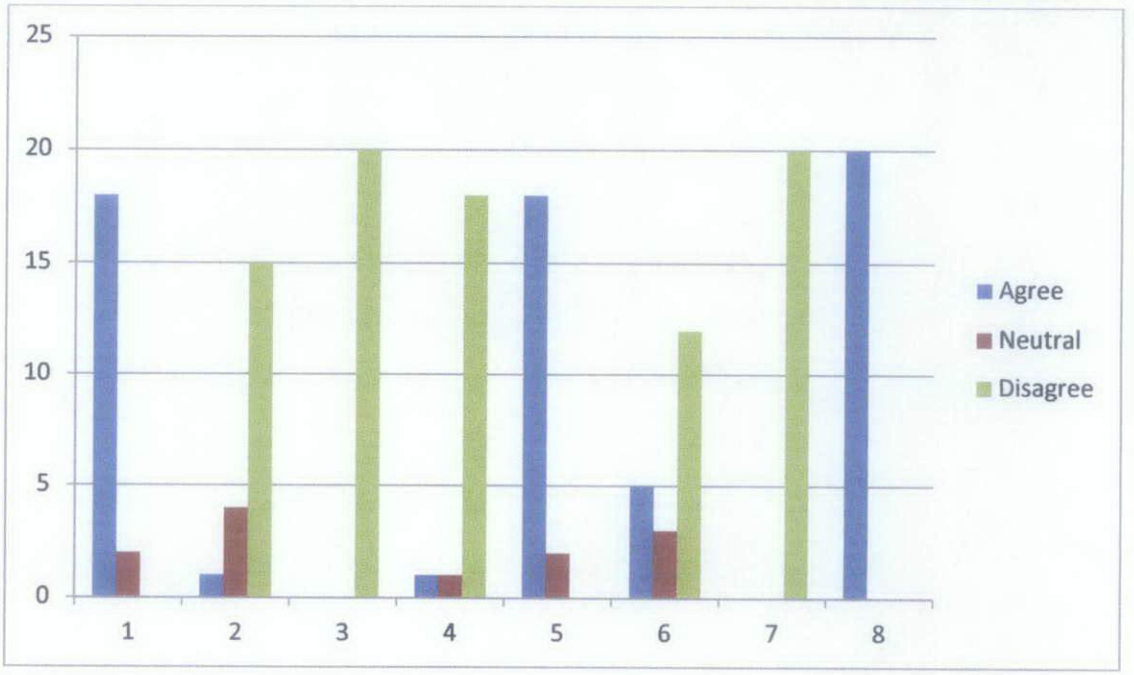

Figure 4.13 – UAT result

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The Emergency Traffic System has proved that it is possible to establish ad hoc network via AODV routing protocol between two nodes where one of it is a moving mobile node. This system has also managed to simulate traffic condition for a three way junction when input is given by the mobile node. This system is worth to be implemented in real life as it would be able to reduce time taken by ambulance to travel between hospital and its destination. This translates into increasing chances of saving a patient's life. Finally with this project, it would make way for further opportunities of developing ad hoc based application.

5.2 Recommendation

There are many ways that this system could be improved into making a better product. Google API could be used in developing the mobile application so that the system could capture the current location of the ambulance, and advice the driver on the route it will be taking to its final destination. The system should be able to advice the driver on the current road traffic condition, updated by road side unit and the system will finally advice the driver on the best route to get to its final destination avoiding the traffic. This are among many potential improvement that could be done to this system as it behold the future of intelligent vehicle.

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