Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF PET HEALTH MONITORING COLLAR WITH GPS TRACKER USING LoRa

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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**A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology (Telecommunications) with Honours**

Faculty of Electrical and Electronic Engineering Technology

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2021

DECLARATION

I declare that this project report entitled "**DEVELOPMENT OF PET HEALTH MONITORING COLLAR WITH GPS TRACKER USING LoRa** " is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

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Date : 11/1/2022

....

DEDICATION

This project is dedicated to my loved ones and pet owners.

ABSTRACT

Pet owners have been the subject of 60% of the complaints received by the Veterinary Services Department (DVS) during the previous two years. In recent times, many pet owners have failed to grasp the complexities of pet health issues. This includes the missing pet cases that have gone up a lot. The main cause for the rapidly growing number of reported cases is that, pet owners are experiencing financial challenges as a result of high-priced veterinary costs. In spite of this, many pet owners find it difficult to assume responsibility for their pet's safety. This project was created to monitor the health state of pets and to track their movements safely. Aside from that, the goal of this project is to validate this developed health monitoring collar towards animals in order to track their location and health status by using smartphone. This project embedded in a pulse/heart beat and temperature sensor to detect, GPS module to track location, LoRa module as transmission medium to transmit data and Arduino Nano to process the data. The real time monitoring health status and location can be present on the Blynk application which have been installed by the pet owners in their smartphones. As the results, this project has been successfully developed and is fully validated with the real pet. The condition and location of the pet can be freely monitored through the Blynk application by the pet owner. In conclusion, the project will be very helpful for pet owners to monitor health status and to track the current location of the pet in real time.

ABSTRAK

Pemilik haiwan peliharaan merupakan subjek 60% bagi aduan yang diterima oleh Jabatan Perkhidmatan Veterinar (DVS) dalam tempoh dua tahun sebelumnya. Sejak kebelakangan ini, banyak pemilik haiwan kesayangan telah gagal memahami kerumitan masalah kesihatan haiwan kesayangan. Ini termasuk peningkatan kes kehilangan haiwan kesayangan yang semakin teruk. Punca utama peningkatan kes yang dilaporkan adalah bahawa, pemilik haiwan kesayangan mengalami kesusahan dari segi kewangan akibat kos veterinar dengan harga tinggi. Walaupun begitu, ramai pemilik haiwan kesayangan merasa sukar untuk bertanggungjawab terhadap keselamatan haiwan kesayangan mereka. Projek ini dicipta untuk memantau keadaan kesihatan haiwan peliharaan dan untuk mengesan pergerakan mereka dengan selamat. Selain itu, matlamat projek ini adalah untuk mengesahkan kolar pemantauan kesihatan yang dibangunkan ini terhadap haiwan untuk mengesan lokasi dan status kesihatan mereka dengan menggunakan telefon pintar. Sistem ini disertakan dengan pengesan nadi/dengupan jantung dan suhu, modul GPS untuk menjejaki lokasi, modul LoRa sebagai medium untuk menghantar data dan Arduino Nano untuk memproses data. Projek memantau status kesihatan dan lokasi semasa boleh didapati di aplikasi Blynk yang telah dimuat turunkan oleh pemilik haiwan peliharaan di telefon pintar mereka. Hasilnya, projek ini telah berjaya dibangunkan dah disahkan sepenuhnya dengan haiwan peliharaan yang sebenar. Keadaan dan lokasi haiwan peliharaan juga boleh dipantau dengan bebas melalui aplikasiI Blynk oleh pemilik haiwan peliharaan. Kesimpulannya, sistem ini dapat membantu pemilik haiwan kesayangaan unutk memantau status kesihatan and menjejak lokasi semasa.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr Haslinah Binti Mohd Nasir and co-supervisor, En Mohd Faizal Bin Zulkifli for their precious guidance, words of wisdom and patient throughout this project.

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My highest appreciation goes to my parents and family members for their love and prayer during the period of my study. An honourable mention also goes to my friends for all the motivation and understanding.

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CHAPTER 1

INTRODUCTION

This chapter will discuss about the background of the project, problem statement, objectives, scope of the project and the project outline.

1.1 Research Background

According to [1] the cases received by the Malaysian's Veterinary Services Department (DVS), an estimated of 60% of our nation households have a pet particularly cats and dogs. Many pet owners have recently struggled to comprehend pet health problems and their own position in detecting and preventing illness. According to research, many pet owners are not responsible for bringing their pets in for a regular checkup to monitor their health status. A heart rate for animal, for instance, the heart rate of a dog will rise for several causes, including anxiety or stress, as well as physical exertion. This is natural, and it will usually get back to normal heartbeat rate level in a short amount of time. If the abnormally fast heart rhythm persists for an extended period, it may be a sign of a medical problem that necessitates veterinary treatment. There are several diseases that caused by rapid heartbeat rate for animals particularly dogs and cats. Tachycardia [2] is a disease marked by an abnormal heartbeat rate in pets.

Basically, there are two types in of Tachycardia disease which is Superventricular Tachycardia and Ventricular Tachycardia. The differences from these both illnesses are, Superventricular Tachycardia [3] arises from heart illness while Ventricular Tachycardia might be result of heart illness, congenital defects, or other severe conditions. Moreover, other illness that can affect by an abnormal heartbeat rate in pets are dilated cardiomyopathy, drug overdose, gastrointestinal, pancreatitis, depression and etc. On the other hand, abnormal temperature rate also affected a pet's health condition which can cause illness. For instance, low temperature rate in pets particularly cats and dogs can cause Hypothermic disease while high temperature rate cause Hyperthermic disease or depression.

Throughout this research that have been made, shows that not many pet owners are not being concern about their pets' health issues and the illnesses that can affect through heartbeat and temperature rate. In addition, normal regular medical checkup is very expensive. However, technological limitations remain in terms of pet health monitoring with the majority of veterinarians using traditional equipment in their clinics.

This project will be very helpful for the owners to detect their pet's current location and monitor their pet's health status in real-time. This project will apparently reduce the number of animal cases which received Veterinarian Service Department (DVS) that have been increase for past few years in all around the world. Moreover, The GPS tracker in this project will be able to detect the pet's current position, which will be helpful in tracking the location of the pet by the pet owners.

1.2 Problem Statement

Currently the process to monitor pet's health condition are only done in veterinary hospitals or clinics. According to [1] , pet owners are paying out thousands of ringgit to look after their pets. Although only going for normal regular vet consultations, it costs a very expensive bill.

Adoption fee	RM50
Cat litter	RM100
Carrier	RM17
Collar tag	RM9
Scratching post	RM30
Cat toys	RM15
Feeding bowl	RM30
Spay or neuter	RM100
Cat food	RM50
Vet check-up	RM150
Grooming	RM30
Total	**RM561**

Figure 1.1: Estimation cost for pet's vet check-up [1]

On the other hand, the cases of missing pets are increasing gradually while the found cases are remaining on the constant rate[4]. Pet owners were unable to locate or trace their lost pets. This difficulty occurs due to carelessness of pet owner to be aware their pet. Furthermore, vetenarians are recommending microchipping pets to most of the pet owners. Microchipping[5] is a small procedure where a small microchip will be inserted under animal's skin permenantly. This microchip will aid the pet owners to track their pets. There are few side effect arises due to microchipping such as cancer risk, abcesses, microchip migration and hair loss.

By using the advance features of the Internet of Things (IoT), pet owners can keep track and monitor their beloved pets, thus take action when necessary. Therefore, to aid the pet owners to key an eye on their pet's health status and get notified on their location in real time, a pet health monitoring collar with GPS tracker using LoRa is proposed.

1.3 Project Objective

The main purpose for this project are:

1. To study characteristics and functionality of LoRa and Blynk application.
2. To develop mobile based monitoring health system utilizing microcontroller.
3. To validate the developed project towards animals.

1.4 Scope of Research

The scope of this project focuses mainly on using microcontroller and LoRa to communicate with GPS tracker, WiFi module, pulse/heartbeat rate sensor, temperature sensor and smartphone application which is Blynk application to alert the pet owners their pet's current health status in real time. The presence of GPS tracker and LoRa module will be able to detect the current location of the animal in long range. The detected location will be sent to owner's smartphone application. Moreover, the pulse/heartbeat rate sensor in this project will sensor the heartbeat rate while the temperature sensor will detect the temperature of the animal. Blynk application is used to received notification from the microcontroller. Last but not the least, this project is dedicated to every pet lover. The performance of the project is analyzed by observing the health condition and location detection in a range of distance.

1.5 Project Outline

This report consists of five chapters that are discussed about the implementation of this project, "Development of Pet Health monitoring collar with GPS tracker using LoRa". According on the objective which have been previously presented and, on the approach, proposed before, this project is made up of five (5) chapters, which contents are summarized as follows:

- Chapter 1 introduces about the background of the pet health monitoring system and GPS tracker using LoRa. A problem statement is stated, and objectives are listed to set as a benchmark to be achieved to solve the problems. Finally, in this chapter it covers the scope of research and the outlines of this project.

- Chapter 2 consist of literature review. In this section, inserted discussion about the related research done by researchers based on the project implementation and functionality. A comparison between the projects is done to discover the main idea, theory and provide a broad view of the essence of implementation which will be satisfactory for this project.

- Chapter 3 consists of the methodology used to execute in this project. The methodology is done by taking certain steps to develop this project while obeying the objectives stated. Moreover, a flowchart is designed to illustrate the whole function of this project system.

- Chapter 4 are included the details of results obtained from the performance of this project. Furthermore, the discussion on the analysis based on this project results and findings is being concluded clearly in this chapter.

- Chapter 5, basically concludes and summarizes the main ideas and states whether the project output has achieved the main objectives that have been list out previously. Lastly, in this chapter there will be a section which gives suggestions on further improvement for this project in future with upcoming technology.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss the important information and details which are found by several study and research from related previous study. Therefore, the discussion begins with the study of smart animal health monitoring and GPS tracker concepts. It is important to research on these concepts because they are the main objective of this project. Furthermore, as this project involve the LoRa technology, it is vital to study the concepts of the technology to have a clear vision of the scope. In summary, this chapter end with the comparison of the related previous projects and the type of the implementation that will be fit in this project.

2.2 Concept of Smart Animal Health Monitoring

In general, smart refers to technology that is sensor-based, data-driven and more programmable. Moreover, it is also involving artificial intelligence. Animal health monitoring is a method where traditional medical scaling is incorporated with innovative technologies. Animal health monitoring benefit in several ways such as monitoring heartbeat rate, temperature rate, respiratory rate and also helps to get faster medical treatment at nearby veterinary clinic or hospital. Furthermore, it will also useful device for pet lovers to monitoring their pet's health status in real time. Heartbeat rate and temperature of an animal are the main important to identify the current health status. It is much simpler if we create an flexible wearable to automatically detect and perform all these tasks [6]. According to that, this technology has done many changes in the pet health monitoring sector such as:

1. Real-time monitoring system
2. GPS tracking
3. Data from sensor will be transfer to mobile application by using LoRa

According to [7], smart animal health monitoring concept consist of smart devices that are connected sensors that are able to monitor an animal health condition in real-time. With that, smart devices are components that are built in with sensors and intelligence to perform autonomous tasks. Moreover, the sensors will be seen to take part in the control system that will be aid to monitor animal’s health analysis. This show it is capable to detect current health status of an animal.

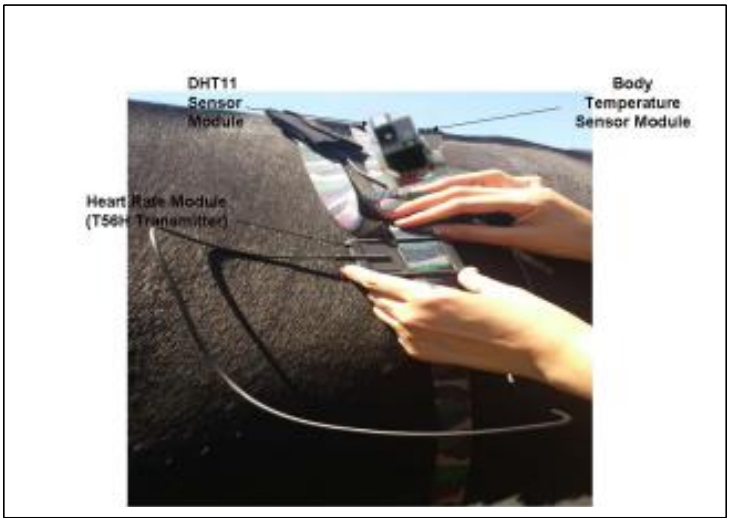


Figure 2.1: The setup of all sensors around the animal body [7]

Y.N.Malek stated that the idea of developing a device of detecting the temperature and be able to transmit the reading to the receiver[8]. Lately, the Internet of Thing (IoT) has widened its scope of accuracy to be used in the pet health monitoring device by adding smart sensors and technologies with low power consumption that are already present in other fields. For instance, this technology has been used widely on home automation, medical field and industrial. This is considered as Smart Health Monitoring which includes, data processing, data collecting and analysis. Data processing can be done through the implementation of IoT frame to assist veterinarian in their field for better actions. Royal Society for the Prevention of Cruelty to Animals (RSPCA) mentioned that a real-time data processing that be develop by using the aid of IoT [9]. This also have been proven by implementing it in collecting healthcare results such as breathing rate, oxygen level and also heartbeat rate. The implementation in this field enables the process of monitoring to be less difficult, reduce the cost and thus could be treated in less time.

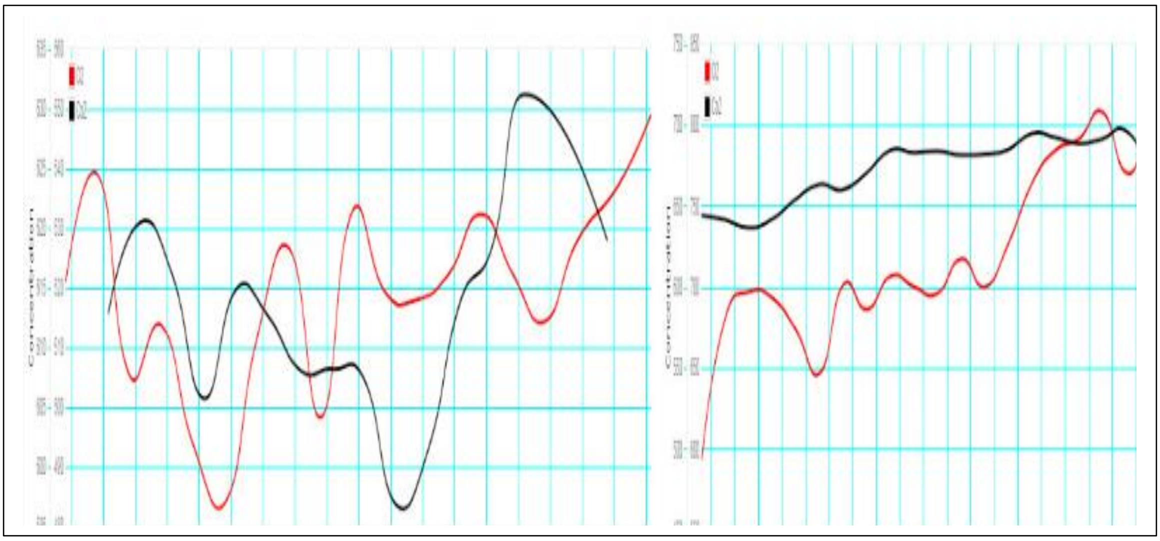


Figure 2.2: Display data for oxygen and carbon dioxide concentration [9]

The usage of a collar for pets especially cats and dogs, has been an identification tag for their safety and protection purpose. Collars were used as protection, identification and restraint pets like cats and dogs [10]. Now, the transition changes to automated and data-centered management. This new evolution is possible to be developed by implementing fundamental technologies such as the Internet of Things and GSM module [11]. Table 2.1 below shows in detail about the fundamental technologies in aiding technologies in smart health monitoring for pets.

Table 2.1: Fundamental Technologies of Smart Health Monitoring.

Internet of Things (IoT)	Microcontroller	Compressed microcomputer that present in a single integrated circuit. It is enhanced to control electronic devices. This small device consists of memory, input-output pins, microprocessor on a single printed circuit board. This device normally used in industrial application and embedded with other devices to provide control and interfacing. Raspberry Pi and Arduino are one of the instances of microcontrollers.

	Micro sensors	Small device that can be able to measure multiple aspects. Therefore, some of this devices operates also on a nanoscale. For instances, sensors that measure heartbeat rate that gives output in digital format. The data that was previously unapproachable can be now measured and analyzed, such as the oxygen level in blood.
	Networking Technology	The desired output from the sensor must be sent over a network for analysis and processing. The networking technologies have considerably and range while reducing cost and power consumption.
	LoRa	It is a chirp spread spectrum (CSS)-based spread spectrum modulation approach. LoRa is a low-power wide-area network modulation method developed by LoRa Alliance. Low power, low cost, and dependable performance make LoRa Technology ideal for crucial smart healthcare applications.
GPS	GPS tracking unit	It is a technology that will be used for the process tracking any object. It has three separate data sets which is known as timing, navigation and positioning. GPS is used in a variety of operations, including military, first responder, commercial, and personal applications.

As the emergent population worldwide, it is necessary to improvise the development of health monitoring system especially for animals to the next level. Smart health monitoring for pets has all the chances to be implemented with the aid of fundamental technologies such as Internet of Things(IoT) and GPS trackers. This implementation requires less human involvement and capable of monitoring the current health status for our beloved pets from all aspects.

2.3 Concept of GPS Tracking

GPS also known as Global Positioning system have been developed by US Air Force for military operations purposes [12]. GPS has a tremendous influence on all location, navigation, and monitoring applications throughout the world, and it has expanded to the point that it is employed in practically every area of our lives during the last few decades. GPS satellites consistently transmit their position and time, and each satellite has a powerful atomic clock for timing estimations. Tracking systems calculate the distance and time it takes for GPS signals from satellites to reach the Earth. As GPS technology is advancing, numerous industries have begun to use the improved tools that it has brought to the market. Tracking devices are now utilized for a variety of reasons, the most common of which is to track people, vehicles, and assets. For instances, GPS have been implemented in healthcare to monitor current patient location status in real time [12]. The tracked data will be sent to the mobile application.

T. Ab and B. Televilt, stated that with the improvised technology, GPS tracking system can detect the location of the animal in real time [13]. This will allow to reduce the time consumption and also easily to give immediate healthcare if emergency happen. Apart from that, developing the system cost very reasonable and cheap. GSM module have been also used in this project for the transmission of data to the receiver. Due to these extended technologies, a smart GPS tracking system for animal is designed to detect the location of the animal in real time at anywhere. This project focuses instead on the tracking of an animal to protect and give healthcare at time.

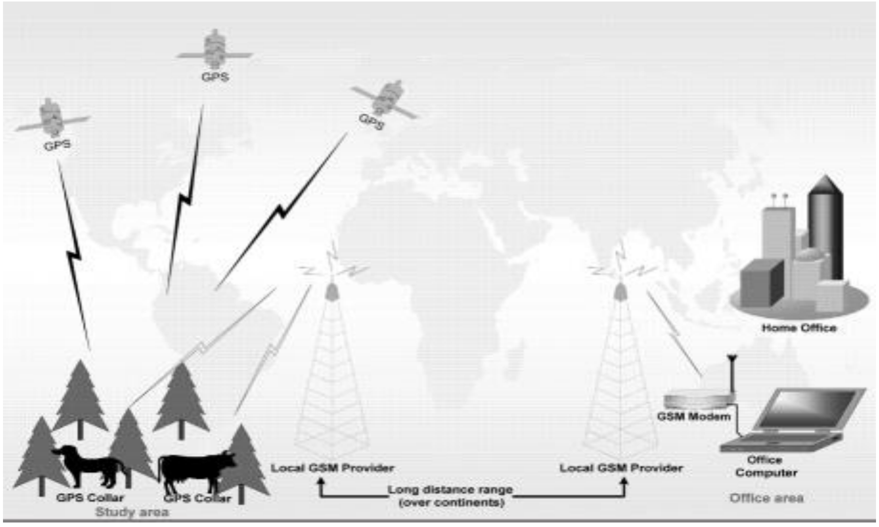


Figure 2.3: GPS Collar use GSM module for data transmission [13]

2.4 Internet of Things (IoT)

According to Big Data Insight, the term Internet of Things was established by Kevin Ashton, who was a member of the team that discovered RFID tag to apply as a communication link to connect objects to the Internet [14]. The term was first used in 1999 and since then, it has been expanding rapidly in a multitude of sectors all around the world. Kevin Ashton has also said that Internet of Things is in comparison to what the Internet has done for the world, it is conceivable to make bigger improvements. Apart from that [15] defined IoT as a network that consist of physical, technological and broad socioeconomic environments. Each of the structures is recorded in the table 2.2 below.

Table 2.2: Structures of IoT [15]

Physical	Environment	Environment is a place where both humans and entity interact with each other. For instances, in hotel room lights and fans that is installed with an RFID reader.

	Individual/ Person	Anyone with a wireless device or anyone that can handle and operate wireless object, such as a smartphone or laptop, can connect to the Internet of Things (IoT).
	Device/Objects	Cars and packages are forms of physical things that connect to the network using any wireless device.
Technological	Networking	Wireless networks are frequently used to link devices and share data. Wireless networks are frequently used to link devices and share data.
	Hardware	Wireless devices such as home automation, smartphones and RFID tags that are used to connect humans and objects to IoT for communication via a wireless medium.
	Software	End-user IoT applications that are built to make

		improvements to utilities and execute output.
	Integrated platforms	A cloud-based platform that makes it possible for hardware, software, and networks to operate together seamlessly.
	Standards	Technical and operational guidelines that guide IoT design and enable smooth internal operations.
	Data	Streams of data produced by IoT devices can be taken and evaluated in real-time and provide better decision-making.
Socioeconomic environments	Entrepreneur	Entrepreneurs who put their technological skills to good use possesses a desire for self-improvement and knowledge and your contribution contributes to the advancement of the Internet of Things. They are more likely to use IoT for entrepreneurship and intrapreneurship.
	Customers	People who are targeted by specialized Smart devices. For instance, an

		IoT security system that monitors for theft or burglary.
	Legislative organizations	Bodies that enforce rules and regulations related to IoT. For example, RFID needs to obey the rules of the Federal Communication Commission (FCC) for near-field communication.
	Associated industries	Industry associations could make a change in the way IoT technologies and applications are established. Their aim is to outline standards for autoidentification technologies such as barcodes.

K. Shafique, B. A. Khawaja, F. Sabir, S. Qazi, and M. Mustaqim, state that, Internet of Things (IoT) is referred to like devices and sensors that are intellectual, addressable exceptionally depending on their communication conventions and independent and adaptable with essential security [16]**.** It has also classified IoT in three visions:

I. Thing oriented: a vision that gives attention to representation, storage and organization of information.

II. Knowledge oriented: a vision that gives attention to representation, storage and organization of information.

III. Internet oriented: a vision that gives attention to the connectivity between devices.

Internet of Things (IoT) gives offer a wider of commercial prospects, allowing organizations to develop new business techniques and models to implement the notion. In addition to innovative research opportunities, researchers and investigators from a spectrum of perspectives will have the ability to engage about IoT. As a result, IoT encompasses engineering skills, science, business studies, and humanities. The Internet of Things also makes the world a smarter place, where everything is widely obtainable in less time and with less energy.

Figure 2.4: Internet of Things (IoT) based smart appliances

In a nutshell, the Internet of Things comprises different types of hardware and software that are connected to the Internet to perform its dedicated purpose. By considering the challenges that will be faded, it is important to design a project with proper planning to achieve the objectives of the project.

2.5 LoRa

According to S. Devalal and A. Karthikeyan, states that LoRa is an emerging technology that is emerging rapidly. LoRa technology meets these needs for battery-powered embedded devices [17]. LoRa technology is a remote energy efficient technology. This article looks at the advantages of LoRa over existing technologies used on the Internet of Things. It also discusses the characteristics of LoRa. LoRaWAN (Remote Wide Area Network) is an open-level security standard for IoT connections. Embedded systems have become integrated in our daily lives. People may now operate, monitor, and do a variety of tasks from afar. This is accomplished by minimizing physical distance between distinct things by linking them. The Internet of Things (IoT) is the networked interconnection of numerous devices. These devices are frequently battery-powered and require a large battery backup. Thus, LoRa have been introduced as a development that cover long range communication.

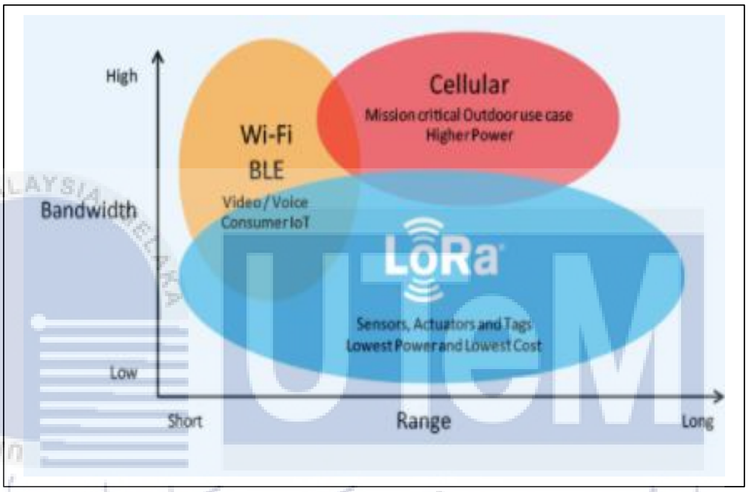


Figure 2.5: LoRa Technology Overview

Apart from that, R.S. Sinha, Y. Wei, and S. H. Hwang, has made a research and survey on LoRa technology. In this paper, the authors have listed down all the characteristic of LoRa technology which is in terms of quality of service (QoS), battery life and latency, network coverage and range, deployment model and cost [18]. Each of the configurations is recorded in the table 2.3 below.

Table 2.3 The Characteristic and Explanation of LoRa

Characteristic	Explanation
Quality of service (QoS)	LoRa is an asynchronous protocol that utilizes unlicensed bandwidth. Although LoRa based on CSS modulation can manage interference,

	multipath, and fading, it cannot deliver the same quality of service as NB-IoT. It depend on the application that does not need the aid of QoS then LoRa will be the best choice.
Battery life and latency	In LoRaWAN, the device can sleep or sleep according to the needs of the application, because it is an asynchronous protocol based on ALOHA. For applications that are not delay sensitive and do not have a lot of data to send, LoRa is the best choice.
Network coverage and range	Main plus point for LoRa usage is, it can be used on one gateway or base station. Plus, its system is much flexible. It also has wider coverage.
Deployment model	The LoRa components and LoRaWAN system are advanced and ready for production, but the national deployment is still in the deployment stage.
Cost	Different cost aspects need to be considered, such as spectrum cost, network cost, equipment cost and implementation cost. Throughout the observation, it clearly shows that LoRa is much more reasonable which comes with several advantages in many terms.

In summary, The LoRa Alliance mainly focuses on the development of standardized technologies and the advancement of technical solutions. LoRa has its own advantages and disadvantages, which must be considered when applying the right technology to the right application. LoRa focuses on low-cost applications with low power consumption.

J. Petäjäjärvi, K. Mikhaylov, M. Pettissalo, J. Janhunen, and J. Iinatti, has stated in the paper that, Low Power Wide Area Networks (LPWAN) represent a new trend in the evolution of communications designed to support a wide range of Internet of Things (IoT) applications [19]. Unlike existing perspective communication technologies (eg 4th generation (4G) or 5th generation (5G)), the high data rate of each device is not considered the most important design element of LPWAN. Instead, the data transfer rate of LPWAN is intentionally suppressed to be low, resulting in longer communication distances. Another important design criterion for LPWANs is energy efficiency. This is because many end devices are expected to be powered by batteries or energy harvesting.

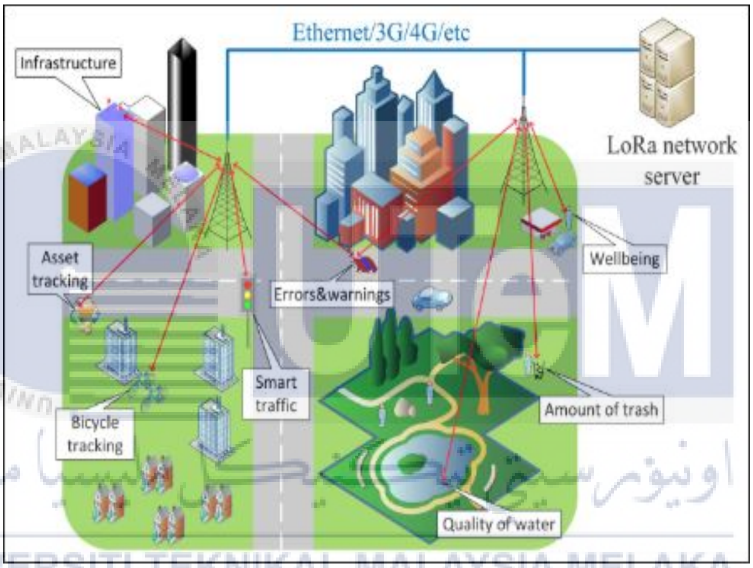


Figure 2.6: Future IoT application that monitored with LoRa

In summary, The LoRa Alliance mainly focuses on the development of standardized technologies and the advancement of technical solutions. LoRa has its own advantages and disadvantages, which must be considered when applying the right technology to the right application. LoRa focuses on low-cost applications with low power consumption.

2.6 Previous Related Projects

To have a good considerate of the project, the study of previous related projects that are mainly focused on health monitoring system via wirelessly is important so that fundamental bits of knowledge is gained to achieve the objectives of this project. This IoT project comprises of smart health monitoring system for the pets. Therefore, this section will be discussing five previous project that apply comparatively similar method and have a similar purpose to achieve this project's main objective.

2.6.1 Wearable Smart Health Monitoring

In the project done by S. Kumari and S. Kumar Yadav, has made a clear vision on various method to monitoring health status [20]. The authors have implemented various sensors to be applied to monitor the current health status of an animal. Basically, in this project sensors that have been used such as temperature, respiratory rate, heart rate and humidity rate. Raspberry Pi is main devices that control this project which comes in together with the built in WiFi module. The authors also created a cloud so that the sensor data can transmitted. The author used android mobile application system to collect the transmitted animal's health status in real time. This project will be very helpful for the person who is charged to be aware of the animal health status and give immediate healthcare.

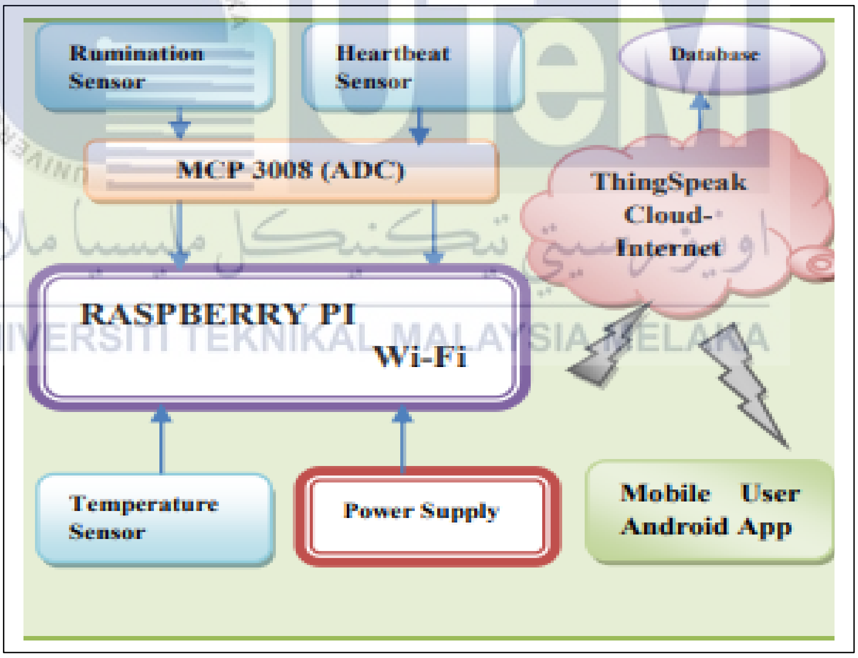


Figure 2.7: Block diagram of animal health monitoring system[20]

2.6.2 IoT-based Health Monitoring

According to V. Akhila, Y. Vasavi, K. Nissie, and P. V. Rao, applying the technology of IoT and the micro sensors can help to monitor an individual's health condition in real time [21]. In this project, the author implemented the same method to a system to monitor a human's current health status. An Internet of Things (IoT) based project that have been used Arduino Uno to collect the digital data that obtained from the micro sensors. The combination of IoT and Arduino Uno in the healthcare sector help to monitor and collect current patient's health status data.

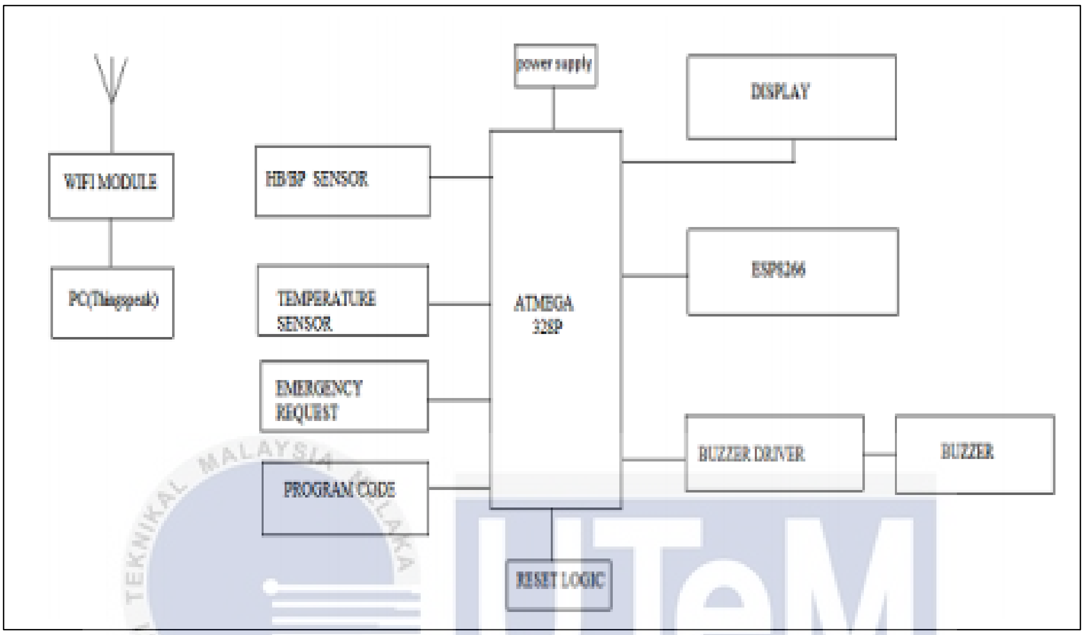


Figure 2.8: IoT based health monitoring system using Arduino [21].

In Figure 2.8, Arduino UNO is used for sensor nodes and gateway. The connection between the doctors and their patients are connected by GSM module. The communication between the nodes in a particular distance is done by GSM. Besides, the communication between these two individuals' mobile location via GSM network. WiFi module is used to access sensor data from the transmitter to the receiver using android mobile application and as connectivity the nodes to clouds in the wireless network.

Arduino UNO is equipped with ATMEGA 328p microcontroller and it is places inside the sensor nodes. Temperature readings, heartbeat readings and blood pressure rate are done by the microcontroller and its sensor. There are two types of sensor are including to the Arduino UNO, which are temperature sensor and HP/BP sensor which is used to measure patient's health condition in real time.

Arduino accesses the cloud server by connecting to the interface with the ESP8266 Wi-Fi modem and the Internet router. The Arduino is connected with an LM-35 temperature sensor that detects the current temperature and a pulse sensor that reads the pulse rate. The measured pulse rate and body temperature are transmitted to the cloud platform by sending the data displayed on the LCD connected to the Arduino to the Wi-Fi access point. This simple and effective device allows continuous monitoring of the health status of critically ill patients. It can be used to track the health of older people who often have heart and blood pressure problems.

2.6.3 LoRaWAN based Smart Agriculture

S. A. M. Chedaod, A. A. B. Sajak, J. Jaffar, and M. S. M. Kassim, are the author of the designed a prototype of a smart agriculture system architecture that consists of several sensors, surveillance facilities and a base stations that communicates with each other and come up with a decision [22]. The system collects data from GPS module and locate animals, especially livestock. This animal tracking device employs LoRaWAN as the data transmission medium. Connect the GPS module and LoRa device to the ESP32 board to read and send data. Data is sent to the server via LoRa and displayed using the server's LCD display for surveillance purposes.

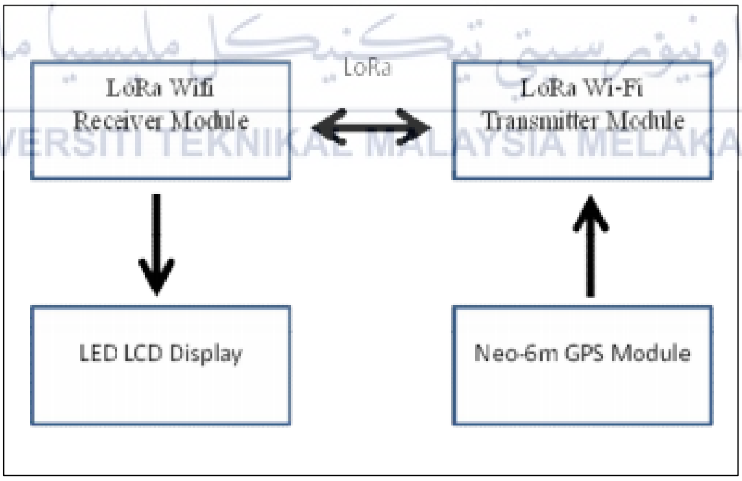


Figure 2.9: Block diagram of the project. [22]

In Figure 2.6 shows, the working prototype project block diagram. The figure shows the required hardware components and the location data being collected from the GPS and transmitted via LoRa to the receiving module and the location data being displayed on the LCD.

2.6.4 Dairy Cows Monitoring System using LoRa

According to S. Benaissa *et al.*,with the development of wireless sensor technology and MEMS, it has become possible to automatically monitor the health of dairy cows using the Internet of Things (IoT) and wireless body area networks [23]. The on-cow measuring device has energy limitations, so the proper characteristics of the external radio channels between the on-cow sensor node and the back-end base station are in the barn, in the optimized placement of these networks. Essential for based on this feature, user can be able to plan their body node network and optimize their energy usage to construct a dependable dairy cow monitoring system.

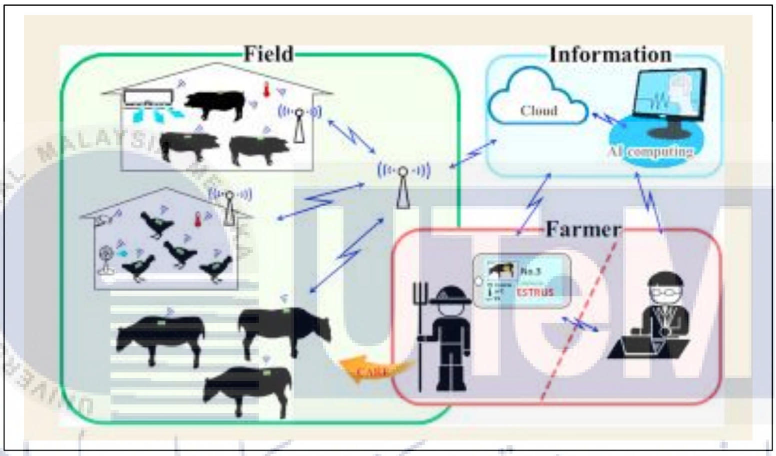


Figure 2.10: Dairy cows monitoring system [23]

2.6.5 Real Time Health Monitoring System.

A. Abdullah, A. Ismael, A. Rashid, A. Abou-Elnour, and M. Tarique, who are the authors that has designed a reliable patient monitoring system that allows Healthcare professionals to monitor patients who are hospitalized or perform activities of daily living [24]. This task proposes a mobile device-based wireless healthcare monitoring project that can provide real-time online information on a patient's physiology. The project is designed to measure and monitor critical physiological data from patients to accurately describe their health and exercise status. In addition, the proposed project can send alert messages about critical health data of patients as text messages or email reports. By using the information contained in text or e-mail messages, healthcare professionals can provide the necessary medical advice. The author has design this project by using several sensors, microcontroller which is Arduino and software which is LabView.

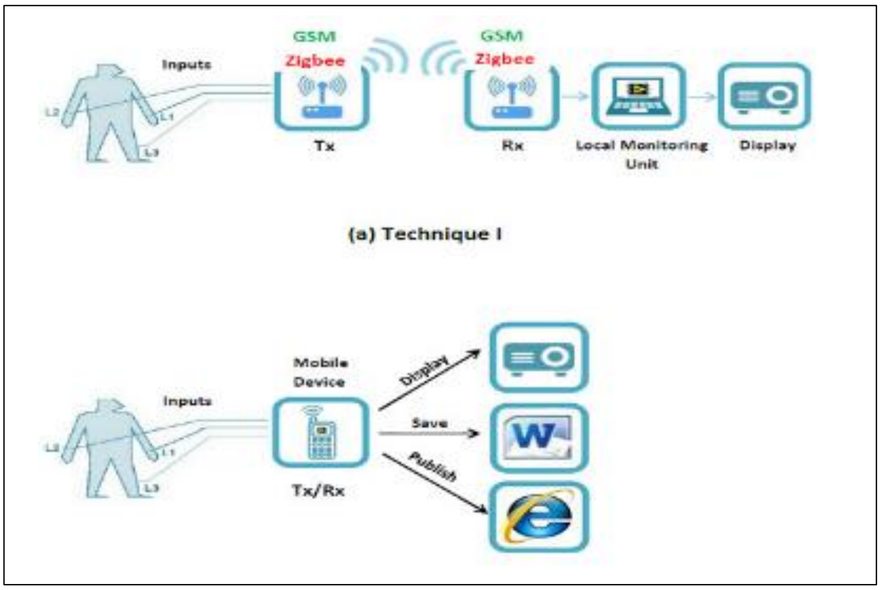


Figure 2.11: Real time monitoring system investing techniques [24]

Figure 2.11 clearly shows, the techniques that have been introduced by the author to operate the project. Basically, there are two techniques have been used in this project. By referring to the part (a) technique it shows the link between the sensors on the patient's body and a transmitter device connected to a ZigBee or GSM network The data is wirelessly sent from the transmitter to a receiver that is likewise connected to a ZigBee or GSM network. The receiver is attached directly to a local monitoring unit's USB port.

Therefore, by referring to the part (b) technique shows the connection between the sensor attached to the patient's body and the mobile device. Mobile devices collect data from sensors and send it to processors running LabVIEW software. The processor receives the data and performs the required analysis. Data can be displayed in an organized GUI (Graphical User Interface). The processor also stores data in worksheets related to Microsoft Excel programs. Finally, it exposes the data to the Internet, allowing healthcare professionals to monitor the data remotely at any time.

2.7 Comparison of previous related projects

Based on the previous research projects that have been discussed, there are some differences can be discussed and compared in terms of the methods used. Therefore, the table below shows the comparison between the research articles in terms of techniques, advantages and disadvantages.

Table 2.4 Comparison of the Previous Related Projects

No	Reference	Method	Advantages	Disadvantages
1.	[20]	This project uses Raspberry Pi which comes with built in WiFi module as a microcontroller in this system, to collect the data from sensors which is temperature, heartbeat rate and rumination. Thus, the collected data will be sent and stored into the Cloud. Meanwhile, the transmitted data will display on owner's mobile application.	-Monitor health in real time -Collect data in android application	-Introduce transmitter box that can display health status.
2.	[21]	It is a IoT based project which uses Arduino UNO is equipped with ATMEGA 328p to collect digital data such as heartbeat rate, temperature and emergency frequency from the transmitter. ESP8266 has been used as the interface to provide WiFi connection for the	-Save cost -user can be alert in anytime	- Can use cloud database to collect the transmit data.

		digital data to be transmitted to receiver which mobile app and display on 16x2 LCD board.		
3.	[22]	LoRa has been used as a transmission medium for collected data from transmitted to be sent to the server. Both GPS module and LoRa module has been connected to the ESP32 to provide an interface to send and receive data. At receiver, LED LCD display is used to display the sent data.	-Low cost -guaranteed notification using LoRa	-Can use buzzer for the message alert.
4.	[23]	Wireless body area network (WBAN) is combined with IoT to keep track on energy status. Transmitter and receiver node has developed for the transmission of the data to take place. Cloud interface has formed as a data storage platform.	-Provides security and also monitoring system -easy to handle and use	-Notify through notification or specific android application to make sure the owner receives data on time.
5.	[24]	A ZigBee network is used as an medium to collect and sent data from sensors to the receiver	-Low cost -Easy to design and use	-Can use LoRa for better transmission range.

		which is attached to the local monitoring unit USB port. The receiver is a mobile application which will process the transmitted data and transmit to the running LabVIEW software.		-Notify through mobile application which makes user be alert all the time on the collected data.

2.8 Summary

Collectively, after a thorough reading and observation done om the previous related projects, it is understandable that the traditional microcontroller brings several disadvantages compared to the Arduino and Raspberry Pi as they are the improvement from the old technology. Hence, it is safe to that Arduino technology is the best and understandable concept that can be implemented in this project due to its practical specifications. The reserach on health monitoring system based project assist in achieving the objectives of the develpment of pet health monitoring collar. As a result, the use of wireless networks in these prior connected projects highlights the pros and cons of each method of communication.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, it presents the method that have been conducted to develop the project, to achieve the objectives. There are three main parts in this chapter, which is known as the study design and elaboration of the process flow and hardware specification. To ensure the flow of the project is constant, detail research on the used hardware was also made to have clear vision and better knowledge regarding the way to handle it and the best model to be use for this project. This chapter is also playing a main role to get an overall view on this project flowchart was created. The process flow is the elaborated in detail and will be followed by the detailing in hardware specifications. Last but not the least, a diagram of the connection of the project is shown and discussed briefly on this chapter.

3.2 Study Design

The aim of this project is to develop a pet health monitoring collar with GPS tracker using LoRa technology for Malaysian pet lover community. Basically, Arduino is used as the brain of this project. The type of Arduino that is used in this project is Arduino Nano. Besides, a pulse rate sensor is used to detect the heartbeat rate of the pet. Then, a temperature sensor is used to detect the temperature of the pet and a GPS tracker have also been inserted into this project to tracker the location of the animal in real time. LoRa module is also used in this project to be able to transmit data in long range. Moreover, WiFi module is used as the receiver to able connect and transmit data to the mobile application. The software that is used in this project is Arduino IDE software to compile and upload the coding in the hardware and Proteus software to construct the operating project virtually.

First, a flowchart tasks of this final year project is shown to validate each of the tasks is taken and implemented with focus and in detail. Furthermore, a flowchart is created to illustrate the process of the procedures that are done to carry in this project.

3.3 Project of process flowchart

3.3.1 Project Implementation Flowchart

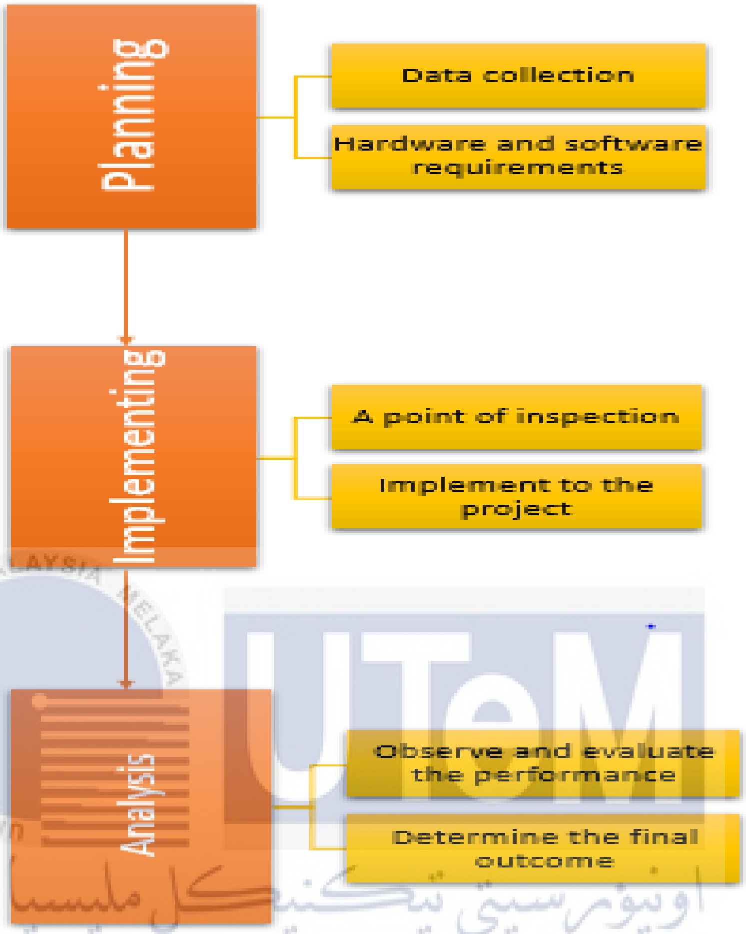


Figure 3.1: Flowchart of this project implementation

By referring to the figure 3.1 above shows, the flowchart of this project implementation. In this part, it will explain the theory part and this part is primary to make sure that the project is done by using information. Mainly, the project implementation have been divided into three process which is the planning, implementing and analysis. Firstly, an observation is performed based on the sources from the literature review. The objectives from the researched literature review assist in planning the problem statement, objectives and methodology to develop this project. Then, researching on the previous projects also gain in determinig the hardware and software of this project.

Second process of the project implementation is implementing the data collection form the literature reviews. In this process, designing of circuit and program code take place in order to inspect the expected outcomes. The circuit designing has been conducted using Proteus 8 software whereas the coding of this project are created using Arduino IDE. When the developed circuit and coding produce an successful outcomes, then it will be implemented to the project.

Final process of this flowchart is the data analysis. The data analysis are divided into two major procedure which is observing and evaluating the performance of the project while another one is determining the final outcome. The observation and evaluation of the developed circuit and coding take place in order to determine performance of the project. Based on the observation of the outcome varies results and analysis are taken to evalute the perfoemance of project. Lastly, determining the final outcome with desired results are recorded to show the accomplishment in achieveing the objectives of the project.

3.3.2 Project Development Flowchart

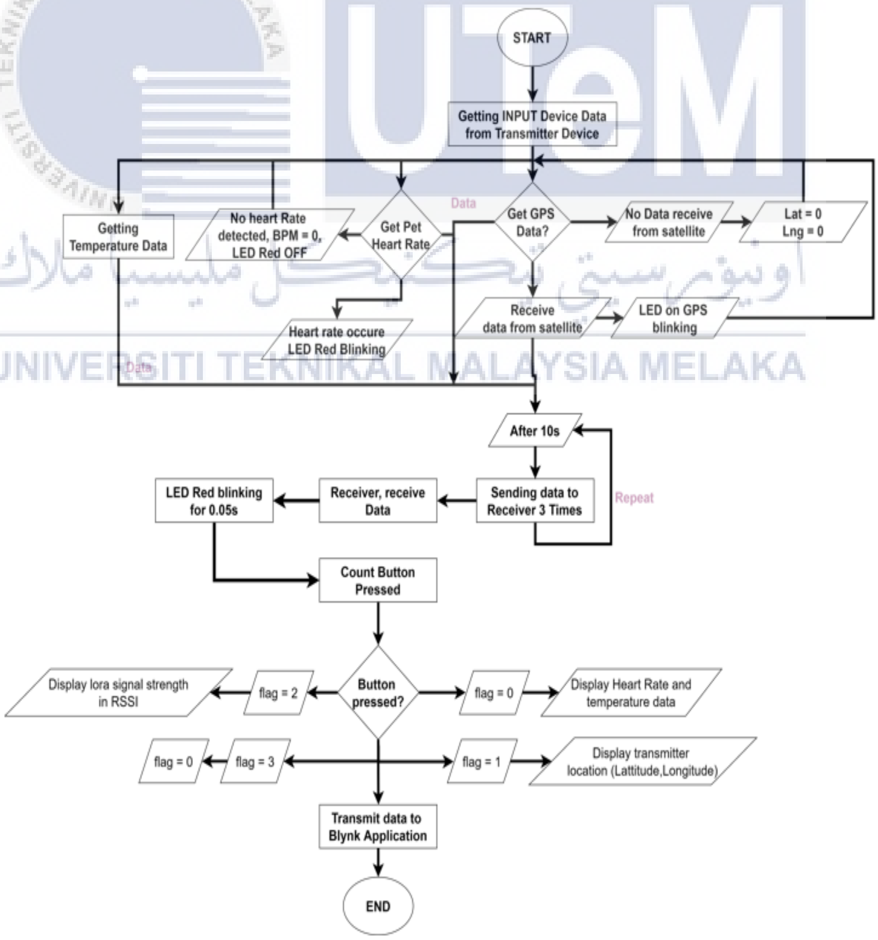


Figure 3.2: Steps of pet health monitoring collar with GPS tracker using LoRa implementation

Figure 3.2 above shows the steps of project development. In this part, suitable hardware component to produce the project were chosen. As for the software, the Arduino IDE is used for the coding. It is easier to use Arduino IDE than other programming software. Since it is also can read the input signal and convert it into output signal such as when the sensor is detecting an object in front the way.

The project begin by getting input device data from the transmitter. Next, carry on with GPS module which have been used to track the location of the pet in real time. Once GPS module receive data from satellite, the LED will be blinking. If there is no data receive, the latitude and longitude will be 0. Then, heartbeat rate sensor also been used in this project to detect the rate of pet's heartbeat. When heartbeat rate of the pet is detected, the LED will be blinking. If there is no heartbeat rate detected, the BPM will be 0. Futhermore, LM35 sensor have also been inserted in this project to detect the temperature of the pet. When the sensor receives the, it will directly transmit it to the receiver.

All this three components on the transmitter will send the received data to the receiver after 10 seconds delay. The collected data from the transmitter is transmit using LoRa as the transmission medium. Moving on to the receiver part, as the receiver get the transmitted data, the LED will blink for 0.05s. This process will be repeating for 3 times. Every data that have been collecte from the transmitter device will be sent to the receiver for every 10s. Moreover, there is a push button in the receiver part as it function to display data on the LCD display on the receiver. When the button is not press the flag will be 0 and it will only display the heartbeat rate and temperature of the pet. When the push button is press for only one time it will display the longitude and latitude of the pet's current location. Then, as the button is press for twice, it will display the LoRa signal strength in RSSI value. As the button is press for three times, the device will reset again where the flag will be equals to 0. Lastly, all the received data will be transmitted to the pet owner via Blynk application that is installed on the owner's smartphone. Then, the owner will be notified about the health and the current location of their beloved pet

3.4 Hardware specificatios

3.4.1 Arduino Nano

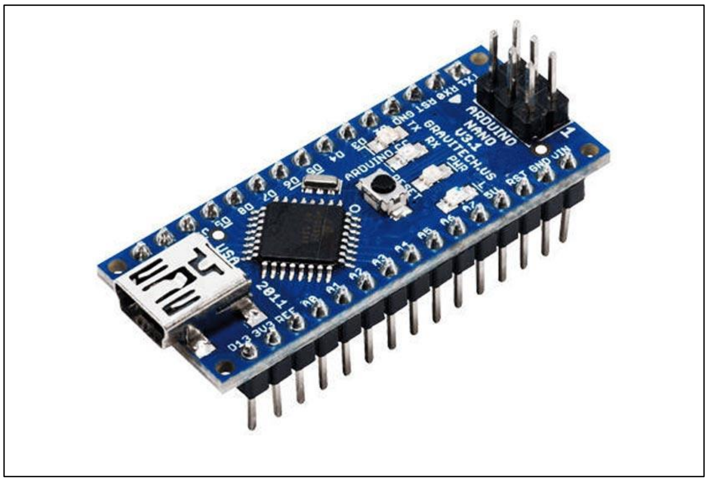


Figure 3.3: Arduino Nano microcontroller unit.

In Figure 3.3 shows, the Arduino Nano board which is designed to make getting established with microcontrollers relatively simple for beginner [25]. This board is very breadboard friendly, which makes handling the connections a breeze. The Nano board has a total of 14 digital pins and 8 analogue pins. As input pins, the digital pins may be used to interface sensors, and as output pins, they can be utilised to drive loads. To regulate their functionality, utilise basic functions like pinMode() and digitalWrite(). For digital pins, the operational voltage is 0V and 5V. Using any of the 8 analogue pins and a simple function like analogRead, the analogue pins may measure analogue voltage from 0V to 5V. In the other hand, there are three ways to power on the Arduino Nano board which is by USB jack, +5V pin and lastly by Vin pin. The size of the Arduino Nano board is smaller compare to Arduino UNO.

3.4.2 Pulse/Heart beat Sensor

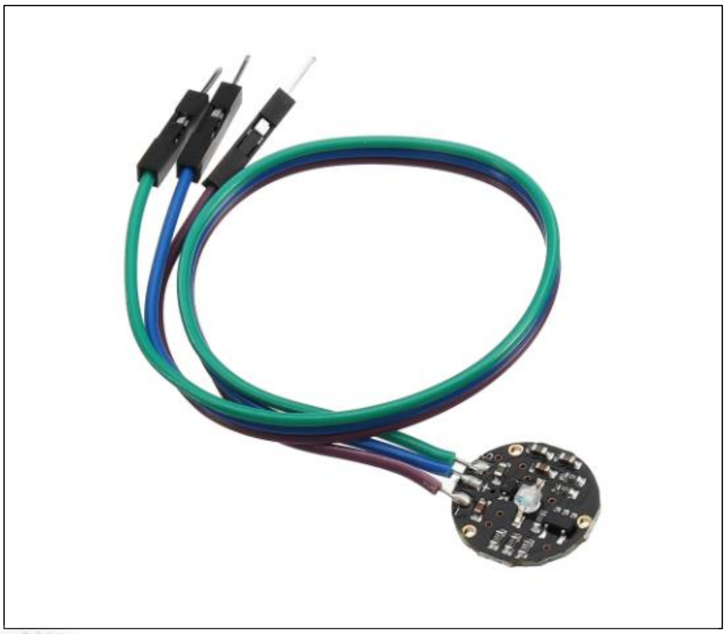


Figure 3.4: Pulse/Heartbeat sensor

Pulse/Heart beat sensor as shown in Figure 3.4 above, the function is same as the heartbeat rate detector sensor. It is one of the simplest sensor to work with as a beginner [26]. Pulse/Heart beat sensor has a two sides. First side of the sensor where LED is attached that comes along with ambient light sensor while looking onto the other side we have some circuitry in it. The purpose of the circuitry is for the amplification and noise cancellation process. This sensor works as the LED on the front side have been placed directly on top of the user's vein. As the sensor detect the heart beat rate the LED will eventually emits light. To monitor the heart beat this will happen as we monitor the blood flow. This is because, the blood flow take place when the heart is pumping. When blood flow is detected, the ambient light sensor picks up more light since it is reflected by the blood, this slight difference in received light is analyzed over time to identify our heart beats. The reason why the Pulse/Heart beat sensor is used in this project is to detect the heart beat rate of the pet in order to keep aware of pet's health condition. Furthermore, the sensor eventually sends an electronic signal to the Arduino UNO to notify the owner. Figure 3.5, shows the both front and back sides view of the sensor.

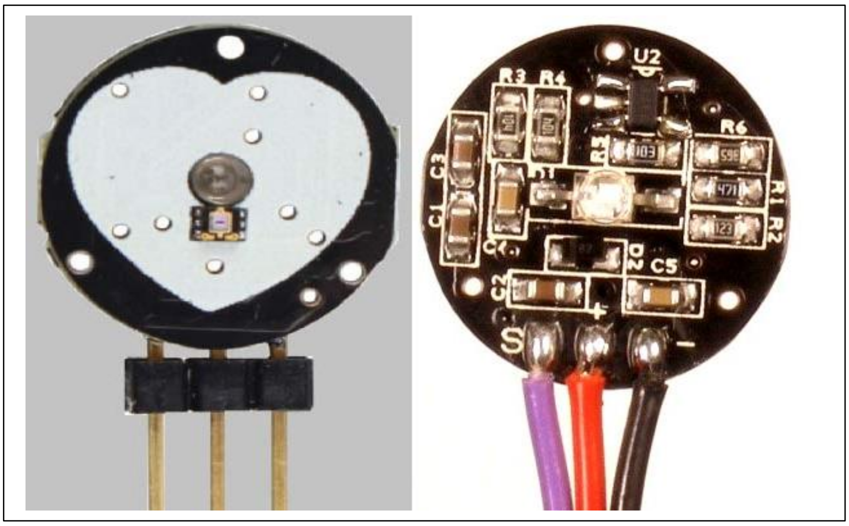


Figure 3.5: Both sides view of the Pulse/Heartbeat sensor [26].

3.4.3 LM35 temperature sensor

Figure 3.6: LM35 temperature sensor.

The LM35 as shown in Figure 3.6, is a temperature sensor with precession whose output voltage modulates depending on the temperature surrounding it [27]. It's a tiny, inexpensive IC that can monitor temperatures ranging from -55°C to 150°C. It may be readily connected to any microcontroller having an ADC function, as well as any development platform such as Arduino. VCC (Pin 1), Out (Pin 2), and Ground (Pin 3) are the three pins of the LM-35 (Pin 3). The VCC and Ground pins are respectively linked to

VCC and ground. The LM-35 can be powered from a voltage range of 4 to 20 volts, thus a 5-volt source is applied to power the Arduino board. The aim for LM35 temperature sensor is used in this project is to detect the temperature of the pet in order to keep aware of pet's health condition. Furthermore, the sensor eventually sends an electronic signal to the Arduino UNO to notify the owner through the mobile application. Table 3.1 shows the LM35 pin configuration.

Table 3.1: LM35 sensor pins configuration [27]

Pin Number	**Pin Name**	**Description**
1	Vcc	Input voltage is +5V for typical applications
2	Analog Out	There will be increase in 10Mv for raise of every 1°C. Can range from -1(-55°C) to 6V(150°C)
3	Ground	Connected to the ground part of the circuit

3.4.4 GPS module NEO6MV2

Figure 3.7 GPS module NEO6MV2

On this module, the GPS module as shown in Figure 3.7, the engine is pretty good, and it also has a high sensitivity for indoor applications. There's also a rechargeable MS621FE battery for backup and an EEPROM for saving setup settings. A DC input in the 3.3- to 5-V range works nicely with the module. The GPS antenna will be different from the usual whip antennas used for linear polarized communications since the GPS signal is right-hand circular polarized (RHCP). The patch antenna is the most common antenna type. Patch antennas are flat antennas with a ceramic and metal body set on a metal base plate. They're frequently cast in a house. The purpose of GPS module NEO6MV2 is used in this project is to track the location of the pet in real time in order to keep aware of pet in safe place. Furthermore, the GPS module eventually sends an electronic signal to the Arduino UNO to notify the owner through the mobile application [28].

3.4.5 LoRa module

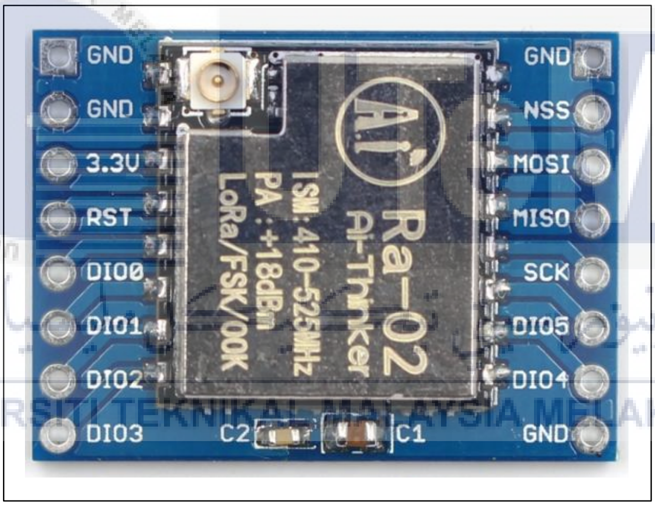


Figure 3.8: SX1278 LoRa module 433M 10KM Ra-02

Ra-02 is a wireless transmission module based on SEMTECH's SX1278 as shown in Figure 3.8, is a wireless transceiver [29]. With advanced LoRa spread spectrum technology, the communication distance can reach 10,000 meters. Strong anti-interference ability, with air alarm clock consumption function. The SX1278 RF module is mainly used for long distance spread spectrum communication, it can resist and minimize current consumption. SX1278 has high -148dBm sensitivity, + 20dBm output power, long transmission distance, and high reliability. At the same time, compared with traditional modulation technology, LoRa™ modulation technology has obvious advantages in anti-blocking and selection, which solves the problem of distance, interference and energy consumption that cannot be considered in traditional design schemes. It can cover thousands of people in the community environment, and is especially suitable for meter reading, smart home, and anti-theft alarm equipment [29].

3.4.6 WiFi module

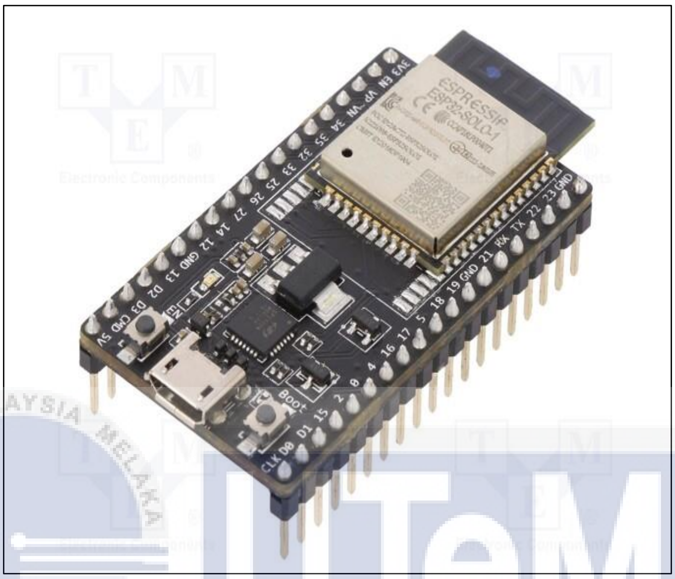


Figure 3.9: ESP32 WiFi module

In Figure 3.9 shows, the ESP32 WiFi module, which is a family of low-cost, low-power system-on-a-chip microcontrollers that have built-in Wi-Fi and dual-mode Bluetooth radios, among other features. It has a high level of integration, with antenna switches, an RF balun, a power amplifier, a low noise receive amplifier, filters, and power management modules all incorporated into the device. The ESP32 offers significant functionality and diversity to your applications while using only a little amount of Printed Circuit Board (PCB) space. ESP32 is a low-power microcontroller designed for mobile devices, wearable electronics, and Internet of Things applications. It achieves this low power consumption by the use of multiple forms of proprietary software [30].

3.5 Software specifications

The purpose of using Arduino IDE as the core software applied in implementing this study to function intended. Besides, the use of this software as a platform to build project in this study. This Arduino Integrated Development Environment (IDE) software is used to configure Arduino UNO which have used as microcontroller for this project.

3.5.1 Arduino IDE

It is open source software, mainly used to write and compile code on the Arduino Module. Arduino IDE is the official Arduino software. The code is too easy to compile. Even the beginner without technical knowledge can be complacent in the learning process. It can be easily used on operating systems such as MAC, Windows, Linux, etc., and runs on the Java platform, which has built-in commands and functions, which are essential for debugging, editing, and compiling code in the environment. Each of them contains a microcontroller on the board that is actually programmed and receives information in the form of code. The main code created on the IDE platform, also called as a sketch, will eventually generate a hex file, then transfer and upload to the board controller. The IDE environment mainly includes two basic parts: an editor and a compiler. The former is used to write the required code, and then it is used to compile and load the code into a given Arduino module. This environment is compatible with C and C++ languages. Figure 3.10 shows the icon of the Arduino IDE software. Meanwhile, figure 3.11 below shows the Arduino IDE software interface.

Figure 3.10: Arduino IDE icon

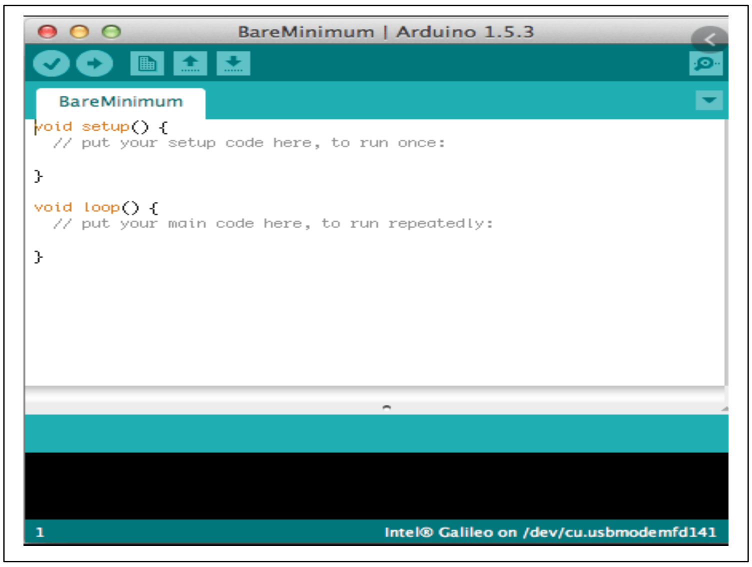


Figure 3.11: Arduino IDE interface

3.6 Mobile application specifications

The purpose of using mobile application in this project is to monitor the health status of the pet in real time. The mobile application that is used in this project in Blynk Application. A few widgets will be created in this platform to monitor the temperature, heartbeat and location of the pet. This mobile application will aid the pet owner to be alert all the time.

3.6.1 Blynk mobile application

Blynk application is a platform with IOS and Android applications to control Arduino, Raspberry Pi, etc. via Internet. It is a digital dashboard where you can build a graphical interface for your project by simply dragging and dropping widgets. Blynk application is suitable for hundreds of hardware models and connection types. User able to select the suitable hardware type. After this, users can be able to select the connection type and the WiFi connectivity in the platform. User, can create widgets to specify on the important things to be displayed on the application. Lastly, the Blynk build program can be upload in the Arduino IDE software to implement it in the project. Figure 3.12 shows the icon of the Blynk application. Meanwhile, figure 3.13 below shows the Blynk application interface

Figure 3.12: Blynk application icon

Figure 3.13: Blynk application interface

3.7 Connection diagram of the project

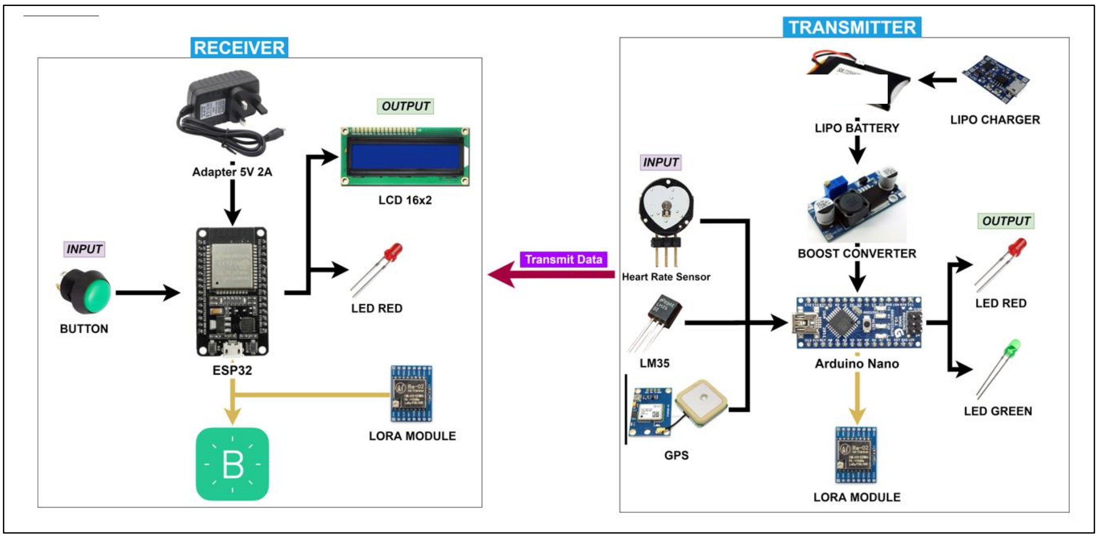


Figure 3.14: Diagram of project implementation

Figure 3.14 shows the connection of the hardware on the transmitter and receiver part of the project. In transmitter part, there are two sensors that mainly we use for this project which is heartbeat and temperature sensor followed by GPS module. Three of these components are connected to Arduino Nano. Arduino Nano is powered using a Lipo battery which are linked up with the boost converter. An appropriate voltage supply is required to prevent the board from being corrupted. As the data from the input devices has been sent to the microcontroller, it will then process by the Arduino Nano. The red LEB on the transmitter side will blink as it detected in coming data while the green LED will blink as it transmits the data. All the data that have been collected from the input devices will be sent over to the receiver through LoRa.

Moving on to the receiver part, ESP32 is used as the interface of the project to provide WiFi functionality. It has been powered with a 5V adapter. A LCD board is also connected to the ESP32 to display the received data from the transmitter. The red LED on this part indicate the data from the transmitter side has been received successfully. Finally through this ESP32, it can connect to users Blynk application that have been installed on the phone.

3.8 Block Diagram of the Project

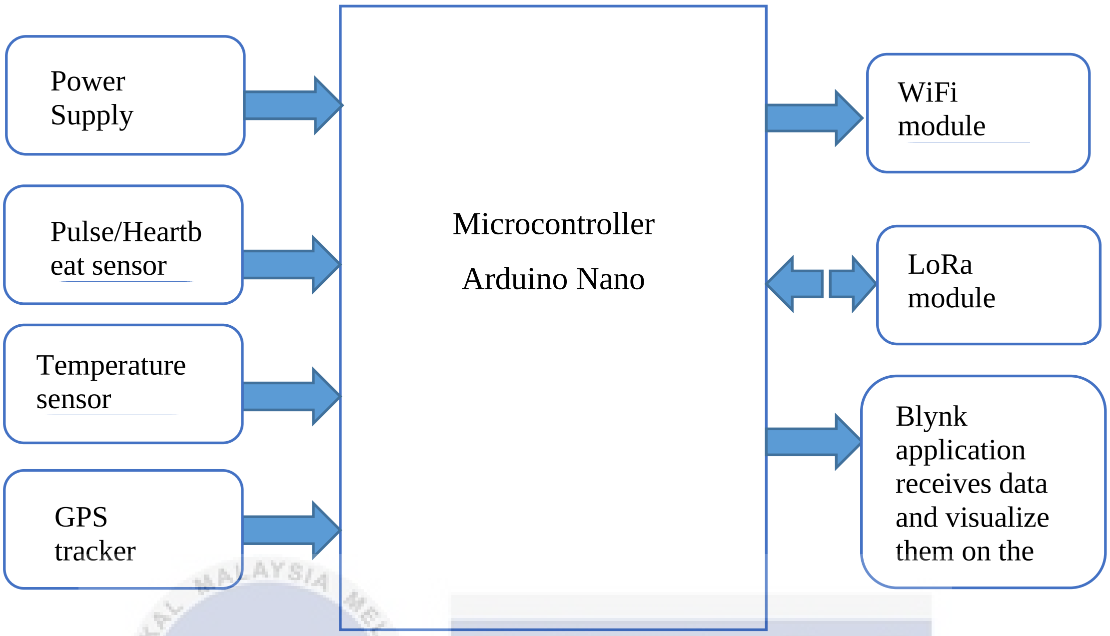


Figure 3.15: Block Diagram of Pet Health Monitoring Collar with GPS Tracker using LoRa

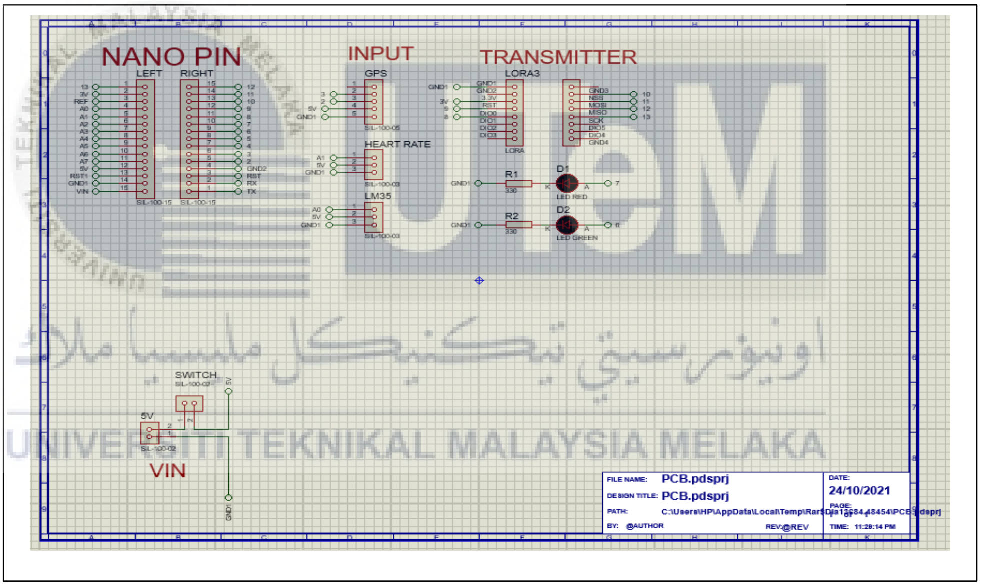
Based on the Figure 3.15 the block diagram represents the basic working concept of the Pet Health Monitoring Collar with GPS Tracker using LoRa. The power source that is mentioned on the figure above is obtained from the USB adapter which need to be connected to the PC or laptop. As the connection is done, an LED emits light from the microcontroller which can be observed that it will blinks a few times and that indicates the power is on and the microcontroller is connected well.

Moving to the sensors, that is used in this project which is temperature and pulse/heartbeat sensors. The sensors will be inserted into the collar which is known as the wearable prototype. This will allow the sensors to detect the temperature and heartbeat of the pet easily. The pulse/heartbeat sensor and temperature will start to detect immediately after the Arduino UNO is powered on. Meanwhile, the GPS module is also have been attached to this prototype as it can be able to trace the current location of the pet.

Then, the data have been collected from the transmitter it will be transmitted to the Blynk application. The data will be transmitted using LoRa module. This is because LoRa can be able to transmit data in a very long range with low power consumption. Lastly, Blynk application that have been installed in the owner's mobile will be receiving the data and will be displayed on the platform.

In the nutshell, after projecting the design concept and the possible outcome of this project, it will certainly be achievable in implementing into the prototype with the aid of the fundamental working principle based on the flowchart and block diagram. However, it is unquestionable that the outcome of the project may vary from the original concept. This notion enables all the pet lovers to be extra aware of their beloved pet's health and prevent from losing them.

3.9 Project Simulation



\ Figure 3.16: Connection diagram of Transmitter

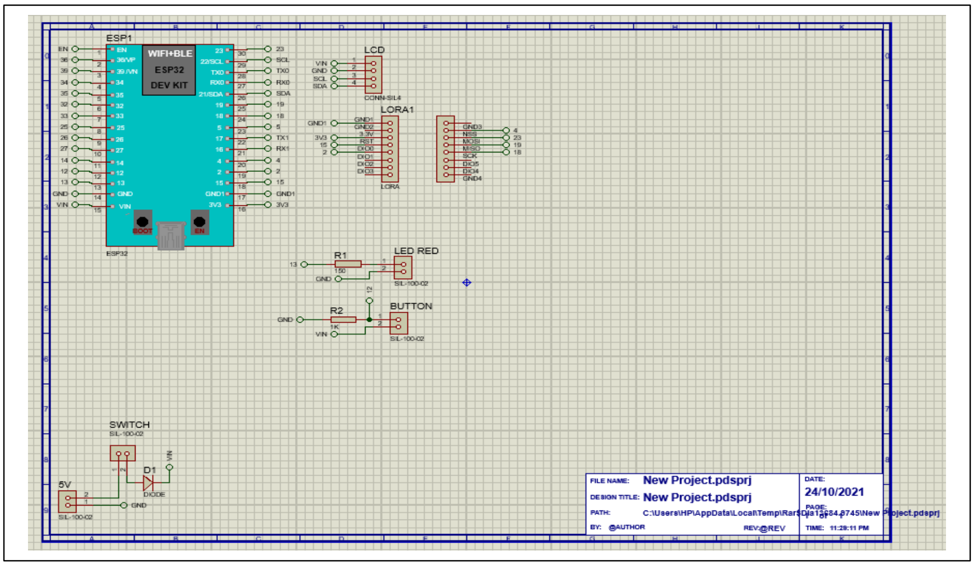


Figure 3.17: Connection diagram of Receiver

In Figure 3.16 show, the connection diagram of the transmitter using Proteus software. The connection is between the microcontroller, LoRa module and input devices such as LM35, heartbeat sensor and GPS module. In Figure 3.17 shows the connection diagram of the receiver using Proteus software. In this diagram, it shows the connection between ESP32, 16X2 LCD board and LoRa module. Other basic electronic elements, such as the switch, power supply, battery, led and push button are also constructed on this both connection diagrams.

3.10 Summary

This chapter describes and explains the methodology of ‘Pet Health Monitoring Collar with GPS Tracker using LoRa’. Project methodology is one of the most significant chapter in handling a project in order to ensure that the project can be completed systematically guided by following the correct sequence of the project methods. The developer of project creates a project development plan, development of the project operation, project determination and complete project integration at four stages of methodology. These four stages are deed as the guidance for completing this project.

Based on previous research and literature review, control parameter was determined in the certain of the project in the creation of the project structure plan. The development of project later was enhanced. The key part of this stage is the analysis and identification of all the components and control element that related to this project. Defining project is a step in design and production of the mechanical, electronic and software design. Next, the complete project integration will be repeatedly and troubleshoot to reach the main objectives of the project. Gantt chart is used to list the sequence and periodic tasks required to ensure a successful time management.

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Introduction

The results and discussion of the overall project will be elaborated in this chapter. All project test results from simulation before final completion of the data, operating conditions and data analysis are included. The final results of these review and evaluation is the guideline for evaluating whether the project goal is achieving

4.2 Software Development

Blynk application is used to receive notification from the LoRa to the pet owner. First and foremost, Blynk application is an app editor which need to be installed by the pet owner in his/her phone. It enables pet owners to integrate with devices and receive messages. Once the sensors and GPS are detected, the data is collected and immediately sent it to Blynk via LoRa. This will help pet owners to be alert on their pet's current health status.

A Blynk account is creating by installing the application at the android play store. Once the account is created select "public server" in the application. Then, a project is created by choosing the hardware model that have been used in this project which is Arduino Nano. A platform is created by using widgets that available in the application. Once a new platform is created, a unique authorization token is provided to the users email that can be used to communicate with the microcontroller and then insertion of coding take place in order for the application work successfully. As the data is send to the receiver, it will send to Blynk application. Moreover, in this application, if the receiver is offline, it will show an offline notification on the platform.

Figure 4.1: Blynk Application interface

In Figure 4.1 shows, the Blynk application interface that have been develop for this project. Three widgets been used in this interface which the BPM which refer to the heartbeat rate meter, temperature unit as the temperature meter and Google maps as to detect the current location of the pet. Moreover, on the taskbar of the interface shows the connection of the transmitter which also refer as pet tracker in offline or online condition.

4.3 Hardware Development

The hardware used in this project are Arduino Nano, ESP42, LCD Board, Heartbeat rate sensor, Temperature sensor, LoRa module, push buttons, 5V adapter, Lipo battery and charger, boost converter and GPS module. There are two side of this project which is on the transmitter and receiver. The hardware configuration is shown in Figure 4.2 and 4.3.

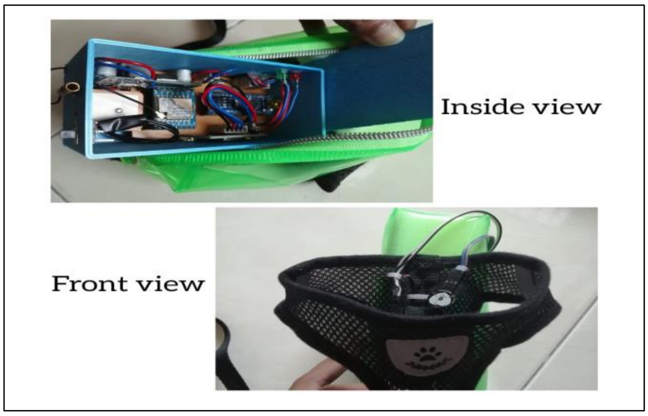


Figure 4.2: Transmitter side of the project

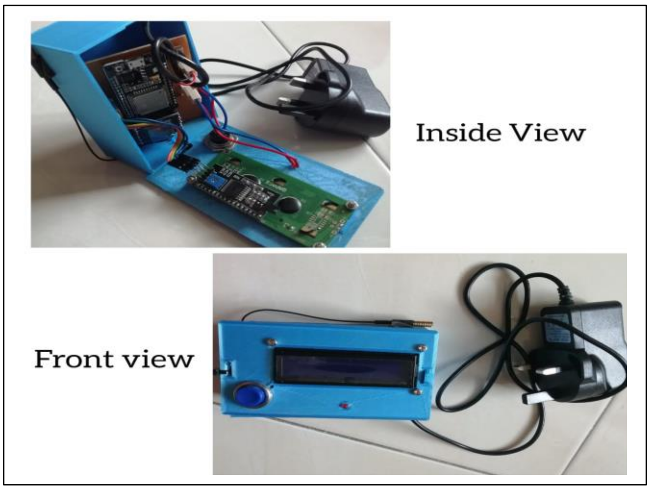


Figure 4.3: Receiver side of the project

Mainly, there are two part of this project which is the transmitter and receiver part. First and foremost, on the transmitter side, there are three input device which is heartbeat rate sensor, temperature sensor and GPS module. Power supply as a lipo battery with its charger and boost converter are attached to the microcontroller. Furthermore, there is a transmitter LoRa module as a transmission medium to send the input data to the receiver. Finally, two LED has also been placed on this transmitter which indicates as data are detected and send to the receiver. Secondly, on the receiver part, there is a ESP32 module which is known as WiFi module. It will set an interface to provide WiFi connection to be able to connect with the Blynk application on user phone. Next, receiver side LoRa is attached to the ESP32 as it collects and send data from the transmitter. There is a LCD board and a push button which will have attach on the body on the receiver box. The purpose of using push button on this receiver side is for the user to control the display data on the LCD board manually.

4.4 Prototype Development

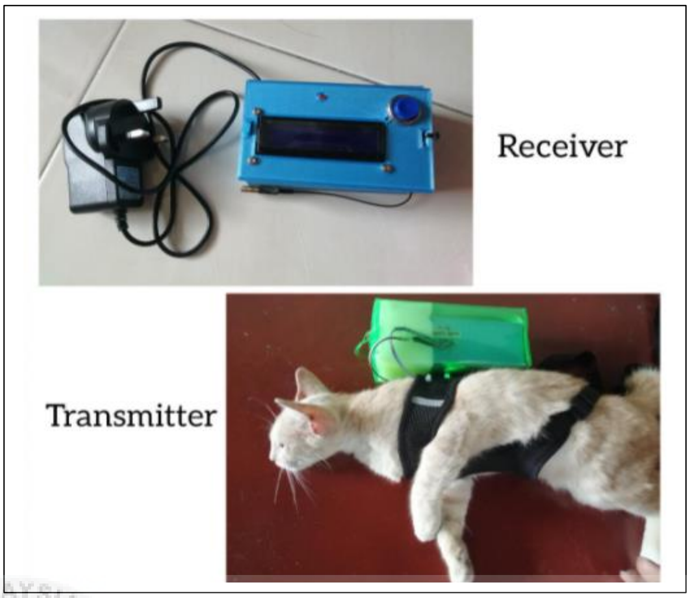


Figure 4.4: Prototype Development

Figure 4.4 shows the prototype model for the pet health monitoring collar with GPS tracker using LoRa. The transmitter side which is attached to the pet's collar and the receiver is placed at the owner's shelter. The heartbeat sensor and temperature are placed on the pet collar so that it will be able to detect pet's temperature and heartbeat rate. On receiver, there is a LCD board and push button which able for the owner to keep track on pet's health status and current location manually.

4.5 Project Integration

The pet health monitoring collar with GPS tracker using LoRa is designed for pet owners only. This project is able to run continuously if the right amount of power is supplied. The workflow of this project is stated in this section.

At first, the pet owners need to charge the transmitter. In the transmitter there is a LED that will indicate the user when it is fully charger. As the transmitter is start charging the LED will turn on whereas when it is fully charged the LED will turn off automatically. To charge the transmitter, user need to use a USB to be able to connect it to the charging port. As the transmitter is fully charged, user now can turn on the switch button, to allow the sensors and GPS to turn on. Then, user need to connect to mobile hotspot according to the

ID and password that have been inserted in the program code. In this project, the internet ID that have been inserted to the source code is “Pet” while the password is “123456789”. Once it is connected, in the Blynk application it will appear a notification that transmitter is in online status. If the mobile hotspot failed to connect to the Blynk application, there will a notification that will notify the user that the transmitter is in offline status. The figure below, will shows the internet configuration and also the pet collar status in Blynk application.

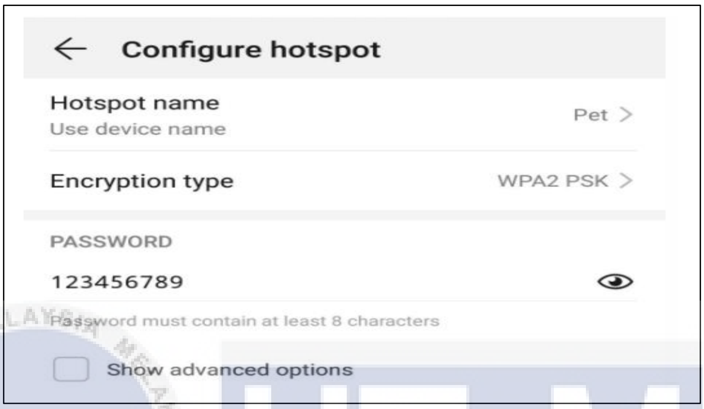


Figure 4.5: Internet Configuration

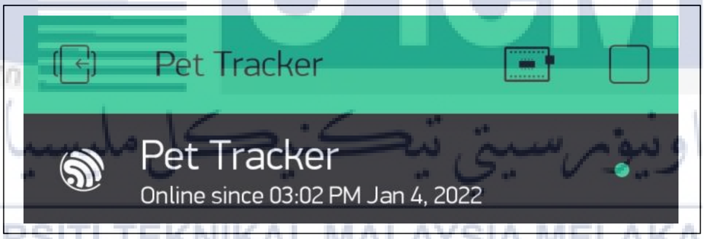


Figure 4.6: The pet tracker online status in Blynk

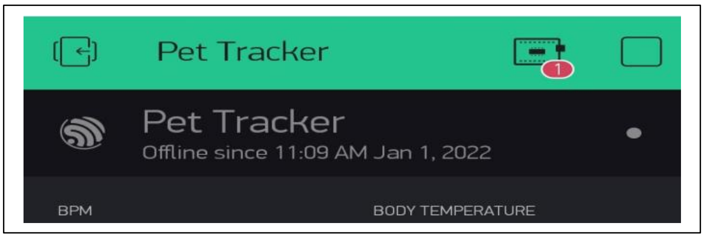


Figure 4.7: The pet tracker offline status in Blynk

Next, as the pet collar is connected to the pet owner’s Blynk application, it will automatically start running. Then, to be able for the pet collar to work, firstly, the vest collar needs to attach to the pet’s body. This is able the sensors and the GPS tracker to collect the data and send to the receiver and Blynk application.

Figure 4.8: Pet health collar testing

Then, once the pet health collar has been worn to a pet, user need to switch on the transmitter in order for the GPS and sensor to work. When the input device of this project which is the heartbeat rate sensor, temperature sensor and GPS collects the data the red LED will blink. Thus, the collected data are ready to send to the transmitter. When the data are sent successfully to the transmitter, then the green LED will blink.

Figure 4.9: LED red blinking

Figure 4.10: LED green blinking

Furthermore, when the data has been transmitted to the receiver, the LCD board will display the received data. When the push button is press for once, the LCD will display the heartbeat rate and temperature of the pet. Next, as the push button is press for the second time, the LCD will display the latitude and longitude of the pet's current location. Then, when the push button is press for the third time, the LCD will display the RSSI value which is the strength of the LoRa module. Lastly, as the user press the button, it will reset back to normal.

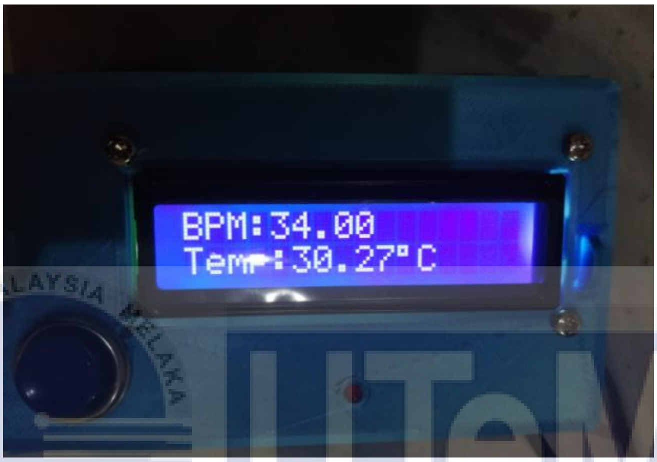


Figure 4.11: Temperature and Heartbeat rate of the pet

Figure 4.12: Latitude and Longitude of the pet's current location

Figure 4.13: Signal Strength of the LoRa module

On the other hand, pet owner is required to install and create an account in Blynk application in order to receive data in real time notification.. In the Blynk application, firstly, pet owner needs to make sure that the pet collar has been connected. As the pet's collar is connected to the Blynk, pet owner need to press the play button on the application in order for the application to run and detect the incoming data from the transmitter.

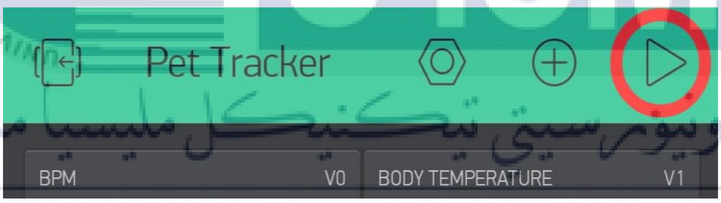


Figure 4.14: Play Button on the Blynk application

Moving forward, as the play button is press, the data from the transmitter will be received. The incoming data from the transmitter is the pet's heartbeat rate, temperature and also the current location. The pet owners will be able to receive pet's temperature rate, heartbeat rate and also current location in real time.

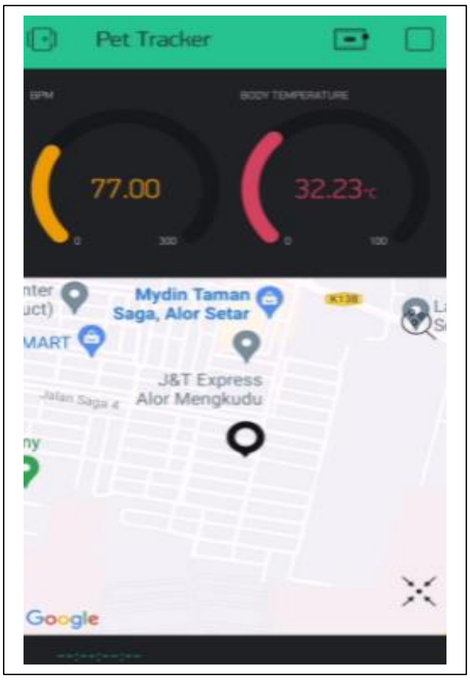


Figure 4.15: Blynk application data display

Finally, all these data that have been collected from the transmitter will be send to the transmitter with the aid of LoRa after every 10s. There will be three reading for the pet owners for every incoming data.

4.6 Data Analysis

An analysis is done to study the effect on RSSI signal strength over the distance between pet and receiver. In terms of RSSI value in negative numbers, a number that is near to zero typically indicates a better signal than a number that is more than zero. When the RSSI value is positive, the stronger the signal, the greater the value of the RSSI and the stronger the signal will be. First and foremost, the receiver and transmitter are set up to the lowest distance. Due to a lack of available area, the distance is reduced to 2 meters.

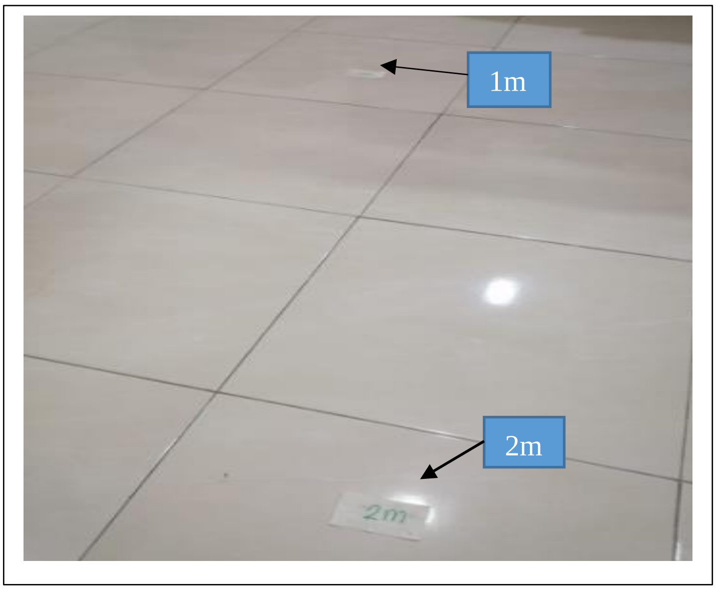


Figure 4.16: Distance between transmitter and receiver

In Figure 4.16, shows a set up to analysis the performance of the project. The transmitter and receiver are placed with the lowest distance. Throughout the observation made, the LoRa is able to detect the data from transmitter up 2 meters and at 1 meter range whereas the RSSI signal strength is higher as the distance is at lowest. Aside from this, the distance is changes to the high. It is observed that the LoRa is able to detect at distance more than 2 meters. Table 4.1 shows the reading taken at every 1 meter distance.

Table 4.1: Results of RSSI signal strength every 1 meter distance

Distance between transmitter and receiver (m)	RSSI signal strength(dBm)
1	-48
2	-54
3	-56
4	-60
5	-61
6	-63
7	-67
8	-73

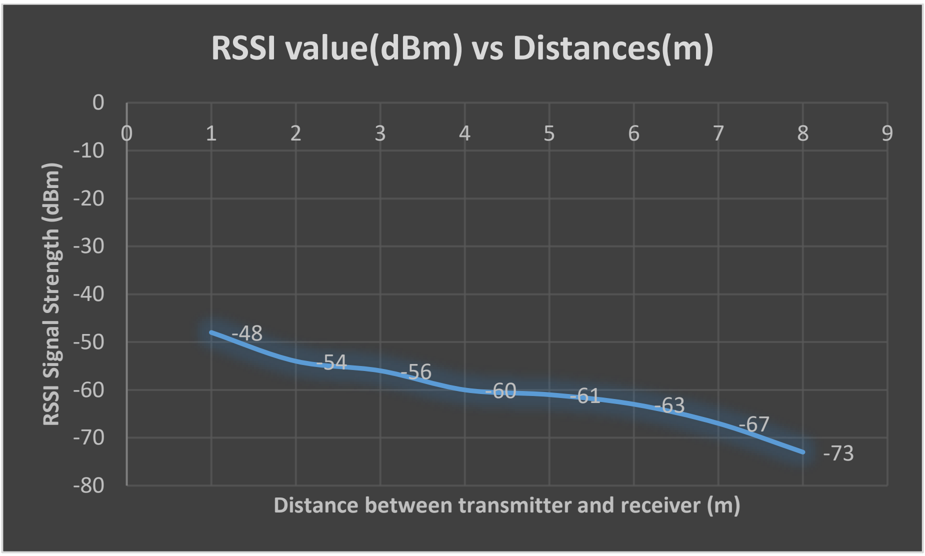


Figure 4.17: Graph of RSSI signal strength taken every 1 meter distance.

Based on the data collected in the Table 4.1, a line graph as shown in Figure 4.17 is plotted against the RSSI signal strength value at every 1 meter distance between the transmitter and the receiver using Excel. Based on the observation from the graph obtained, the RSSI signal strength value is decreasing as the distance between the transmitter and receiver increase. Therefore, it can be concluded that the RSSI signal strength of this project is detectable as there is increase in the distance between the transmitter and receiver, thus it also able to provide data in real-time at owner's Blynk application.

Another analysis is done where the pet's heartbeat rate has been detected every minute to analyze the heartbeat rate when the pet which is a cat, resting and walking. Based on the research, a normal heartbeat rate of cat is in range of 70-140 per minutes [31]. This will be divided mainly into two condition where the heartbeat rate of a cat is normal at 70-120 per minute if it is in resting state. The other condition is when the cat is in active state where the normal heartbeat rate will be around 120-140 per minute. The Table 4.2 shows the reading taken at every minute, as the pet resting and walking.

Table 4.2: Results of pet's heartbeat rate per minutes in resting and walking condition

Minutes	Resting	Walking

1	126	99
2	93	99
3	107	118
4	77	123
5	77	127
6	112	99
7	139	137
8	87	142
9	93	143
10	104	126

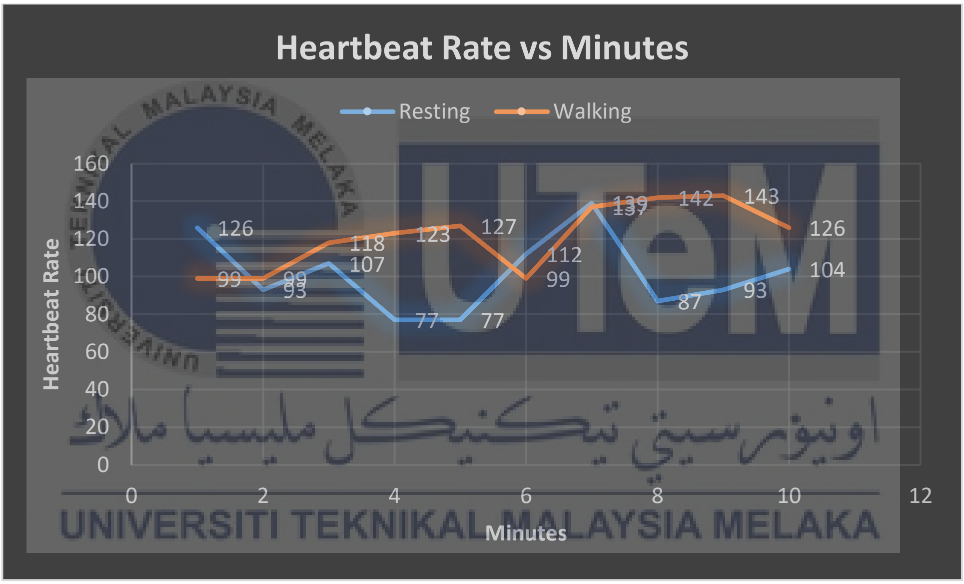


Figure 4.18: Graph of Heartbeat rate every minute.

Based on the data collected in the Table 4.2, a line graph as shown in Figure 4.18 is plotted against the heartbeat rate at every minute distance from 1 to 10 minutes range using Excel. Based on the observation from the graph obtained, there are different condition which is in resting and walking. Thus, the heartbeat rate when is higher, compare when its resting. Nevertheless, the heartbeat rate obtained from both condition fluctuates every minute. Therefore, it can be concluded that the heartbeat rate of the pet is detectable at every minute, thus it also able to provide data in real-time at owner's Blynk application.

4.7 Summary

This chapter explains one of the final outcomes from the project. The result of constructing the pulse/heartbeat sensor circuit is included. Moreover, the results of the compiled coding also have been included as the prove to successfully collect the data without any troubleshoot.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The overall project implementation is concluded, and future recommendation are suggested in this chapter.

5.2 Conclusion

Pet is a good companion for all the pet owners. The safety of pets needs to be given importance as keeping it secure in good environment. Therefore, this pet health monitoring collar will be a good solution for the safety of pets. The objectives of this project are achieved as the pet health monitoring collar with GPS tracker using LoRa is successfully developed. The developed project able to conduct research of the LoRa and Blynk application's characteristics and functioning. The data received on the Blynk application shows the connection between the transmitter and the receiver are develop successfully with the transmission medium LoRa. Thus, this will assist the pet owners to monitor the pet's health status and track the location in real time.

Furthermore, this project successfully developed a mobile application interface using Blynk application. The widgets in this mobile application, clearly displaying the data from the transmitter for the pet owners. Throughout the development mobile application on this project, it enables the pet owners to keep a track of their pet's health and safety. In term of versatility, this concept is satisfying as it helps the pet owners to easily check on their pet's health status in real time. It's a key reason for this project to cover the task in a short time.

Lastly, the performance of the developed project is analysed by observing the response towards pet's temperature rate, heartbeat rate and the current location in real time. GPS module, LM35 sensor and heartbeat sensors able to detects the current location, temperature, and heartbeat rate of the pet. The collected data is also successfully transmitted to the Blynk application with aid of LoRa module and ESP32. This project could also be commercialized because it has the potential to be commercialized in the healthcare industry. This project will not only convenient for dogs and cats but also for other animals. This is because most of the pet owners tends to waste their time and money to get regular checkup for their pets without any symptoms of illness. In summary, this project will not only will be helpful for pet owners but also for Malaysian Veterinary Service Department to minimize hard work and work force in the country. Therefore, this Pet Health Monitoring Collar with GPS Tracker may become environmentally friendly goods and may be important to the future pet owners and healthcare industry.

5.3 Future Recommendations

Although the develop project prevents any interference to take place, there are still room for improvements. Latest version of LoRa module which is STEVAL-STRKT01 LoRa can be used to improve the tracking functionability in this project. It is also ideal for IoT tracker applications such as asset, person, and animal monitoring, as well as fleet management.Moreover, it’s battery-powered solution with intelligent power management. Last but not the least, the pet health monitoring collar concept feature can be added to give warning to the pet owner, if there is emergency cases happen to their pet. Lastly, the size of this project can be minimized by using an appropriately sized component that is acceptable for the pet’s comfort and safety.

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APPENDICES

APPENDIX A

GANTT CHART BDP 1

No	Project Activity	Expected / Actual	Week														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Final Year Project briefing by JK PSM	Expected															
		Actual															
2.	Topic confirmation and discussion with supervisor	Expected															
		Actual															
3.	Meeting with supervisor for Introduction (Week 1)	Expected															
		Actual															
4.	Study on project background and writing on Chapter 1	Expected															
		Actual															
5.	Meeting with SV for chapter 1 correction and chapter 2 briefing	Expected															
		Actual															
6.	Make a research and writing on chapter 2	Expected															
		Actual															
7.	Meeting with SV for chapter 2 correction and chapter 3 briefing	Expected															
		Actual															
8.	Make a research and writing on chapter 3	Expected															
		Actual															
9.	Report Draft Submission	Expected															
		Actual															
10.	Prepare for	Expected															

	Presentation	Actual															
11.	Video Presentation submission	Expected															
		Actual															
12.	PSM Presentation Evaluation	Expected															
		Actual															

GANTT CHART BDP 2

No	Project Activity	Week														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Final Year Project briefing by JK PSM	■														
2.	Listing out and purchasing components	■														
3.	Meeting with supervisor (Week 1)	■														
4.	Construct the circuit in software	■	■	■	■											
5.	Construct the hardware part of the project					■										
6.	Make connection with hardware and software					■	■	■	■	■						
7.	Research and testify on the coding of the project										■					
8.	Update the thesis report									■	■	■				
9.	Thesis draft submission to supervisor											■	■	■		
10.	Finalize Thesis submission supervisor and panel													■	■	
11.	Video Presentation submission to supervisor and panel														■	
12.	PSM Presentation Evaluation														■	■

APPENDIX B

Transmitter Code

```
#include <LoRa.h>
int val = 0;
int nss = 10;
int RESET = 9;
int dio0 = 8;

int potVal;

int SyncWord = 0x22;

int dutyDuration = 10000;

//dummy data:
uint8_t address = 1;     // 1 byte
float heartRate = 80.78; // 4 bytes
float bodyTemp = 36.5;   // 4 bytes
uint8_t emergency = 1;   // 1 byte
float lat = 5.656005;    // 4 bytes
float lng = 100.880058;  // 4 bytes
uint8_t checksum = 0;    // 1 bytes

// total bytes = 19 bytes
uint8_t buffer[19];

void setup()
{
  LoRa.setPins(nss, RESET, dio0);
  Serial.begin(9600);
  while (!Serial)
    ;
```

```
  // Serial.println("LoRa Sender");

  if (!LoRa.begin(433E6))
  {
    // Serial.println("Starting LoRa failed!");
    while (1)
      ;
  }
  LoRa.setSpreadingFactor(12);     // ranges from 6-12,default 7 see API docs
  LoRa.setSignalBandwidth(62.5E3); // for -139dB (page - 112)
  LoRa.setCodingRate4(8);          // for -139dB (page - 112)
  LoRa.setSyncWord(SyncWord);
}

void loop()
{
    buffer[0] = address;
    buffer[1] = ((byte *)&heartRate)[0];
    buffer[2] = ((byte *)&heartRate)[1];
    buffer[3] = ((byte *)&heartRate)[2];
    buffer[4] = ((byte *)&heartRate)[3];

    buffer[5] = ((byte *)&bodyTemp)[0];
    buffer[6] = ((byte *)&bodyTemp)[1];
    buffer[7] = ((byte *)&bodyTemp)[2];
    buffer[8] = ((byte *)&bodyTemp)[3];

    buffer[9] = emergency;

    buffer[10] = ((byte *)&lat)[0];
    buffer[11] = ((byte *)&lat)[1];
    buffer[12] = ((byte *)&lat)[2];
    buffer[13] = ((byte *)&lat)[3];
```

```
    buffer[14] = ((byte *)&lng)[0];
    buffer[15] = ((byte *)&lng)[1];
    buffer[16] = ((byte *)&lng)[2];
    buffer[17] = ((byte *)&lng)[3];

    checksum = 0;
    for (int i = 0; i < 18; i++)
    {
      checksum = (uint8_t)(checksum + buffer[i]);
    }
    checksum = 0xFF - checksum;
    buffer[18] = checksum;

    Serial.write(buffer, 19);
    if (LoRa.beginPacket() == 1)
    {
      // random backoff
      // int _delay = random(0, dutyDuration / 2);
      // Serial.print("Backoff for : ");
      // Serial.print(_delay);
      // Serial.println(" ms");
      // delay(_delay);
      LoRa.write(buffer, 19);
      if (LoRa.endPacket() == 1)
      {
        //success
        // Serial.print("P1:");
        // Serial.println(potVal);
      }
      // delay(dutyDuration - _delay);

      return;
    }
}
```

Receiver Code

```
//======================== LORA VARIABLES ===============
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
//===================== Blynk Setup ================
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

char auth[] = "nkunVA3oCTLVnPKnWnDhYIY8oRZhAM4y";          // You should get
Auth Token in the Blynk App.
char ssid[] = "Pet";                              // Your WiFi credentials.
char pass[] = "123456789";
WidgetMap myMap(V2);
//======================== LORA VARIABLES ===============
#include <LoRa.h>
int val = 0;
int nss = 4;
int RESET = 15;
int dio0 = 2;

int SyncWord = 0x22;

int rssi;
int rxByte;

uint8_t rxBuffer[17];
//======================== Data From Transmitter ===============
float bodyTemp;
float heartRate;
float lat;
float lng;
uint8_t checksum;
//======================== Data From Transmitter ===============
float bodyTemp_Node1;
float heartRate_Node1;
uint8_t emergency_Node1;
float lat_Node1;
float lng_Node1;
//======================== IO PIN ===============
const int LED_RED = 13,
          Btn = 12;

int Btn_State = 0,
    last_Btn_State = 0,
    Cnt_Btn = 0;

//======================== VOID SETUP ===============
```

```
void setup()
{
  LoRa.setPins(nss, RESET, dio0);
  Serial.begin(9600);
  lcd.begin();

  lcd.clear();
  lcd.print("Starting System");

  while (!Serial);
  // Serial.println("LoRa Receiver");
  if (!LoRa.begin(433E6))
  {
    // Serial.println("Starting LoRa failed!");
    while (1);
  }
  LoRa.setSpreadingFactor(12);     // ranges from 6-12,default 7 see API docs
  LoRa.setSignalBandwidth(62.5E3); // for -139dB (page - 112)
  LoRa.setCodingRate4(8);          // for -139dB (page - 112)
  LoRa.setSyncWord(SyncWord);      // ranges from 0-0xFF, default 0x12, see API docs

  pinMode(LED_RED,OUTPUT);
  pinMode(Btn,INPUT);

  Serial.print("SSID:");
  Serial.println(ssid);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Connecting to   ");
  lcd.setCursor(0,1);
  lcd.print(ssid);

  Blynk.begin(auth, ssid, pass);

  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Wifi Connected");

  delay(500);
  lcd.clear();
  lcd.print("Done Startup");
  delay(1000);
  lcd.clear();
}
//======================== VOID LOOP ===============
void loop()
{
  Blynk.run();
  //Extract data after received data from transmitter
  Extract_Data();
```

```
  //Count Button
  Cnt_btn();
  //Send Data to Blynk App
  myMap.location(V2,lat_Node1,lng_Node1,"value");
  Blynk.virtualWrite(V0,heartRate_Node1);
  Blynk.virtualWrite(V1,bodyTemp_Node1);
}
//======================== Extract Data From Transmitter ===============
void Extract_Data() {
  // try to parse packet
  int packetSize = LoRa.parsePacket();
  if (packetSize)
  {
    //TX_MODE = 1;
    // read packet
    int rxCount = 0;
    long verifyChecksum = 0;

    while (LoRa.available())
    {
      rxByte = LoRa.read();
      if (rxByte < 0)
      {
        continue;
      }
      verifyChecksum += rxByte;
      rxBuffer[rxCount++] = rxByte;
    }
    Serial.println("");
    ((byte *)&heartRate)[0] = rxBuffer[0];
    ((byte *)&heartRate)[1] = rxBuffer[1];
    ((byte *)&heartRate)[2] = rxBuffer[2];
    ((byte *)&heartRate)[3] = rxBuffer[3];

    ((byte *)&bodyTemp)[0] = rxBuffer[4];
    ((byte *)&bodyTemp)[1] = rxBuffer[5];
    ((byte *)&bodyTemp)[2] = rxBuffer[6];
    ((byte *)&bodyTemp)[3] = rxBuffer[7];

    ((byte *)&lat)[0] = rxBuffer[8];
    ((byte *)&lat)[1] = rxBuffer[9];
    ((byte *)&lat)[2] = rxBuffer[10];
    ((byte *)&lat)[3] = rxBuffer[11];


    ((byte *)&lng)[0] = rxBuffer[12];
    ((byte *)&lng)[1] = rxBuffer[13];
    ((byte *)&lng)[2] = rxBuffer[14];
    ((byte *)&lng)[3] = rxBuffer[15];
```

```
    checksum = rxBuffer[16];

    Save_Data();


  }
}
//======================== Save Data From Transmitter ===============
void Save_Data() {
     heartRate_Node1 = heartRate;
     bodyTemp_Node1 = bodyTemp;
     lat_Node1 = lat;
     lng_Node1 = lng;
     digitalWrite(LED_RED,HIGH);
     delay(50);
     digitalWrite(LED_RED,LOW);
     Display_data_Node();
}
//======================== Display Data Node 1 ===============
void Display_data_Node() {
  Serial.println("=================== Data ================");
  rssi = LoRa.packetRssi();

  Serial.print("Heart Rate : ");
  Serial.println(heartRate_Node1);

  Serial.print("Body Temperature : ");
  Serial.println(bodyTemp_Node1);

  Serial.print("Latitude : ");
  Serial.println(lat_Node1, 6);

  Serial.print("Longitude : ");
  Serial.println(lng_Node1, 6);

  Serial.print("rssi:");
  Serial.println(rssi);
  Serial.println("=================== END ================");
}

void Cnt_btn(){
  Btn_State = digitalRead(Btn);
  if(Btn_State != last_Btn_State){
    if(Btn_State == 1){
      Cnt_Btn++;
    }
    if(Cnt_Btn > 2){
      Cnt_Btn = 0;
    }
    delay(50);
```

```
    lcd.clear();
    last_Btn_State = Btn_State;
  }

  switch(Cnt_Btn){
    case 0:
      lcd.setCursor(0,0);
      lcd.print("BPM:");
      lcd.print(heartRate_Node1);
      lcd.print("   ");
      lcd.setCursor(0,1);
      lcd.print("Temp:");
      lcd.print(bodyTemp_Node1);
      lcd.print((char)223);
      lcd.print("C  ");
    break;

    case 1:
      lcd.setCursor(0,0);
      lcd.print("Lat:");
      lcd.print(lat_Node1,6);
      lcd.print("   ");
      lcd.setCursor(0,1);
      lcd.print("Lng:");
      lcd.print(lng_Node1,6);
      lcd.print("   ");
    break;

    case 2:
      lcd.setCursor(0,0);
      lcd.print("Signal Strength");
      lcd.setCursor(0,1);
      lcd.print("RSSI:");
      lcd.print(rssi);
    break;

  }

}
```