Faculty of Engineering

HEALTHCARE MONITORING SYSTEMS USING LORAWAN TECHNOLOGY

Mohamad Shazwan bin Aziz

Bachelor of Engineering (Hons)

Electrical and Electronics Engineering

2022

HEALTHCARE MONITORING SYSTEMS USING LORAWAN TECHNOLOGY

Healthcare Monitoring Systems Using Lorawan Technology

MOHAMAD SHAZWAN BIN AZIZ

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering (Hons)

Electrical and Electronics Engineering

Faculty of Engineering

Universiti Malaysia Sarawak

2022

UNIVERSITI MALAYSIA SARAWAK

Grade: ____________

Please tick (√)

Final Year Project Report ☑

Masters ☐

PhD ☐

DECLARATION OF ORIGINAL WORK

This declaration is made on the ......21........day of.....July......2012.

Student's Declaration:

I MOHAMAD SHAZWAN BIN AZIZ (64865), from FACULTY OF ENGINEERING (PLEASE INDICATE STUDENT'S NAME, MATRIC NO. AND FACULTY) hereby declare that the work entitled HEALTHCARE MONITORING SYSTEMS USING LORAWAN TECHNOLOGY is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

21/7/2022
Date submitted

Mohamad shazwan bin Aziz (64865)
Name of the student (Matric No.)

Supervisor's Declaration:

I Dyg Norkhairunnisa Abang Zaidel (SUPERVISOR'S NAME) hereby certifies that the work entitled ~~Healthcare~~ Healthcare Monitoring systems using LoRaWan Technology (TITLE) was prepared by the above named student, and was submitted to the "FACULTY" as a * ~~partial~~/full fulfillment for the conferment of Banchelor of Engineering Electrical and Electronic Engineering (PLEASE INDICATE THE DEGREE), and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: Dyg. Norkhairunnisa
(Name of the supervisor)

Date: 21/07/2022

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*

☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done)*

☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirm with free consent and willingly declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature Showen (Date) 21/7/2022

Supervisor signature: (Date) 21/07/2022

Current Address:
Faculty of Engineering (FENG), 94300, Kota Samarahan, Sarawak

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services]

ACKNOWLEDGEMENT

First and foremost, I would like to express my gratitude to my supervisor, Dr Dyg Norkhairunnisa Binti Abang Zaidel from the Department of Electrical and Electronic Engineering, for her patience and guidance throughout completing my research under her supervision.

Besides, I also would like to thank my family, especially my parents, for giving me their moral support, motivation, and encouragement throughout completing FYP1 research at home due to pandemic COVID-19.

Finally, special thanks to my fellow friends, especially my colleagues, who have always been there for me and encouraged me not to give up throughout this hectic semester. I appreciate your kindness, advice, and motivation. I would never go this far without their support.

ABSTRACT

In this era of globalization, the Internet requires a network solution that can support these criteria of Things (IoT) vision, which calls for a rising number of interconnected sensor nodes. Additionally, crucial components of IoT include other difficulties, including latency, range coverage, and bandwidth. As a result, it considers the enormous volume of expected nodes connected to the Internet. The LoRaWAN (Low Power WAN Protocol for Internet of Things), a data-link layer with long-range, low power, and low bit rate emerged as a possible option for IoT in which end-devices use LoRa to interact with gateways over a single hop, is a promising alternative. This paper will focus on developing a healthcare monitoring system using LoRaWAN technologies that are able to measure heart rate and oxygen level with a broader range in real-time data transmission. This thesis will focus on the distance between Hotspot and LoRaWAN, where a comparison is made between both technologies. The outcome of this thesis is that LoRaWAN can detect heart rate (BPM) and oxygen saturation (SpO2) more comprehensive, 2.36km, compared to Hotspots, 15m from CAE Lab 1. The main issue during this project is that the current device is incompatible with The Things Network (TTN) and takes a lot of time to connect to the LoRa gateway. Furthermore, weather and buildings also affected the range of both technologies.

ABSTRAK

Pada era globalisasi ini, Internet memerlukan penyelesaian rangkaian yang boleh menyokong Internet Pelbagai Benda (IPB), yang memerlukan peningkatan bilangan nod sensor yang saling berkaitan. Selain itu, komponen penting IPB termasuk kesukaran lain, kependaman, liputan julat, dan lebar jalur. Akibatnya, ia menganggap jumlah besar nod yang dijangka disambungkan ke Internet. LoRaWAN (Protokol WAN Kuasa Rendaah untuk Internet Pelbagai Benda), lapisan pautan data dengan jarak jauh, kuasa rendah, dan kadar bit rendah muncul sebagai pilihan yang mungkin untuk IPB di mana peranti akhir menggunakan LoRa untuk berinteraksi dengan lawing laluan memalui hop tunggal, adalah alternatif yang menjanjikan. Kertas kerja ini akan menumpukan pada membangunkan system pemantauan penjagaan kesihatan menggunakan teknologi LoRaWAN yang mampu mengukur kadar denyutan jantung dan paras oksigen dengan julat yang lebih luas dalam penghantaran data masa nyata. Tesis ini akan memberi tumpuan kepada jarak antara Hotspot dan LoRaWAN, di mana perbandingan dibuat antara kedua-dua teknologi. Hasil daripada tesis ini ialah LoRaWAN dapat mengesan kadar denyutan jantung (BPM) dan ketepuan oksigen (SpO2) dengan lebih komprehensif, 2.36km, berbanding Hotspot, 15m dari CAE Lab 1. Isu utama semasa projek ini ialah peranti semasa tidak serasi dengan The Things Network (TTN) dan mengambil banyak masa untuk menyambung ke get laluan LoRa. Tambahan pula, cuaca dan bangunan turut mempengaruhi julat kedua-dua teknologi

TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF ABBREVIATIONS

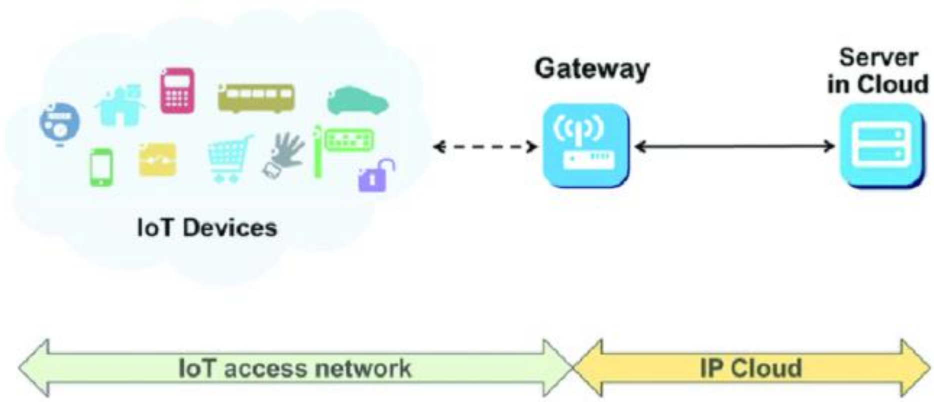
HMS	-	Healthcare Monitoring System
LoRaWAN	-	Long Range Wide Area Network
LoRa	-	Long Range
IoT	-	Internet of Things
LPWAN	-	Low-Power Wide Area Network
FYP	-	Final Year Project
I2C	-	Inter-Integrated Circuit
GPS	-	Global Positioning System
LCD	-	Liquid Crystal Display
BPM	-	Beats per Minute
SpO2	-	Oxygen Saturation

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Internet of Things (IoT) is an ideal concept for embedding sensors, actuators, and processors in various things that compute and communicate via the internet. The benefits of IoT in healthcare include life-saving telemedicine, remote diagnosis, patient monitoring, and therapy [1-2]. The IoT is an architectural framework that enables data interchange and integration between the real world and computer systems using the current communications framework. Therefore, many products, such as smartphones, laptops, healthcare devices, and other electronic devices, are designed around the IoT concept throughout the year. Based on [3], *healthcare* is defined as improving health through diagnosing, treating, and preventing diseases by health professionals such as doctors, dentists, and other medical practitioners. **Figure 1.1** show a general scheme of IoT architecture and a real-time patient monitoring system.



1Figure 1.1: General architecture of IoT [4-5].

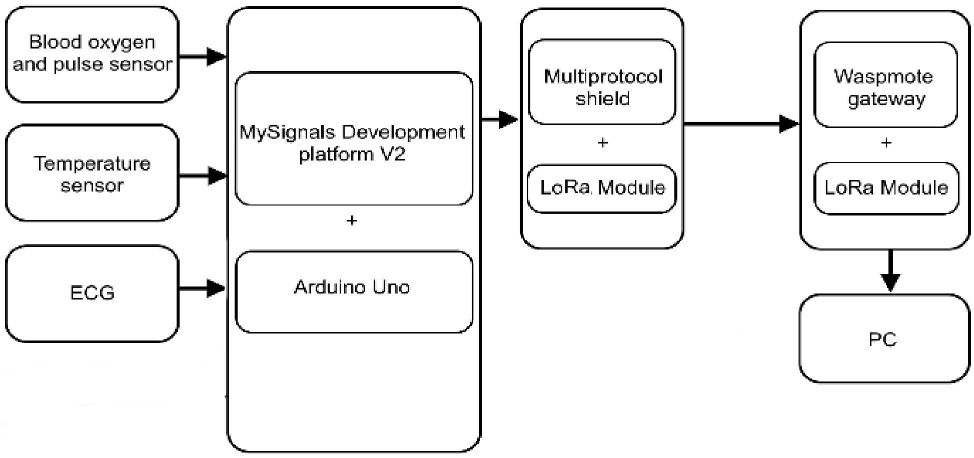
Multiple physical-layer networks are consolidated into a single converged network in an IoT access network, which overcomes these concerns. Furthermore, a single network can make enrolling IoT sensors and devices easier, create universal security protocols, and unify IoT endpoint administration and policymaking. In a nutshell, an IoT access network enables businesses to reap the benefits of IoT use cases more rapidly [6]. For example, the IoT is at the centre of today's IoT access control, also known as smart door locking system applications.

Each key, clamp access controller, scanner, and other associated device is assigned an IP address used for communication throughout this system. This intelligent equipment is generally connected to their centralised management software or mobile application in a single building through wireless networks [7]. These apps may be set up to operate various locks and controllers automatically or manually. Security alerts and notifications can also be set up to get real-time updates from mobile apps.

A IoT network is an extensive network that facilitates IoT devices and systems. The architecture, platforms, and storage necessary for real-time computing and processes are included in this category. An IoT cloud also consists of the services and standards required to connect, manage, and secure various IoT hardware and software. IoT clouds provide a cost-effective, flexible, and scalable method for organisations with limited resources for offering the structure and service required to allow IoT technologies devices and systems [8]. IoT clouds providing:

- On-demand,
- Low-price hyper-scale,
- It made it possible for companies to use the IoT's enormous potential without needing to create the necessary services and infrastructure from scratch.

RFID (Radio-frequency identification), utility computing, wireless communication systems, and LPWAN technologies such as NB-IoT and LoRa are promising for large-scale IoT application development [9]. They aid in improving device internet connectivity and the efficiency with which IoT apps work. LoRa is a spread spectrum modulation technique that evolved from chirp spread spectrum (CSS) technologies because of the need for more bandwidth while transmitting a signal [10]. LoRa's modulation approach makes it resilient to channel noise such as data and information.



2Figure 1.2: Block diagram of HMS with LoRa Communication Technology [9].

Figure 1.2 illustrates the HMS development process; biomedical sensors are coupled to MySignals and the Arduino Microcontroller to gather health information. The authors [9] stated that acquired data is subsequently sent to the personal computer through the LoRa module as well as gateway. Wi-Fi, Bluetooth 4.0 and Zigbee are well-known wireless technologies for Local Area Networks (LAN) and are all well-established protocols in both. These wireless technologies have dominated the IoT market due to their popularity and simple protocol. However, there is a disadvantage or difficulty with that technology in IoT which is the transmission range [10-11].

In addition, the HMS not only provides patients with seamless healthcare in a comfortable home environment while reducing medical treatment costs, but it also allows limited hospital resources to be utilised for persons in need of emergency care.

1.2 Problem Statement

The existing HMS cannot provide real-time patient health updates and is limited by the patient's distance from the hospital. According to [10], [12-13], the authors conducted an indoor positioning test using Wi-Fi and LoRa technologies, respectively. The Wi-Fi-based locating system in [12] has a coverage area of only 2 metres. In comparison, the work in [13] can accomplish a maximum coverage area of 200 metres and a placement precision of 28.8 metres. Both authors demonstrate the limitations of Wi-Fi technology in locating systems as compared to LoRa technology. The solution will be more expensive to implement if Wi-Fi or Bluetooth technology is used to establish a long-range communication network that requires an additional range extender. This drives the development of numerous LPWAN technologies, such as LoRa, to meet these requirements.

Still, the current approach is inefficient in terms of collecting measures from patients and is not cost-effective. LoRa Technology's low power, low cost, and consistent performance make it perfect for vital, intelligent healthcare applications [14]. Moreover, IoT solutions based on LoRa sensors and gateways can continuously monitor high-risk patients or systems, guaranteeing that the health and safety of patients and systems are never jeopardised.

1.3 Research Objectives

There are two main objectives in this research which includes;

1. To construct a low-cost HMS that can work in wide-ranging distance by using LoRaWAN technology that can:
   i. Measure the heart rate and oxygen level.
   ii. Real-time data transmission.
   iii. Display the information collected by sensors.

2. To develop a mobile app (Blynk) that connected to the health monitoring system.

1.4 Project Significance

In this research, a newly developed health monitoring system that can transmit more extended range up to **2 km suburban** and give real-time health reports whenever and wherever construction is taking place.

1.5 Thesis Outline

The thesis report is organised into five sections: introduction, literature review, methodology, results and discussion, and conclusion. The first chapter will go through the research's background, research problem, research objective, and project significance.

The research literature review is explained in Chapter 2. It all starts with a health monitoring system in the background. The current authors' proposed strategy for health monitoring systems and their application will be discussed next. Next, the basic concept of vital human signals, such as pulse rate and oxygen levels, will be presented. LPWAN technologies such as LoRa, LoRaWAN with their classes were also introduced. Finally, this chapter will go over the comparison in LPWAN systems briefly.

In Chapter 3, the author will choose which model to create the system, the Waterfall model, Spiral Model, and Prototyping Model. Then, research approach is detailed using a conceptual framework, and design requirements. This chapter also covers how and what sort of hardware will be connected and the software that will be utilised in the design.

Chapter 4 presents the prototype results of the HMS device between Hotspots and LoRaWAN. The results will be presented based on distance measurement. Besides, the constraint of GPS will be analysed. Finally, the comparison between Hotspots and LoRaWAN will be explained in detail.

Chapter 5 focuses more on the summary of the research. The suggestion and recommendations for future research are also stated.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

A basic explanation of the health monitoring system (HMS) is provided in this chapter. Contemporary authors' proposed approach for HMSs will next be explained, along with the application. Next, the fundamental notion of vital human signs, including pulse rate and oxygen levels, will be discussed. Then there were LPWAN technologies like LoRa, SigFox, Fiber-Optics, WI-SUN, NB-IoT, DASH7, and SNOW. Finally, this chapter will provide a brief explanation of cost estimation and comparison among LPWAN systems.

2.2 Human Health Monitoring System

2.2.1 Overview

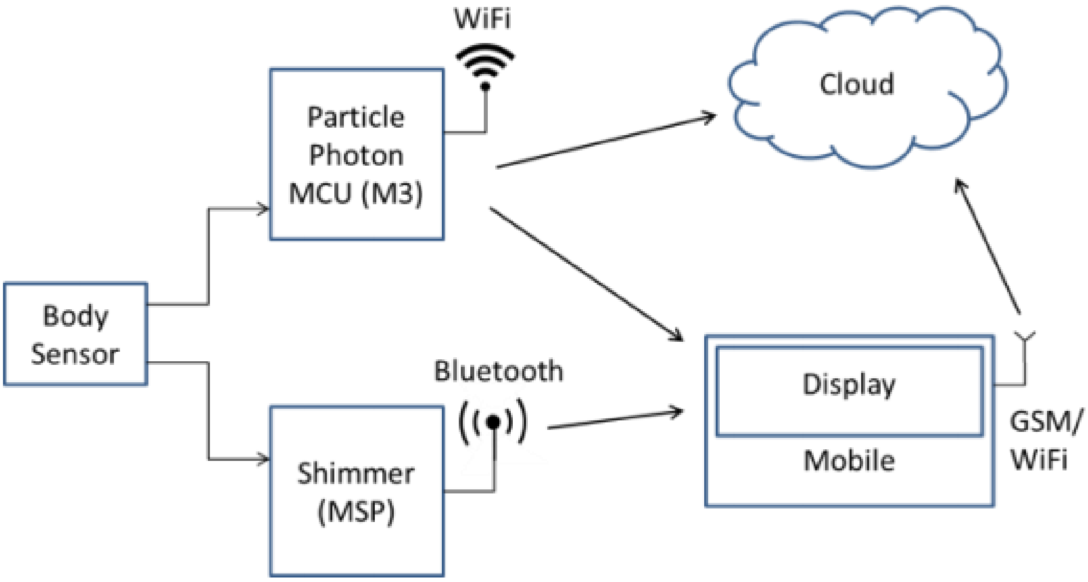
A HMS measures the vital indicators of the human body regularly. Health monitoring is critical because it provides medical practitioners with the information, they need to analyse a patient's status and diagnose the problem they are experiencing. However, today, the HMS is built fast because it cannot provide real-time health updates and is constrained by distance. This project aims to create a functioning prototype of a wireless HMS that can update health information regardless of time or location.

The phrase "health monitoring" refers to tracking a wide range of physiological indicators. One of these signals is heart rate, which is linked to the state of the body's circulatory system. Recently, heart rate monitoring has been accessible from manufacturers using an onboard or wearable heart rate sensor. Although heart rate monitoring is usually utilised for individual usage, especially in sports, it may also be used as part of a warning system for persons at risk while participating in physical activity and for the elderly [15].

2.2.2 Current Health Monitoring Systems

P. Jangra and M. Gupta [16] demonstrated an IoT-based intelligent healthcare monitoring system that uses biological signals to provide real-time patient surveillance. Biosensor-based data gathering, and aggregation utilities benefit from the proposed multi-layered structure. In high-stress conditions, it also leads to creating a real-time, efficient decision-making system. Moreover, before transmitting data to the edge node, this strategy may compress data perceived by sensors, lowering the amount of power required by the sensor device to provide the sensed data. After then, an intelligent node, which may be a smartphone, a laptop, or a tablet, will get this minimally processed data. The remaining processing is finished here, and the obtained data is then delivered through the internet to medical personnel and doctors. A mobile app might be developed to make the edge node more intelligent and smarter. The proposed design is simulated using LABVIEW software.

Meanwhile, an EPIC sensor system detects Heart Rate (HR) and Respiration Rate (RR) before delivering the data over Wi-Fi connectivity to mobile platforms or the cloud, according to Hegde et al. [17]. When combined with a proper analogue pre-processing board, all body sensors can be sampled using a low-power microcontroller. Instead, as indicated in **Figure 2.1**, a shimmer approach may be used to test the sensor; it transfers data to a smartphone at a shorter distance through Bluetooth. Consequently, the shimmer device has the benefit of allowing the output to be pre-filtered 3D orientation and synchronised with the sensor data. Furthermore, the receiving device can take many forms, and data may be taken and transmitted immediately to the cloud through Wi-Fi; the transmitted data is saved and processed further in the cloud. The smartphone enables real-time or offline data editing and exhibits on the phone screen.



3Figure 2.1: Internet of Things Monitoring Network [17]

Tamilselvi et al. [18] proposed technique was created utilising the ThingSpeak IoT technology as shown in **Figure 2.2**. In this system, the Eyeblink and SPO2 sensors are also employed to monitor the coma patients' eye blink and oxygen saturation percentages. All the sensors in the proposed architecture and their output values are used to monitor the health of coma patients. These sensors have been utilised in IoT to transmit medical data via the ESP8266 Wi-Fi module, and the patient's data may be saved, analysed, and shown as graphs. Additionally, it may be seen via a mobile application.