RANGE-BASED USER POSITIONING SYSTEM BASED ON INTERNET OF THINGS (IOT)

TEH CHEE WAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

RANGE-BASED USER POSITIONING SYSTEM BASED ON INTERNET OF THINGS (IOT)

TEH CHEE WAN

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2022

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : RANGE-BASED USER POSITIONING SYSTEM BASED ON INTERNET OF THINGS (IOT)

Sesi Pengajian : 2021/2022

Saya TEH CHEE WAN mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐ **SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐ **TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.)
☑ **TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

DR. ABD SHUKUR BIN JA'AFAR
Senior Lecturer
Faculty of Electronics And Computer Engineering
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka

Alamat Tetap: No 275, Simpang Tiga, Jalan Rungkup, 36200, Selekoh, Perak

Tarikh : 1 June 2022

Tarikh : 1 June 2022

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this report entitled “Range-Based User Positioning System Based on Internet of Things (IoT)” is the result of my own work except for quotes as cited in the references.

Signature : .....

Author : TEH CHEE WAN .....

Date : 1/6/2022 .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : _____

Supervisor Name : DR ABD SHUKUR BIN JA'AFAR

Date : 1/6/2022

DEDICATION

To my supervisor Dr. Abd Shukur Ja'afar who was backbone in helping me throughout the journey. Also, to my parents and friends who supported me.

ABSTRACT

Real-time location of user has become critical for service deployment in many fields. Global Positioning System has been wildly succeeded but it is less accurate to locate users at the place where the GPS or satellite technologies are lack precision. For this reason, a project of Range-Based User positioning system based on Internet of Things (IoT) have been proposed and developed. The system is based on Node MCU (ESP32) and it will collect RSSI from the BLE beacon. Log-Distance and ITU propagation models have been embedded to compute distance estimation from collected RSSI vector. The system will be connected to the IoT Platform and notify PIC when the user exceed certain range through Telegram application. Then, the range estimation for indoor Line-of-Sight and indoor Non-Line-of-Sight were analysed using both propagation models as mentioned. Kalman filter is also implemented to mitigate the effect of multipath fading. The estimated range utilizing Log-Distance and ITU propagation models were compared to the actual distance to analyse error of range-based accuracy in term of RMSE and CDF. The CDF shows 90% of distance estimation error using model ITU for LOS is lower than 3.6 meters while for NLOS is 5.6 meters. Whereas 90% of distance estimation error using model Log-Distance for LOS is lower than 4.1 meters while for NLOS is 7.2 meters.

ABSTRAK

Lokasi masa nyata bagi pengguna menjadi sangat kritikal bagi sesetengah perkhidmatan. Global Positioning System telah menjadi keutamaaan bagi penentududukan. Tetapi system ini kurang tepat untuk menentukan kedudukan pengguna di mana teknologi satelite kurang berkesan di sesetengah kawasan. Oleh sebab itu, satu project bertajuk "Sistem Penentududukan Berasaskan Jarak Berdasarkan Internet of Things (IoT)" telah dibangunkan. Sistem tersebut dibangunkan berdasarkan Node MCU (ESP 32) di mana ianya akan mengumpul data RSSI dari pemancar BLE. Model perambatan Log-Distance dan ITU telah diprogramkan untuk mengira jarak anggaran dari vector RSSI. System ini akan disambungkan ke platform IoT dan akan memaklumkan orang yang bertanggungjawab apabila pengguna melebihi tahap jarak menerusi aplikasi Telegram. Kemudian, jarak anggaran untuk kondisi garis penglihatan (LOS) dan bukan garis penglihatan (NLOS) dianalisis menggunakan kedua-dua model perambatan tersebut. Penapis Kalman digunakan untuk mengurangkan kesan pemudaran berbilang laluan. Jarak anggaran menggunakan model Log-Distance dan ITU dibandingkan dengan jarak sebenar untuk analisis ralat bagi kejituan berasaskan jarak dari segi RMSE dan CDF. Keputusan CDF menunjukkan 90% ralat jarak

anggaran meggunakan ITU untuk LOS lebih rendah dari 3.6m sedangkan untuk NLOS adalah 5.6m. Manakala, 90% dari ralat jarak anggaran menggunakan model Log-Distance bagi LOS adalah lebih rendah dari 4.1 m dan untuk NLOS adalah 7.2 m.

ACKNOWLEDGEMENTS

First thing first, I would like to express my deepest gratitude to my supervisor, Dr. Abd Shukur Ja' afar who has been guiding me and giving me continuous support throughout this journey. It was an honor to study under their guidance.

Next, I could not have done this without my parent support. Thank you to my parent, Teh Teck Seng and Lim Soo Peng, who continuously encouraged me. Moreover, not forgetting my friends who constantly helped me and being there for me from the beginning till the end as well.

Last but not the least, I would like to express my gratitude to everyone who contributed directly or indirectly in completing this project thesis successfully.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

IoT	:	Internet of Things
RMSE	:	Root Mean-Square-Error
CDF	:	Cumulative Density Function
GPS	:	Global Positioning System
IPS	:	Indoor Positioning System
Wi-Fi	:	Wireless Fidel
BLE	:	Bluetooth Low Energy
RSSI	:	Received Signal Strength Indicators
LoRa	:	Long Range Radio
LOS	:	Line-of-Sight
NLOS	:	Non-Line-of-Sight
PIC	:	Person in Charge
ITU	:	International Telecommunication Union
OLED	:	Organic Light-Emitting Diode

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Positioning system has become important in human daily activities and critical for service deployment in many fields nowadays[1]. Although Global Positioning System has been wildly successful, however, it is less accurate to locate users at the place where the GPS or satellite technologies are lack precision[2]. For this reason, the project entitled 'Range-based User Positioning System Based on Internet of Things (IoT)' is proposed. It aims to design a user positioning system to locate the users inside the building in range-based cell as well as investigate the distance estimation for indoor Line-of-Sight (LOS) and indoor Non-Line-of-Sight (NLOS). Also, the error of distance estimation accuracy was analyzed in term of Root Mean-Square-Error

(RMSE) and Cumulative Density Function (CDF). To develop an indoor user positioning system, the proposed project has implemented Bluetooth and LoRa for communication of indoor positioning. A GPS module also been used to obtain the latitude and longitude wherever the user over the range. The system consists of 5 parts that are Bluetooth Beacon, GPS module, Transceiver Node MCU ESP32, LoRa communication module and IoT Platform. Bluetooth beacon will emit RSSI and will be received by Transceiver ESP 32 and the distance estimation with Bluetooth beacon will be completed. After that, GPS module will read the location longitude and latitude of the Transceiver ESP 32. Then, Receiver ESP 32 will receive the positioning data through LoRa modules and save in the IoT Platform for users to view. At the end of this project, a range-based user positioning system based on IoT will be developed by utilizing LoRa, BLE and GPS module.

1.2 Problem Statement

Global Positioning System has been a huge succeed but it lacks the precision to locate users inside a building [3]. One of the main problems is the GPS signal was blocked or cannot penetrate building. Therefore, to use GPS for indoor approximation is useless and other technologies need to be investigated.

According to Qureshi, U. M., Umair, et.al., the user positioning system uses Wireless Fidelity (Wi-Fi) and Bluetooth Low Energy (BLE) to determine the user's location based on signal strength as determined by Received Signal Strength Indicators (RSSI)) [4].

However, Wi-Fi has a higher center of frequency so it cannot penetrate through heavy objects of buildings causing it to be unstable due to the multipath effect or noise [5]. Also, the range of connectivity of Wi-Fi is limited to approximately 20 meters [6]. If there are many obstacles such as heavy objects in a building, the accuracy of the positioning system will be lowered as Wi-Fi cannot penetrate through the heavy objects and it is unstable. Besides, the access to the Wi-Fi location mainly on coverage at the first place but not focus on positioning.

Therefore, in this project, positioning system based on Long Range Radio (LoRa) and Bluetooth is introduced. LoRa has a cheap cost and very low power consumption, and its signal with city-level range is resistant to multipath effect, as well as a higher range of connectivity in an application of tens or hundreds of kilometers. As a result, LoRa signals have higher penetration power and stability compares to Wi-Fi in which LoRa will have the higher accuracy in positioning.

1.3 Objective

The objectives of the project are:

- To develop a range-based positioning system utilizing BLE and LoRa based on IoT.
- To investigate the range-based estimation propagation model for indoor Line-of-Sight (LOS) and indoor Non-Line-of-Sight (NLOS).
- To analyze the error of range-based accuracy in term of RMSE and CDF.

1.4 Scope of Project

The scope of work is mainly focus on the development of cell-based positioning system utilizing BLE and LoRa based on IoT and investigate the range-based estimation for indoor and outdoor range as well as analyze the error of range-based accuracy in term of RMSE and CDF. LoRa and Bluetooth will be implemented in this project. LoRa has good penetration ability and stability. It makes the positioning system to have a higher accuracy in positioning although there is multipath effect or noise. However, Bluetooth has higher center of frequency which means it is harder to penetrate through the heavy object and it will affect the accuracy of the position. Also, a GPS module is used to identify the longitude and latitude of the user which make the accuracy to be increased when the user is at the outside of the building where the GPS signal are strong. The data of the positioning will be sent and stored in IoT Platform through LoRa gateway. An alert message will be sent to the person in charge (PIC) when the user has moved beyond the set distance. Programs are written and uploaded to the microcontroller Node MCU ESP32 by using Arduino Software.

1.5 Project Impact - Importance and Significant.

This project provides the real-time insight of the user. The user can get the real-time information on what is going on in the facility so that the user can find out where are the users are located at any time. Next, we can have the quicker incident respond to keep the people safe. As far as we know the user's real-time location, someone can report the accident or emergency as soon as possible when accident happens. In addition, this project is vital in some application such as smart home like health, surveillance and security. This is because they require a real-time room based of positioning user to locate the user exact position, which especially crucial for elders and people with physical impairments [6]. This device as a CSR project and soon will be tested at the Pusat Kebajikan Villa Harapan, Bukit Katil Melaka.