

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

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**UNIVERSITI TEKNIKAL MALAYSIA
MELAKA**

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

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

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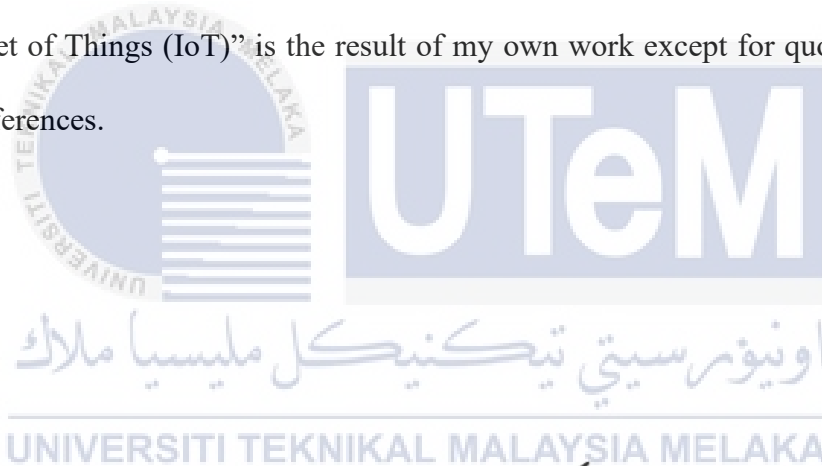
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DECLARATION

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.



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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 widely 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 keutamaan bagi penentuan kedudukan. 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 Penentuan Berasaskan Jarak Berasaskan *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 menggunakan 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.



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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 Fidelity
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

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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 success 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.

