INVESTIGATION ON LOCATION IDENTIFICATION METHODS FOR IOT DEVICES USING BLUETOOTH LOW ENERGY (BLE)

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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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DEDICATION

Thanks to my supervisor, family, friends and all lecturers who willing to guide me and support me throughout this final year project.

ABSTRACT

Indoor localization is a positioning method that used for closed environment condition. Since Internet of Things or IOT devices come with small size microcontroller units, positioning algorithms are studied and three of them are tested based on three parameters which are accuracy, algorithms response time and programming bit size. In this project, three Radio Signal Strength Indicator or RSSI based positioning algorithms are used to get the results which are trilateration, fingerprinting and proximity. Based on the data collected, proximity algorithm gives the highest accuracy, lowest response time, and lowest programming bit size. This project can be improved by sending the location of IOT devices to cloud so that it can be track by other IOT devices.

ABSTRAK

Penyetempatan dalaman merupakan kaedah kedudukan yang digunakan untuk keadaan persekitaran tertutup. Sejak peranti IOT datang dengan unit mikrokontroler yang bersaiz kecil, algoritma kedudukan dipelajari dan tiga daripada mereka diuji berdasarkan tiga parameter iaitu ketepatan, masa respon algoritma dan saiz bit pengaturcaraan. Dalam projek ini, tiga algoritma kedudukan, trilateration, cap jari dan jarak dekat, yang berdasarkan Penunjuk Kekuatan Isyarat Radio atau RSSI telah digunakan untuk mendapatkan data. Berdasarkan data yang dikumpulkan, algoritma jarak dekat memberi ketepatan yang tertinggi, masa respon yang terendah, dan saiz bit pengaturcaraan yang terendah. Projek ini dapat diperbaiki dengan menghantar lokasi peranti IOT ke cloud supaya dapat ditrek oleh peranti IOT lain.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

Aps	:	Access Points
B_1	:	Beacon 1
B_2	:	Beacon 2
B_3	:	Beacon 3
BLE	:	Bluetooth Low Energy
dBm	:	decibel-milliwatts, unit of signal strength
Gps	:	Global positioning system
int32	:	32 bits integer
IOT	:	Internet of Things
kb	:	kilobytes, unit used for calculating size of software file
Method 1	:	Trilateration
Method 2	:	Fingerprinting
Method 3	:	Proximity
PAN	:	Personal Area Network
RFID	:	Radio Frequency Identification
RSIC	:	Reduced Instruction Set Computing
RSSI	:	Received Signal Strength Indicator
µs	:	Microsecond, unit of time used
WiFi/Wi-Fi	:	Wireless fidelity
WLAN	:	Wireless Local Area Network
X_ave	:	Average value on x axis
Y_ave	:	Average value on y axis

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Localization is a technology that used to detect the location of an object. Nowadays, there have several algorithms that can be used for estimating the position of an Internet of Things (IOT) device. However, most of the IOT devices come in smaller sizes of microcontroller unit. Three types of algorithms have been studied and the performance of the algorithms on IOT board has been evaluated.

1.1 Background of Study

IOT is defined as a set of technologies that used to access the data collected by individual or multiple devices through wireless and wired Internet networks [1].

In recent year, indoor localization is widely used in a variety of applications to track and locate people or IOT devices inside a building or closed area such as locating

patients in hospital [2] and customer tracking [3]. There have several positioning systems for indoor localization such as Global positioning system (GPS), wireless local area network (WLAN), radio frequency identification (RFID) and Bluetooth Low Energy (BLE).

BLE beacon is used to identify the location of the IOT devices in a closed environment. BLE is a wireless personal area network (PAN) which can provide low power consumption and cost while maintaining the similar communication range [4]. The beacon is an energy saving device which come in a small size that can broadcast a Bluetooth signal periodically [5].

Nowadays, most IOT devices come with small size microcontroller units which results in a small memory size. To overcome this problem, three algorithms are used to make the positioning estimation and the performance of these algorithms are compared according to the parameter set. At last, the algorithm with the algorithm that give the best accuracy on localization predict, fast response time and with small programming bit size will be chosen.

1.2 Problem Statement

Nowadays, the IOT devices come with small size microcontroller units. The bigger programming code file will results longer operating time. Therefore, this study is conducted to find the best indoor location identification algorithm for IOT device, especially for STM32 microcontroller board based on the parameter or target set which are accurate, algorithm response time and programming bit size.

1.3 Objectives

The objectives of this project are as follows:

i. To study the indoor positioning algorithms for the IOT device board.

ii. To evaluate the performance of the accuracy, response time, and programming bit size for all tree algorithms.

iii. To evaluate the best algorithm based on the performance that can fit into the IOT device board.

1.4 Scope of Work

This project is to choose the best indoor location identification algorithms for the STM32 microcontroller IOT board. The technology use for indoor location identification will concentrate on BLE where the NRF 51422 dongles will be used as a beacon.

1.5 Thesis Outline

This report is done with five main chapters which are the introduction, literature review, methodology, discussion and result, and conclusion.

In chapter 1, the main idea of the project is briefly explained via background of study, objectives, problem statement, scope of work. It provides project guideline and list out the limitation of this project.

In chapter 2, study background related to the project will be done. Overall literature will produce a framework that shows the link between research projects with theories and concepts.

In chapter 3, the method used in this project is discussed. Flow charts related to this project are constructed step by step. The purpose of this chapter is to explain the method and techniques used though-out this project.

In chapter 4, all the data collected from this project are represented. These data will be compared and discussed clearly.

In chapter 5, the overall summary of this thesis will be summarized based on the objectives given previously. In addition, the future work and recommendation related to this study will be discussed too.

CHAPTER 2

BACKGROUND STUDY

This chapter will discuss the background and technology of object localization. In order to investigate the algorithms used in localization technology, various papers which done by other researchers are analysed and compared.

2.1 Object Localization technology

Object localization or positioning systems are technology that used to locate and track the position of the objects. There have two types of positioning systems which are indoor (closed environment) and outdoor positioning [2].

2.1.1 GPS

In the year 2010, authors Koyuncu and Yang [2] state that the GPS is the most widely used satellite-based positioning system that is used to determine the physical locations of the user at the outdoor environment. The location of the user can be detected by receiving the signals from multiple satellites and employing a triangulation process. However, GPS is not suitable for indoor location identification due to the building materials will weaken the electromagnetic waves transmitted by the satellite. Besides that, the authors also state out the solution to solve this problem by using High Sensitive GPS which can track people behind 3 layer brick wall but still resulting in a low accuracy positioning. These authors [6] state although GPS can offer the maximum coverage, but it is impossible to be used in an indoor environment. This is because the propagation of electromagnetic waves or the line-of-sight transmission between receivers and satellites are more complex. Based on the article, the GPS signal is influenced by the barrier such as walls, equipment, and human beings. This author [7] state that GPS need huge energy consumption and having accuracy within 10m.

2.1.2 Bluetooth Low Energy Beacon

In year 2015, the authors state that BLE or Bluetooth smart is designed to operate in low power that can run on coin battery and easy to be installed. By comparing with the Wireless fidelity (Wi-Fi), BLE has a low overall received signal strength and small signal attenuation coefficient due to low power operation. According to the authors, the BLE signal does not spread widely like Wi-Fi network [8]. In the same year, M. E. Rida, F. Liu, Y. Jadi, A. Ali, A. Algawhari, and A. Askourih state that BLE 4.0 is a great solution to overcome some of the challenges met during indoor localization such as cost, instability, low accuracy, low precision and high-power consumption. BLE 4.0 technology has allowed a low cost and low power consumption, indoor location