INDOOR LOCALIZATION AND DIRECTION SENSING VIA RFID APPROACH

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INDOOR LOCALIZATION AND DIRECTION SENSING VIA RFID APPROACH

by

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LIST OF ABBREVIATIONS

RFID	Radio Frequency Identification
GPS	Global Positioning System
RSSI	Receive Signal Strength Indicator
TDOA	Times Difference of Arrival
AOA	Angle of Arrival
TOA	Times of Arrival
TDOF	Times Difference of Flight
RF	Radio Frequency
UWB	Ultra-wideband
API	Application Programming Interface
DIN	Data In
USB	Universal Serial Bus
PC	Personal Computer
NLS	Nonlinear least square

ABSTRAK

Pengenalan Frekuensi Radio ialah sejenis peranti yang menggunakan frekuensi radio untuk berkomunikasi. Permohonan RFID telah digunakan secara meluas dalam sistem penyetempatan dalaman. Sistem penyetempatan dalaman yang cekap diperlukan untuk mencari lokasi objek yang tidak diketahui. Tujuan utama projek ini adalah untuk mengurangkan ralat anggaran jarak dari pemancar dan penerima. Sistem ini menggunakan teknologi RFID untuk menjadikan sistem lebih berkesan. Perkakasan utama yang digunakan dalam projek ini ialah modul Xbee. Modul Xbee boleh ditetapkan untuk berfungsi sebagai sistem RFID dengan menggunakan perisian XCTU yang merupakan penyelaras sebagai pembaca dan peranti akhir atau kerja penghala sebagai tag. Kaedah yang digunakan dalam projek ini adalah RSSI yang mengukur isyarat antara pemancar dan penerima. Dari nilai RSSI, jarak yang dianggarkan dapat dikira dengan menggunakan persamaan. Seterusnya, trilateration digunakan untuk mencari kedudukan nod yang tidak diketahui. Untuk menggunakan kaedah trilateration, nilai jarak diperlukan sekurang-kurangnya selama tiga titik. Dari nilai jarak, bulatan akan dibentuk untuk setiap jarak sebagai jejari mereka. Hasil simulasi Matlab akan memaparkan skrin dengan tiga bulatan. Persimpangan tiga lingkaran adalah di mana nod diketahui. Ketepatan lokasi dari hasil trilaterasi boleh dikurangkan kira-kira 4.39% untuk sistem ini berbanding kerja sebelumnya.

ABSTRACT

Radio Frequency Identification is a kind of device that use radio frequency to communicate. RFID application has been widely used in indoor localization system. An efficient indoor localization system is needed to find the unknown location of an object. The main purpose of this project is to reduce the error of estimated distance from transmitter and receiver. This system using RFID technology to make the system is more effective. The main hardware used in this project is Xbee module. Xbee module can be set to work as RFID system by using XCTU software which is coordinator as reader and end device or router work as tag. Method apply in this project is RSSI which is to measure the signal between transmitter and receiver. From the RSSI value, estimated distance can be calculated by using equation. Next, trilateration is used to locate the position of the unknown node. To apply trilateration method, distance value needed is at least for three point. From the distance value, a circle will be formed for each distance as their radius. The result of simulation of Matlab will display the screen with the three circles. The intersection of three circle is where the unknown node is. The accuracy of location from trilateration result is able to be reduced about 4.39% for this system compared to the previous work.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, indoor localization and indoor positioning system has become popular in every state and have given more attention to enhance the system. This system is widely used in industry, home, institution and more. This system can be applied in finding or locating an object in a building or indoor. Next, it can be used to help elder people with eye vision problem or blind people to navigate them in an unfamiliar place [1]. This system is achieved by applying several of technique by consider the accuracy and reliability and also the estimation speed and distance in indoor environment.

Besides, there are a lot of technology such as Global Positioning System (GPS), cellular phone tracking system, Wi-Fi positioning system and RFID positioning system. The well-known technology of localization in outdoor environment is Global Positioning System (GPS). GPS apply a direct line-of-sight between receiver and satellite in an unshielded environment. GPS has very poor performance for indoor environment [2].

RFID is being recognized as the future technology for indoor localization project due to high accuracy and low cost. Wi-Fi module and Bluetooth module also can be used in indoor localization system but the costs is one of the challenge that have to consider and also the process of designing and setting up the module is another challenge to take care. For this project, the indoor localization system is focused on active RFID instead of passive for the purpose of better performance and affordable cost [3].RFID has become one of the main means to construct a real time locating system [5].

Many different methods to get the estimation of distance have been proposed for real time of indoor localization system including Angle of Arrival (AOA), Received Signal Strength (RSSI), Time of Arrival (TOA), Time Difference-of-Arrival (TDOA) and Time Difference-of-Flight (TDOF). AOA is a technique of localization technologies based on the measurement of angle between reference points [4]. RSSI uses signal strength to determine the distance between the sender and receiver. The signal will be converted to distance by using several formula [5]. TOA method measures the time it takes for a signal to travel between source and receiver. For TDOA method, the system can be measure by determine the difference between the times of arrival of the same RF signal at different locations [6]. The position determination using different types of algorithms such as trilateration, triangulation, fingerprinting and Landmarks [5].

According to [3], the researchers applying the RSSI method and trilateration method to find the location of a node. There is still some errors about 1.5 meters until 2.8 meters. So, in this project, we proposed the same method which is RSSI and trilateration method by using the different algorithm and difference location to enhance the result of accuracy.

Today, indoor positioning is well-known system and will be the main system used for indoor environment in the future. For example, most of the time, people always having problem with loss of things in their own house. By choosing the Xbee series 2 or ZigBee as the main component, this will help to increase the accuracy of position and location of an object. ZigBee will be setting up to be operating as the RFID system which is reader will be set to coordinator and tag will be set as end device and router.

1.2 Problem Statement

Since the GPS cannot perform well for indoor positioning and localization system, the indoor positioning and localization topic become a popular topic nowadays. Many researchers have conduct experiments for indoor experiments either indoor positioning or indoor localization. However, the most challenging for researchers in conducting indoor localization and positioning experiment is to estimate the range of the distance between transponder and interrogator accurately and to locate the position of the tagged object.

Other than that, cost of system used is another challenge for indoor experiment. Furthermore, the methods widely apply for indoor localization and positioning system are based on the measurement of distances or angles between reference points. The techniques apply such as RSSI, TDOA, TDOF and TOA, but to get accurate range of distance from reader to the tags of RFID is difficult. This is due to several factors such as environmental factors, which is interference that effect the signal measurement.

Focus of this project is to get the more accurate estimation of range distance between transmitters to the receiver and to reduce error from the previous project. From the research before [3], the method applied through the project is RSSI and trilateration method to find the unknown location of node. The error from the output in trilateration shows that the error is from 1.5meters until 2.8 meters [3]. In this project, the error will be reduced by using the same method which is RSSI and trilateration method but the algorithm for trilateration method and the location is different.

1.3 Objectives of Research

Received Signal Strength Indicator (RSSI) and trilateration method are proposed in this project. The objectives of this project are:

- To investigate the enhancement of indoor localization using RFID system based on WSN platform.
- To develop Received Signal Strength Indicator (RSSI) method and trilateration through this project.

1.4 Scope of Research

The scope of this project is to enhance the localization system for indoor environment by applying RSSI method. The location of the node to find can be found by applying trilateration method. This project consist of hardware and software implementations. Arduino Uno will be interface with ZigBee to be operating as coordinator and end device or router. The coordinator and end device will be setting in the X-CTU software. The software used in this project are X-CTU software to set up the ZigBee, the IDE software which is software for Arduino and MATLAB. MATLAB is used to display the output after the trilateration method is applied. The MATLAB will display the coordinate of the node or coordinator by referring to the distance value getting from the signal from two ZigBee. The ZigBee will be operating as the RFID system which is the coordinator as the reader and the end device or router as the tag. The design specification of this project are by using low cost component with better performance and get more accurate result.

1.5 Thesis Outline

This part describe the outline of this thesis. This thesis has been organized into five chapters including chapter one which is tell about introduction until chapter five, the chapter about conclusion and future work.

Chapter two summarize the literature review of the research information. It is all based on the previous work of the others that doing the indoor localization and indoor positioning. Some of researchers do this project by using other RFID types such as passive RFID. Some articles used several methods for indoor localization such AOA, TOA and Triangulation. The basic theory is explained, especially the method that applied in the indoor environment.

Chapter three discuss the overall methodology of this project. The flowchart and explanation of overall process is in this chapter. Also for this chapter include the hardware development and software development. Step by step of process of each method also explained in this chapter.

Chapter four explained and discussed the results of this research project. This part include the result for both hardware and software part.

Lastly, chapter five is the summary of the thesis with the research findings, conclusion and recommendations for the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents of methods and devices use through this project and the contribution to the industry in the future. The review carried out to gain the knowledges, ideas and though in assisting to enhance from the previous project. The method of RSSI and localization algorithm applied through this project are to make it more effective and efficient in the future and to reduce the error from the previous project. The application of the RFID system is studied for uses in the daily life, industry and for the indoor and outdoor work to help deeper understanding about the accuracy distance for indoor localization.

2.2 Indoor Localization System

Localization system is widely developed nowadays. This system can be used in industry, university, home, school and more. It can be applied for small or wide area. For example, a child location can be trace by their parents if they are missing from their parents in the shopping mall. But, the challenge in indoor localization is to get the accurate estimation distance between transmitter and receiver.

A various type of localization techniques can be proposed for indoor localization purpose such as RSSI, TDOA, TOA and TOF [2]. These techniques are used to get more accurate distance for indoor localization. To get the location of the node also has several method can be developed which are trilateration and triangulation. For indoor localization system by other researchers, there are few devices have been developed, such as passive RFID, Bluetooth, sensors, NFC and other radio frequency technologies [14]. Through this

project, active RFID system have been proposed in this project through ZigBee component. This is to consider the cost with better performance [8].

2.3 Received Signal Strength Indicator (RSSI)

According to C. Wang, Z. Shi and F. Wu, RSSI based system are more suitable for tight indoor environments even though this method also can be used for outdoor environments [2]. This can be supported by Y. Álvarez López, M. E. de Cos Gómez, and F. Las-Heras Andrés, "A RFID-based indoor location system that makes use of Received Signal Strength (RSS) information is presented" [7]. The RSSI method is most method being used for indoor localization based on several factors.

Furthermore, in an observation-based study by R. Elamsri, D. W. Engels, J. S. Choi, the positioning system based on the RSSI measurement has two main advantages which are simple implementation and cost effectiveness [9]. This study takes into account the technological problems and considerable costs, and the basic RSSI measurement method based on localization is adopted.

These studies have found the similar results where RSSI is mostly used because of its easier and not complicated, as eloquently quoted by S.F.Wong and X.Ni, "RSSI has been widely adapted for its maturity and simplicity" [10].

Furthermore, as stated by E. Goldoni, A. Savioli, M. Risi and P. Gamba, RSSI is widely used techniques for indoor localization because the process based on RSSI does not require additional hardware [15]. For example ZigBee which include native support for the Received Signal Strength. So that this technique can reduce the total cost and power consumption of a sensor node.

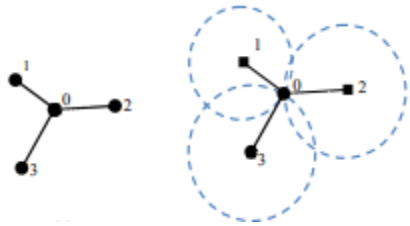
However, these claims can be contended by M.Kim and N.Y.Chong, who indicated that RSSI-based schemes are easily implementable, but the accuracy is highly dependent on the environment and the distance [16]. Although scarce, this assertion by M.Kim and N.Y.Chong can be reinforced by similar allegations by Z. Farid, R. Nordin and M. Ismail [17]. In recent studies, Y.Fu, P.Chen, S.Yang and J.Tang have reasserted that RSSI is the suitable method to be implemented based indoor localization system and indoor positioning system [21].

2.4 Trilateration Method

R. Jarvis, A. Mason, K. Thornhill, B. Zhang, trilateration makes it possible to find a node of an object whether it is two dimensional or three dimensional for indoor positioning or localization. The process can be done from the RSSI, the signal is measured and converted to distance [11]. This distance is needed to apply in the trilateration. This has been agreed by A.J. Yves, and P. Hao, stated that trilateration is a technique use to find unknown location for indoor environment. Furthermore, mentioned that for technique like trilateration, the location of accuracy is improved by increasing the number of reference points [18].

As indicated by Z. Farid, R. Nordin and M. Ismail, trilateration refer to a position determined from distance measurements. It determines the position of an object by measuring its distance from multiple reference points. So, it is called range measurement technique [17]. This can be supported by P. Cotera, M. Velazquez, D. Cruz, L. Medina and M. Bandala which location of a point in space is calculated using the distances from such a point to series of known geometrical entities, for example a sphere or a circle [19]. X. Zhu, Y. Feng, also agree with the statement, “In trilateration, there are two techniques

used, by measuring distance to 3 anchor nodes and by ranging circles," [4]. The techniques used in trilateration is shown in Figure 2.1.



(a) (b)

Figure 2.1: Trilateration: (a) measuring distance to 3 anchor nodes (b) ranging circle

D.Zhang, F.Xia, Z.Yang, L.Yao and W.Zhao mentioned that "tri" says that at least three fixed points are necessary to determine a position. Technique based on the measurement of the propagation-time system such as (TOA, RTOF and TDOA) and RSS-based and received signal phase methods are called lateration techniques [20].

2.5 Wireless Sensor Network (WSN)

Wireless Sensor Network (WSN) were a formed of battery-powered device commonly used for environmentally communication module. It had most recent success in most application involving microwave, solar cells and low-power and battery-lifetime radio communication. WSN main function was to allow electrical devices to be continuously charged and lose the constrained of power cord [22].

ZigBee communication was widely used for transmission through hubs or intermediate devices for over a long distance. According to IEEE 802.15.4 part 15.4, a ZigBee communication applied for low date of 250Kbps and low power consumption that operates at 2.4 GHz band applications [23].

ZigBee was an alternative name of IEEE 802.15.4, a wireless network protocol released in 2005. It was mainly function as a two-way communication technology, suitable for automated control and remote control based on wireless network. It was supported in various embedded hardware microcontroller family [24]. Robert, Arthur, Kevin and Bobby pin-point some of ZigBee characters as a low-power dissipation, low cost, low transmission rate over short distance, short time delay which was 15ms for general working process and 30ms for connecting between nodes. Add on to that, ZigBee module was a high capacity and high security with high frequency band communication module[11].

Table 2.1 : General comparison between Wi-Fi and WSN [25]

Specification	Wi-FI	WSN
Protocol	TCP/IP	Propriety
Power source	Fixed power lines	Fixed power lines or battery
Data rate	High (megabits)	Low (kilobits)
Data type	All sorts	Sensor data
Sleep mode	Impractical	Possible
Range	Up to 100m	Up to 1000 m

2.6 RFID Overview

RFID technology is provided with wireless identification and tracking ability. RFID is a wireless sensing application and and use wireless power transmission at UHF [26]. RFID can be categorized into three categories. This can be categorized according to the frequency used in the RFID. The frequency ranges of UHF band are 433MHz, 865-956MHz and 4.25GHz. The higher the frequencies can provide longer read ranges or distance between transmitter and receiver [27].

RFID technology is a technology used to identify an object or person by using the radio waves. It can works in wireless communication. RFID system enables identification from far or short distance. Identification of the object that are searching for is possible due to the unique numbers or ID number that stored information in the microchip. RFID works by transferring the data stored in the RFID tag using the reader. Then, an antenna on the RFID technology system received signal transmitted by the reader. From the process of the transmitted and received signal in RFID, this shows that RFID system composed of three main components which are RFID tag, RFID reader and antenna [9]. The flowing of how the RFID works is shown as in Figure 2.2.

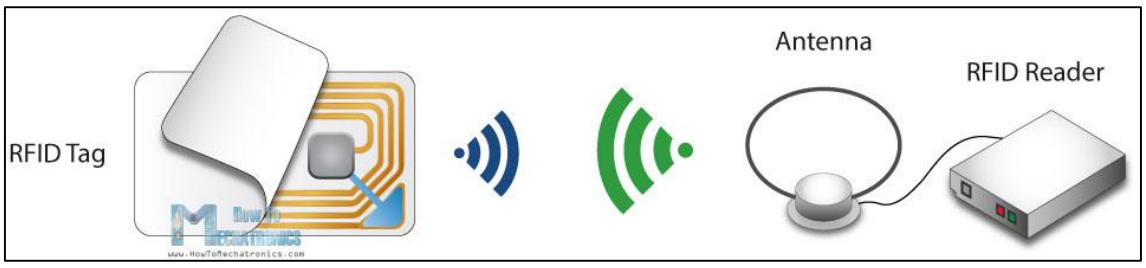


Figure 2.2: The working of RFID

2.6.1 RFID Tag

RFID tag is a component that consist of antenna and microchip to make the RFID to function well. The microchip is used to store the information when in the process which is the unique number. RFID tags is normally being placed at product in industry, for people or also can be put on the animal or pet. This is easier for the owner to find their pet. The antenna on the tag worked by receiving electromagnetic energy from the RFID reader's antenna. The tags sends the radio waves back to the reader by using the power from the reader's electromagnetic field. [9]

RFID tag can be divided into two types of classes, one is active RFID while the other one is passive RFID. For active RFID tag, power source is required since they used energy stored in the integrated battery. Active RFID works in UHF which is ultra-high frequency band and broadcast their own signal for the transmission of the information stored.

Next, the other type of class of RFID is passive RFID. For this type of RFID, the battery is not needed for the passive RFID tag to operate. Passive RFID tag consist of an antenna, a semiconductor chip and some fore of encapsulation. Passive RFID works in three type of frequency which is low frequency, high frequency and ultra-high frequency (UHF) band. Table 2.2 shows the type of RFID tag which is divide to 3 types, active, semi-passive and passive type.

Table 2.2: Type of RFID Tag [3]

Type of RFID tag	Price Range	How it work?	Advantages	Disadvantages
Active	High	Battery run tags that constantly emit radio frequency signal. Some type are battery assisted which are only turned on when they need to transmit or receive data	• Extremely long read range of 100 feet. • Used to manage other devices like sensors. • Larger data storage capacity compared to passive tag	• Expensive • Realibility is impossible to determine. • Unable to function without battery power. • Large in size • Requires long term maintenance cost.
Semi-passive	High	Battery run tags when the radio frequency signal from reader activate the tag and transmit data back to the reader.		
Passive	Low	No internal power source. Activated by electromagnetic wave from the RFID reader. These waves turn on the tag so it can reflect the information stored in the tag to the reader.	• Longer lifespan compare to active tags. • It has wider range of form factors. • Mechanically flexible. • Lower cost • Smaller size	• Distance limited to 4-5m (UHF) • Reader difficult to work through metal/liquid. • Requires high power from reader.

2.6.2 RFID Reader

The interrogators or reader is a device or component that send and receive radio signals through antenna coupled to them. Reader is able to capture data stored in the tags. The choice of reader type to be used is depends on the range or distance needed for let the project or system function well. Reader antenna may work in both short and long range.

2.7 Related work

IEEE 802.15.4 is a widespread standard for low-power and short range communication which is natively support RSSI. Localization with the RSSI index is possible due to its relationship with distance. But, the RSSI index is very unstable, this is due to the reflections and fading of the radio waves. So, this give the great amount of errors. [15]

According to the [19], the commonly used localization techniques include infrared, ultrasonic, Bluetooth, and Ultra-Wideband, WIFI, but they are not suitable for indoor localization. Infrared not suitable because it can easily influenced by light in the room, while Bluetooth and Ultra-Wideband require special equipment, the cost is too high. At present, more and more indoor WIFI access points are open and free.

From [14], there are four frequently used localization technologies based on the measurement of distances or angles between reference points which is TOA, TDOA, AOA and RSSI. TOA and TDOA based systems are more suitable for outdoor or large-scale open indoor environments, RSSI based system is the most suitable for tight indoor environment has found that RSSI has two advantages which are simple implementation and cost effectiveness.

The results demonstrate the unstable nature of distance estimation within a highly reflective indoor environment. The outdoor trials gave an approximate resolution of 1 meter, which is the expected resolution when using the log-distance path loss-model. The indoor environment trials had varying results due to the type of environment and node position within the environment. [3]

Besides, the RFID is widely used in the indoor localization system due the low cost. [3]. RFID has been widespread technology for logistics and goods management, thanks to the RFID tags that can store more information. Besides RFID readers are now capable of providing additional information about the signal backscattered in the RFID tags, such as RSS.

While RFID tags and readers are widely available, setting up an experimental system is not a straightforward task, as capturing wireless signal is full of challenges [26]. While simulation results can be used to verify principles and theoretical aspects evaluate RFID localization performance as the wireless signals are affected by many factors. Due to the difficulties of capturing and processing RFID communications, localization systems commonly rely on available wireless measurements at the receivers such as received signal strength (RSS).

Location estimating techniques can be classified as range-based and bearing-based. Range-based approaches trilaterate the transponder position using the estimated distance at reference points. Distance can be estimated from either received signal strength (RSS) measurements or time based. RSS-based schemes are easily implementable, but the accuracy is highly dependent on the environment and the distance. [11]

Table 2.3 shows the comparison between previous work in same area with this project and their limitations. For this project, this project attempts to employ an active solution for RFID system with small area with 3m x 3m.

Table 2.3 : Comparison of previous work and the limitations.

Related work	Method	Application	Highlights
Z.Turgut, G.Zeynep, G. Aydin, A.Sertbas (2016)	AOA	Wi-Fi access point	• More suitable for outdoor environment. • Accuracy is dependent on number of receivers or the rotating device.
M. Kim, H.W.Kim, N.Y.Chong, (2009)	Potential Error in the DOA	RFID system and using three RFID antenna	• Limit in accuracy, obstacle detection • Highly cost
R. Elamsri, D.W.Engels J.S. Choi, (2011)	RSSI	Passive RFID	• Not good in performance for a distance of severeal meters.
S. Shue, L. E.Johnson, J.M.Conrad (2017)	RSSI	Active RFID	• Project takes place at wide area • RMS error for this project is high.

2.8 Summary

The earlier study of this indoor localization system via RFID development is to provide the information and idea to be applied in this project. All this knowledge collected to make this project reliable and a success. The most explained in this chapter is the research on the indoor localization area. Indoor localization has been used widely in the industrial area nowadays.

The concept of indoor localization at the same time development of RFID system based on WSN platform is similar from previous work, even though they are using different technologies. This chapter has provided an understanding about the development of RFID in indoor localization.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter shall explain the research and applicable method available for the study. This project has two parts which are hardware and software. Hence, through this chapter, the outlines describe the methods involved during the development of the hardware and software, the presentation of a list of main components which have been applied to make this project a success.

The information about this project is collected in accordance with the design that was planned. By study the previous research and resource, data were obtained and compiled, then the improvement of the project is conducted through this project. This chapter covers the design, planning, performance and evaluated process of this project. The methodology flow is organized to ensure that every stage of this project is done effectively and smooth.

3.2 Project Development

The process flow is needed and formed to ensure the process can be done effectively and smooth according to the plan. Firstly, research and literature review has been done to collect the knowledge and information of the indoor localization technology in the scope of using based RFID to be applied in this project. Then, with the knowledge getting from research of the previous work, the best solution will be figure out and the process will be verify to be formed in this project. The process is to decide the best method to be used in this system, the main component and the RF module should be used and

suitable with this project. In order to implement all these knowledge, as study of RFID is needed so that there is an idea and knowledge to choose the suitable components.

This project is done by dividing into two parts which are mainly hardware and software part. Hardware is a part where to see how the RFID and other components such as microcontroller function. So, it is very important to choose the right component to ensure the system success. The RFID that implemented in this project is transceiver ZigBee and connected to Arduino Uno. This RF module can become transmitter and also receiver. Whereas, the software part is for controlling the system and to make the system function when both hardware and software are combined. The software used in this indoor localization process is Matlab. Other than that, to program the ZigBee module and Arduino Uno, the software related to the component should be used. The software used are X-CTU software which is for ZigBee and Arduino software used for program the Arduino.

Besides, the type of battery should be consider when in the step of designing the hardware part. For this project, a suitable li-po battery has been choose as the power supply to supply the voltage to ZigBee which connected to Arduino Uno. The battery is chose based on the power that suitable to be power up to main component. The battery is LIPO battery 7.4V 900mAH. It is suitable for low power consumption usage such as circuit board, sensors and micro size DC motors. Its specification is the battery has 2 cell li-po in series, rated voltage is 7.4V and the fully-charge voltage is 8.4V. This li-po battery is rechargeable type of battery and it has its own charger.

The next step is start to program the main component which are ZigBee module and Arduino Uno. ZigBee module will be programmed by using its software which is X-CTU software. The ZigBee module used in this project is ZigBee S2C. To communicate

wirelessly between transmitters and receiver, the X-CTU must be install and need to program the software.

Next, testing the ZigBee module and Arduino Uno for their serial communication. After program, ensure that the ZigBee can detect the signal from transmitter to receiver. If receiver receives signal from transmitter than this process can be continue with RSSI technique. Then, the signal received will be converted into distance by using equation. Next, the trilateration technique will be applied to find the position of the receiver or reader. The software that will display the position of the transceivers is by using Matlab.

Table 3.1, Table 3.2, Table 3.3, Table 3.4 and Table 3.5 explained the design requirement for this project for Xbee S2C module, Li-po battery, Arduino Uno, setting for coordinator and router. Figure 3.1 shows the process flow chart for overall process for this project.

Table 3.1 : Specification of the Xbee S2C module

Specification	**Xbee S2C**
Supply voltage	2.7 – 3.6 V
Frequency band	ISM 2.4 GHz
Indoor coverage	Up to 60 m
Outdoor RF line-of-sight range	Up to 1200 m
Data rate	250 kbps
Form factor	Through-hole, surface-mount
Number of channels	16 (11-26)
Frame payload	Up to 80 bytes

Table 3.2 : Li-po battery specification

Specification	**Li-po battery**
Rated voltage	7.4V
Fully charge voltage	8.4 V
Capacity	900mAH
Rechargeable	Yes
Dimension	5.8 x 54 x 54 mm
Weight	36 g

Table 3.3 : Microcontroller specification

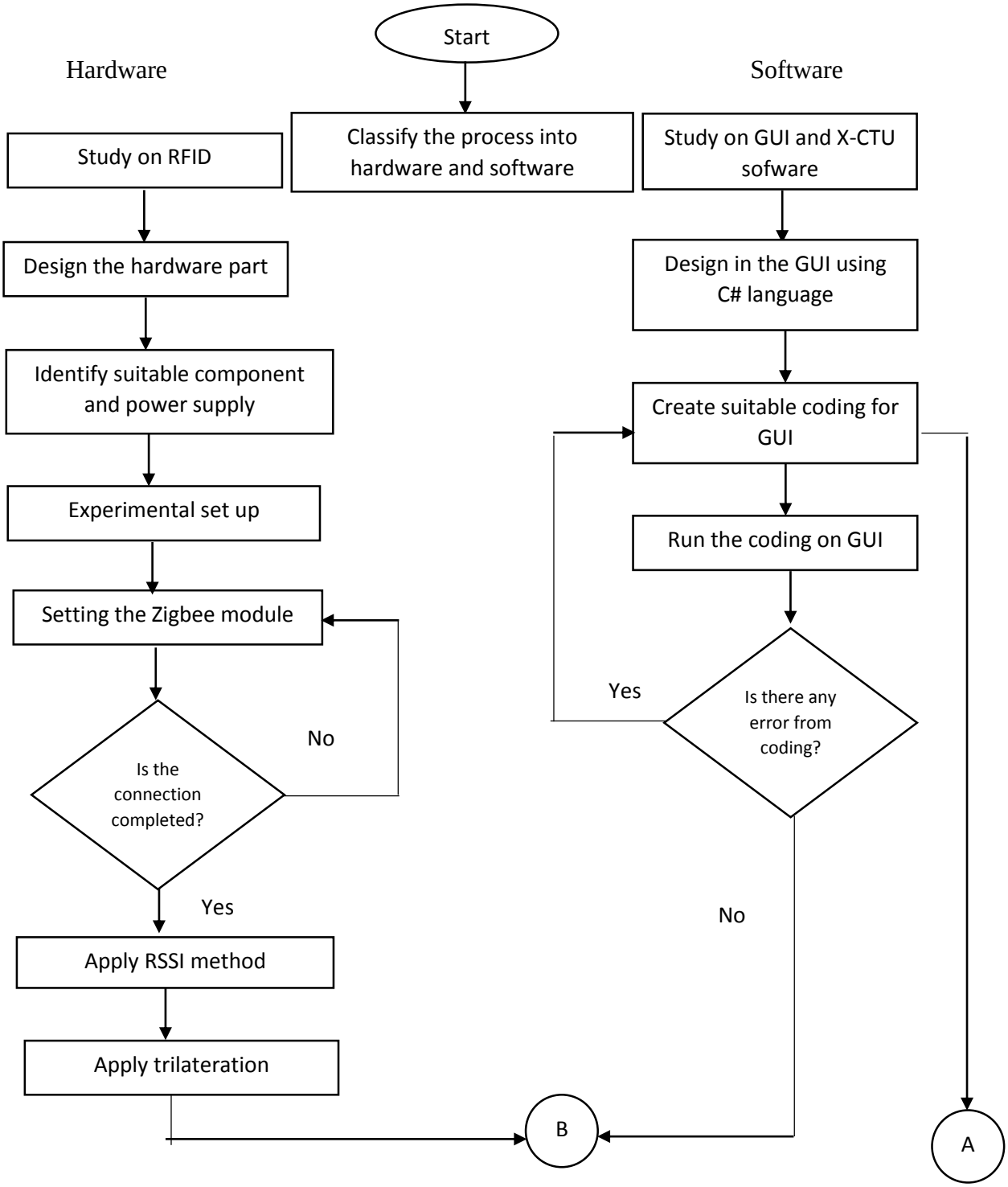
Specification	**Arduino Uno**
Microcontroller	ATmega328
Operating Voltage (OV)	5V
Recommended input voltage	7 V to 12 V
Limit of input voltage	6 V to 20 V
Digital I/O Pin	14 (6 provides PWM output)
Analog Input Pin	6
DC Current per I/O Pin	40 mA
DC Current for 3.3 V Pin	50 mA
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Table 3.4 : Specification of Coordinator's Xbee module

Specification	**Coordinator**
Function	ZigBee TH Reg
64-bit MAC address	0013A2004154CC85
Function set	ZigBee Coordinator API
PAN ID	1234
ZigBee Stack Profile	0
Channel Verifications	Enable
Coordinator Enable	Enable
Destination Address Low	FFFF
Transmit Options	C0

Table 3.5 : Specification of Router's Xbee module

Specification	**Coordinator**
Function	ZigBee TH Reg
64-bit MAC address	0013A2004176Dc53
Function set	ZigBee Router API
PAN ID	1234
ZigBee Stack Profile	0
Channel Verifications	Enable
Coordinator Enable	Disable
Destination Address Low	0
Transmit Options	C0


Start
Hardware
Software
Classify the process into hardware and software
Study on RFID
Study on GUI and X-CTU sofware
Design the hardware part
Design in the GUI using C# language
Identify suitable component and power supply
Create suitable coding for GUI
Experimental set up
Run the coding on GUI
Setting the Zigbee module
Is there any error from coding?
Yes
No
Is the connection completed?
No
Yes
Apply RSSI method
Apply trilateration
B
A

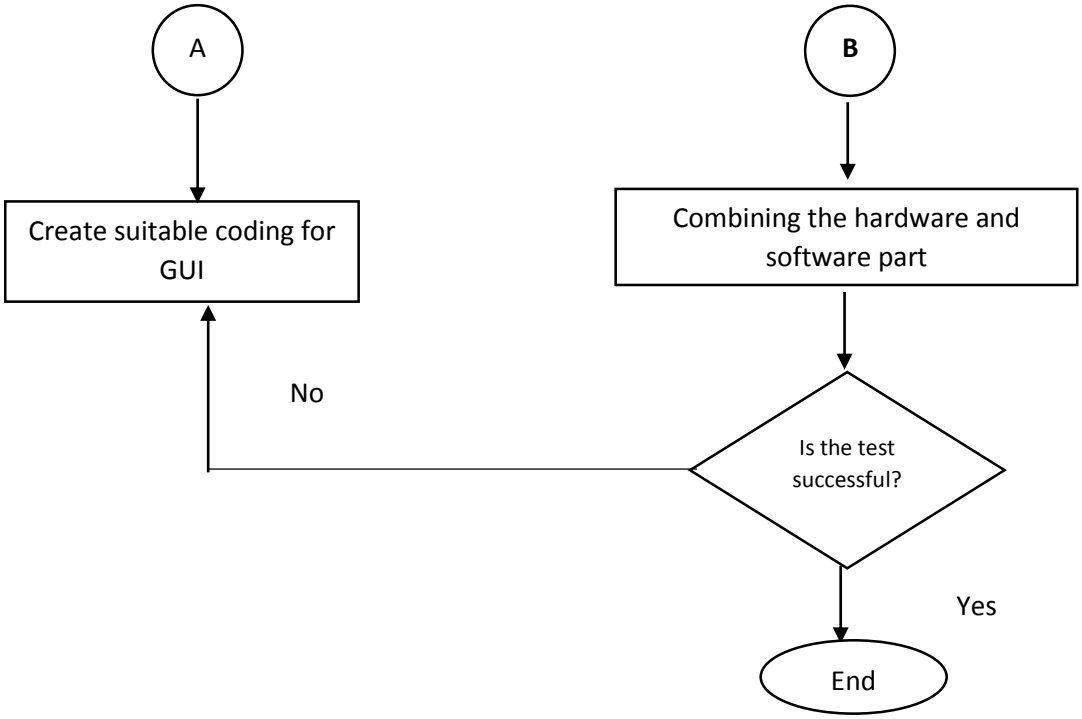


Figure 3.1: Flowchart of the overall process

3.3 Project Description

The indoor localization system in this project is using ZigBee module which is series 2 and known as ZigBee S2C. ZigBee can be a transmitter and also can act as receiver. It is transceiver RF module. Arduino UNO also one of the main component in this project. To get the estimation distance for indoor localization, the RSSI method will be implemented in this project.

For the method RSSI, the signal between transmitter and receiver is recorded and measured. Then, the signal will be converted into distance by using several equations. After that, by using the estimation distance, the location of unknown point or receiver can be determine by applying the trilateration technique. This technique have algorithm that needed to be apply to get the trilateration result. The position of all transceivers can be display in the result in Matlab simulation.

3.4 Software Development

Through this project, there are few software used to make this project a success. The software used in this project is XCTU software and Matlab. XCTU software is used to program ZigBee so that two ZigBee can be communicate while matlab display the result of the coordinate of node that are searching for which is result of trilateration.

3.4.1 XCTU Software

In this project, ZigBee is being chosen as the suitable component for this project. X-CTU software is used in this project to make the connection between Xbee modules. First, the Xbee module should be connected correctly to 'COM port" to the computer used. If the module is connected and the 'COM port' is correct, the LED on the ZigBee will be blinking. If the ZigBee connected to computer is more than one, the 'COM port' must be correct to make the ZigBee function. Figure below show the ZigBee and the port shown in the X-CTU software. Figure 3.2 shows the "COM port" in XCTU software.

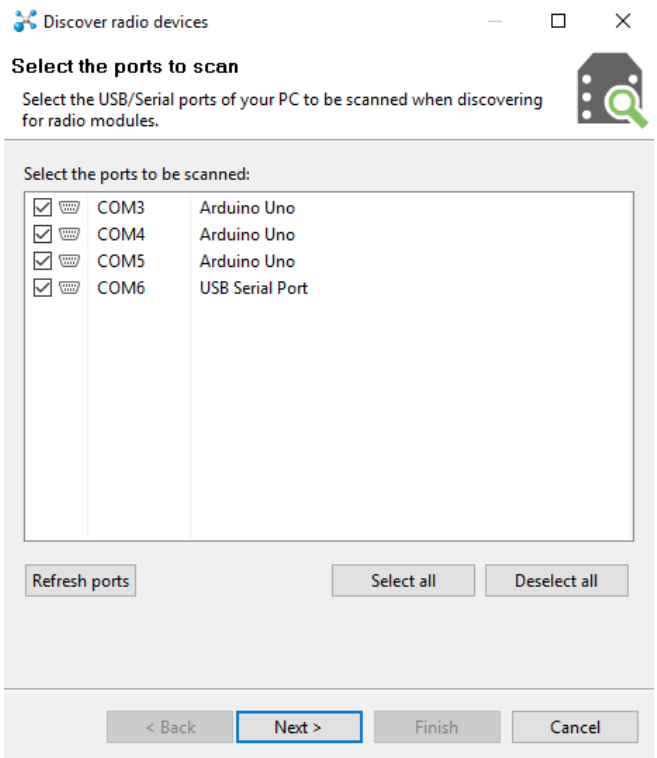


Figure 3.2: "COM port" of Xbee modules