"I hereby declare that I have read through this report entitle "iBEACONS LOCALIZATION FOR INDOOR COORDINATION (RETAIL SALES)" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation & Automation)"

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iBEACONS LOCALIZATION FOR INDOOR COORDINATION (RETAIL SALES)

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor in Electrical Engineering (Control, Instrumentation & Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I declare that this report entitle "*iBEACONS LOCALIZATION FOR INDOOR COORDINATION (RETAIL SALES)*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Businesses are facing fierce competitions amongst one another and a solution is needed in order to stay ahead of other competitors. The solution for the problem stated will be Indoor positioning, it is commonly used in hospitals, shopping complexes and social networking. iBeacon technology is the only technology that will be used to achieve indoor positioning for retail application in this project, it uses Bluetooth Low Energy (BLE) with a great longer lasting period of service compared to other technologies. In this project, an algorithm for an iOS device application with the use of iBeacon will be developed to achieve an indoor localization system for retail stores. This changes the way of interaction between the retailers and their precious customers in order to attract more customers and increase their sales. Furthermore, this project will also measure the reliability of the iBeacon signal due to obstructions through an experimental setup designed. It is found that iBeacon technology can be incorporated into retail businesses, however the reliability of the iBeacon signal can be affected variedly by different obstructions. By applying iBeacon technology in retail, a business may flourish and continue to thrive in this fierce competition.

ABSTRAK

Perniagaan menghadapi pertandingan sengit antara satu sama lain dan satu penyelesaian diperlukan supaya dapat memenagi pesaing lain. Penyelesaian untuk masalah tersebut adalah “Indoor Positioning”, ia biasanya digunakan di hospital, pusat membeli belah dan rangkaian sosial. Teknologi “iBeacon” adalah satu-satunya teknologi yang akan digunakan untuk mencapai Indoor Positioning untuk digunakan dalam kedai-kedai runcit dalam projek ini, ia menggunakan “Bluetooth Low Energy” (BLE) dengan tempoh perkhidmatan yang lebih tahan lama berbanding dengan teknologi lain. Dalam projek ini, algoritma untuk aplikasi Peranti iOS dengan menggunakan iBeacon akan dibangunkan untuk mencapai sistem Indoor Positioning untuk kedai-kedai runcit. Ini mengubah cara bagi interaksi antara peruncit dan pelanggan mereka dalam usaha untuk menarik lebih ramai pelanggan dan meningkatkan jualan mereka. Tambahan pula, projek ini juga akan mengukur kebolehpercayaan isyarat iBeacon kerana halangan melalui proses persediaan eksperimen direka. Ia didapati bahawa teknologi iBeacon boleh dimasukkan ke dalam perniagaan runcit, bagaimanapun kebolehpercayaan isyarat iBeacon boleh terjejas oleh halangan yang berbeza. Dengan menggunakan iBeacon teknologi dalam perniagaan, sebuah syarikat boleh berkembang dan terus berkembang maju dalam persaingan sengit ini.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Retail is a process involves the selling of goods or services to customers through multiple distribution channels for profit. Indoor Location Based Services (LBS) can be applied to track consumer in-store for their locations. Valuable information can be efficiently delivered to customers through the system and on the other hand, better marketing sales can be identified to improve their competitiveness [1]. LBS have been generally applied in several fields, applications and devices; their location awareness has become an important part of our life. Positioning can be divided into outdoor and indoor positioning. Nowadays, the indoor LBS gains more attention in mobile applications market, as people tend to spend more time in indoor rather than outdoor due to the increasing number of buildings in public places such as shopping malls, schools, universities, and hospitals [2].

Indoor positioning is still a challenging problem since current satellite-based approaches work well for outdoors but not for inside buildings [2]. Therefore, we are required to use other technologies for indoor positioning. iBeacon is a technology introduced by Apple in 2013. It is a system of internal positioning that quoted by Apple as " a new class of low-powered, low cost transmitters that can notify nearby iOS devices of their presence" [3]. An iOS device is able to receive push notification from the nearby

iBeacon through this technology. iBeacon works with Bluetooth Low Energy (BLE), also known as Bluetooth 4.0 or intelligent Bluetooth. Through iBeacons, the position of customers in a shop can be identified and notifications on promotion or any informations can be delivered to customers efficiently. Besides, customers can pay without taking money out from the wallet or even a credit card to pay [3].

This technology is one of the best approaches in solving the problem faced with indoor localization. It has numerous significant advantages compared to the other types of indoor positioning technologies available, such as a less expensive hardware, less energy consumption, an internet connection is not required and being able to receive notifications while in background. This technology will change the way retailers communicate with customers indoors [2]. iBeacons can be used to send a welcoming message to customers who visited the store and show location-specific deals, discounts, recommendations and rewards [4]. This will greatly improve the shopping experience of consumers and while it helps the retailers for better marketing planning which allow for a more effective sales that focused on consumer needs. These are from the function of iBeacons that allows users to track the data about goods and popularity. With an effective sales plan, the retail business will bloom and open up new opportunity for others.

1.2 Problem Statement

The economy in our country has been slow where retailers are facing a hard time to keep up with a profitable income and businesses are closing here and there. Indoor LBS can be applied in retail to identify the strategy needed for better marketing solutions. The usage of iBeacon technology can be used to monitor the popularity of products or services among customers so that retailers can devise an appropriate marketing strategy to increase sales. iBeacon technology can also be used to promote sales by sending push notifications to Bluetooth devices regarding the promotion on products or services to attract more customers to the store.

Outdoor localization can be resolved by Global Positioning System (GPS). However, GPS signals are denied in indoor environments, thus it is a challenging problem to achieve indoor localization using GPS. WiFi-based localization is one of the possible solutions to indoor localization. However, due to the large variations of WiFi signals and high power consumption, WiFi-based approaches are unsuitable to achieve an accurate and a long-term indoor localization. Alternatively, smartphone sensors can provide a different way for indoor localization. Theoretically, the double integration of accelerations can yield the trajectories of the users. But, since the accuracy of smartphone accelerometers are low and the variation during walking is large, this integration will drift very quickly [5].

Apparently, the iBeacon technology released by Apple is the best solution for long-term indoor localization. This technology is very energy efficient because it is built upon Bluetooth Low Energy Version 4.0 and it can be utilized for location based on the Received Signal Strength (RSS) of BLE devices [5].

1.3 Objective

The main objectives of this research are to:

1. To develop an algorithm for indoor localization system by using Objective-C programming language in Xcode, an integrated development environment (IDE).
2. To apply the indoor retail sales localization system.
3. To measure the reliability of the iBeacon signal due to obstructions.

1.4 Scopes

An iOS application is developed using an algorithm that is constructed in Xcode with Objective-C programming language. The algorithm for the application will allow iOS devices to receive push notifications when the iOS device users entering the region of signal emitted from iBeacons in close proximity. The model of iBeacon to be used is the Estimote Proximity Beacon.

To measure the reliability of the iBeacon signal strength due to obstructions, a series of experiments will be carried out by placing an obstruction in between the iOS tablet device and the iBeacon at a certain distance, and the distance reading from the device is recorded. The results will be analyzed in order to find out the reliability of the signal from an iBeacon with the existence of an obstruction.

1.5 Significance of Study

Implementing the iBeacon technology in retail sales helps to increase the level of technology used in Malaysia. In addition, it can provide a new and great shopping experience to the customers. Due to the various functions of iBeacon technology, data collection may also become possible where it allows identification of sales marketing planning, for example, the popularity of the products according to a sales tracking system, and the shopping behavior of customers. This can greatly improve the sales and the profits for the retailers.

CHAPTER 2

LITERATURE REVIEW

2.1 Indoor Positioning System (IPS)

An Indoor positioning system (IPS) is a system for locating objects or people inside a building by using radio waves, magnetic fields, acoustic signals, or other sensory information collected by mobile devices [6]. Both non-radio and wireless technologies can be used for an IPS.

Non-radio technology includes magnetic positioning and inertial measurements. Magnetic positioning is based on the iron inside buildings that generate local variations in the Earth's magnetic field. Un-optimized compass chips inside smartphones can sense and record these magnetic variations to map indoor locations [7]. Meanwhile, wireless technology includes Wi-Fi positioning system (WPS), Radio-Frequency Identification (RFID), Bluetooth and many others. Radio-frequency identification (RFID) is the wireless use of electromagnetic fields to transfer data and for identifying and tracking tags which contains electronically stored information that are attached to objects; RFID are used for item level tagging in retail stores. Bluetooth is more focused on proximity instead of exact location which makes it an indoor proximity solution, not an indoor positioning solution [8]. Indoor mapping has been associated to Bluetooth and to the BLE based iBeacon developed by Apple Inc [9].

2.2 iBeacon Technology

iBeacon technology is developed and introduced by Apple. It is an efficient, built-in, cross-platform technology for Android and iOS devices, which utilizes the Bluetooth Low Energy (BLE) for indoor positioning. Due to this technology uses the BLE, it provides the user with longer battery life. This technology will also require devices which are supporting BLE version 4.0 for it to work. The devices that generate iBeacon advertisements are known as Beacons. Beacons establish an area surrounding it with the iBeacon signals. The iOS device can later determine if it has entered or exited from the area, and it can approximate its distance to the beacon via signal strengths. Besides, an iOS device can also be turned into a beacon by using Core Bluetooth Application Programming Interface (API) to send iBeacon advertisements [2]. Figure 2.1 shows two beacons from different vendors, LightBlue™ Bean on the left and Estimote on the right.

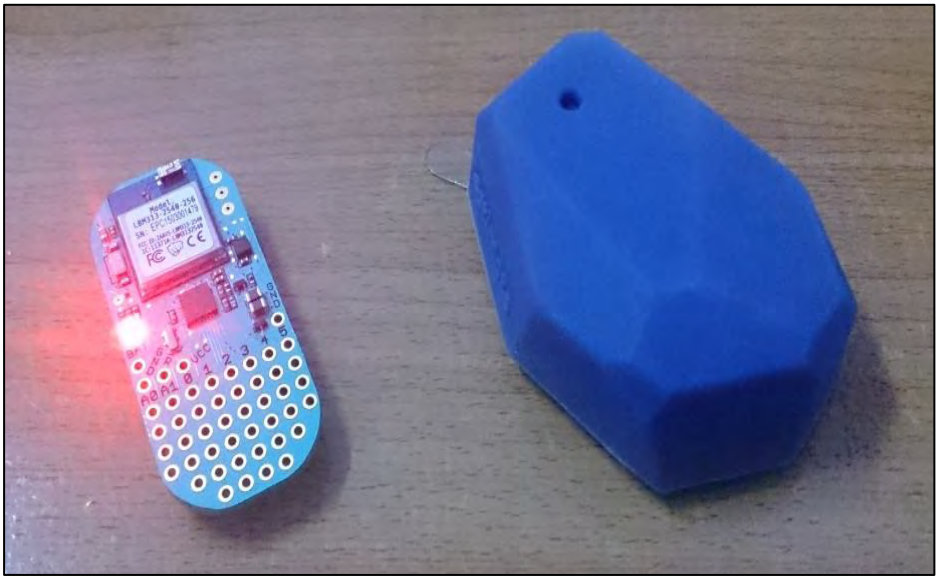

Figure 2.1: Beacons from different vendors

Each beacon transmits a unique signal ID. This signal ID is made of three structures: Universally Unique Identifier (UUID), Major and Minor. The UUID with a 128-bit integer is used as an ID for all beacons in an application. The Major structure with a 16-bit integer is used for differentiating beacons with the same UUIDs. The Minor with a 16-bit integer is used to differentiate between beacons of the same UUIDs and Major values [2]. Figure 2.2 shows the data format of an iBeacon. The data format starts with the Company ID, Type and Data Length. The bytes for these three are always the same and it cannot be changed. However, the bytes of UUID, Major and Minor can be changed without any limitations to suit the needs of the user.

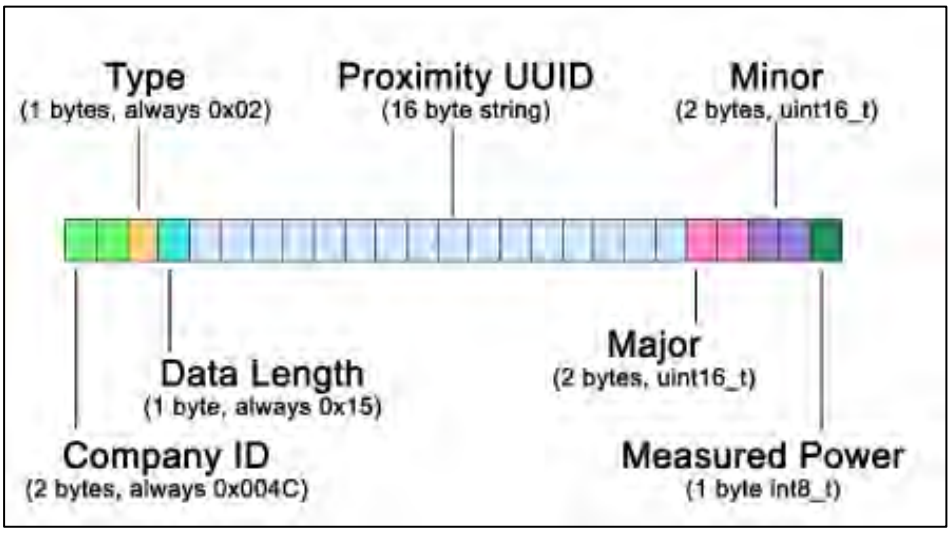

Figure 2.2: iBeacon data format [10]

There are five important parameters in iBeacon; broadcasting power, advertising interval, RSSI, measured power and proximity zones. Broadcasting power is the amount of power a beacon used to broadcast the signal and the value ranges between -30 dBm and +4 dBm. It affects the signal range directly where stronger power implies larger range. The advertising interval describes the time between each signal broadcast at the value ranges between 100 milisecond (ms) and 2000 ms. Both two parameters are adjustable and they will affect the battery life of the beacon.

RSSI is the abbreviation for Received Signal Strength Indicator, which is the strength of a beacon's signal as seen on a receiving device. The signal strength depends on distance and broadcasting power value. The measured power is a factory-calibrated, read-only constant which indicates the expected RSSI at a distance of 1 meter to the beacon. By combining it with RSSI, the distance between the device and the beacon can be estimated.

The proximity between an iBeacon and the device that receives the signal is calculated from the measured power. There are four proximity zones which are used to calculate the proximity; Unknown, Far, Near and Immediate. The state "unknown" represents no device is detected within 30 meters from the iBeacon. State of "far" refers to the device is detected to be within proximity between 2 to 30 meters. State of "near" and "immediate" show that the device is in a distance from the iBeacon from 0.5 to 2 meters and within 0.5 meters respectively [10]. Figure 2.3 shows the distance calculation.

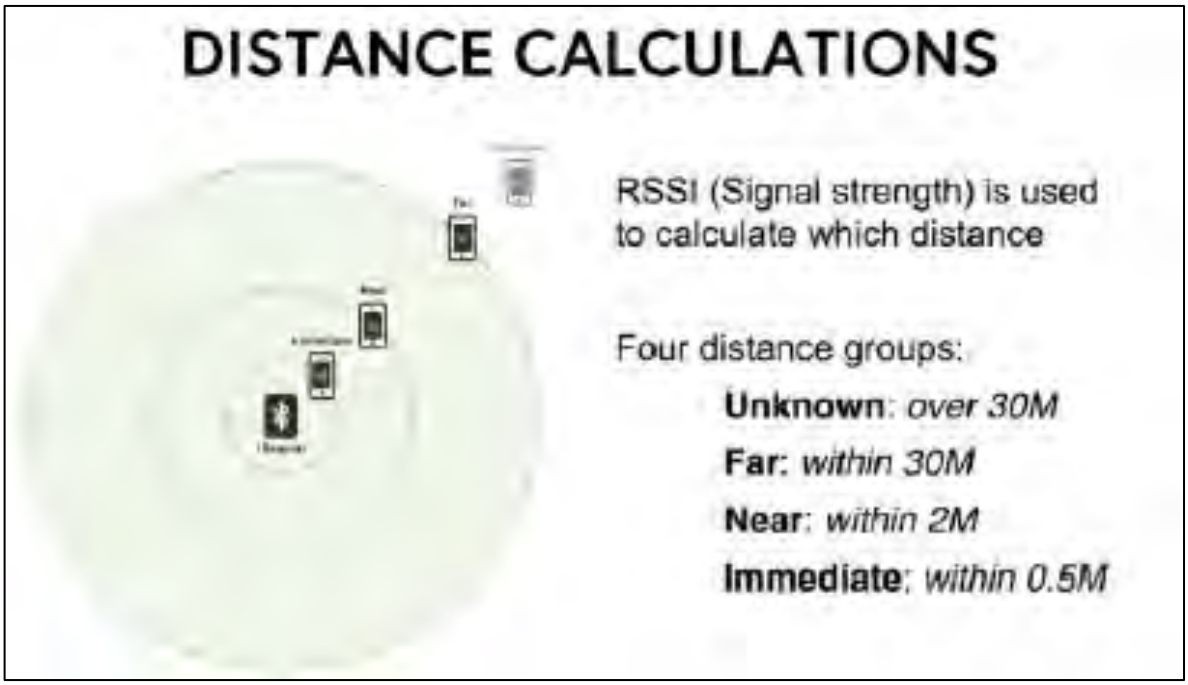

Figure 2.3: Distance Calculation with iBeacon [10]

The restriction of this technology is that Bluetooth uses signals that have a frequency of 2.4GHz, these signals are faced with problems of damping [10]. The Figure 2.4 and Figure 2.5 both shows the signal propagation under different situations.

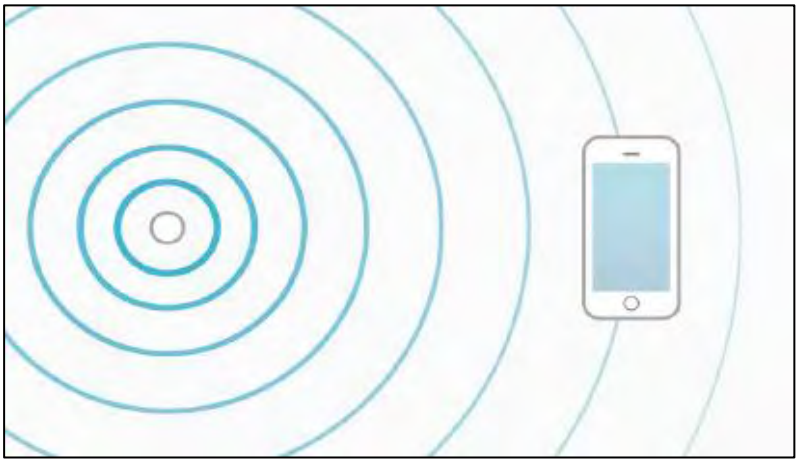

Figure 2.4: Signal propagation without barrier [10]

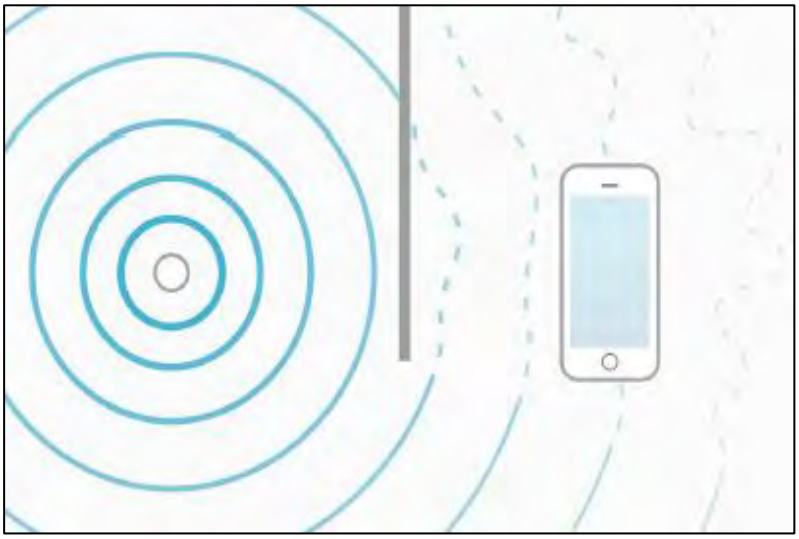

Figure 2.5: Signal propagation with wall barrier [10]

There are several studies that are focused on the damping and absorbing of radio frequency signals. The results from a research done by Apple on the radio frequency signal reflecting and absorbing obstructions at 2.4GHz are shown in Figure 2.6.

Type of Barrier	Interference Potential
Wood	Low
Synthetic material	Low
Glass	Low
Water	Medium
Bricks	Medium
Marble	Medium
Plaster	High
Concrete	High
Bulletproof glass	High
Metal	Very high

Figure 2.6: Radio frequency reflection and absorption obstructions [10]

According to the same research, the actual distance between an iBeacon and iPhone is 0.10 meters apart while the calculated distance between the iBeacon and iPhone without obstruction in between was approximately 0.10 meters. The calculated distance was 0.49 meters when a 0.04 meters wide water layer is used as an obstruction. A human hand between both gives a calculated distance of 1.50 meters meanwhile a 0.01 meters metal layer leads to 2.21 meters [10]. This confirms that the result from the research done by Apple is valid.

2.2.1 iBeacon Technology in Retail Market

The number of applications of iBeacon in retail is rapidly increasing with large companies such as Macy's, Mcdonald's and Major Baseball League are taking the lead [11]. Apple had implemented iBeacons in all of its stores from the United States of America in December 2013, shoppers are able to receive notifications when their order has been assembled in the in-store stock room through the official iOS Apple Store application [11]. Figure 2.7 shows the implementation of the iBeacon in the official iOS Apple Store application.

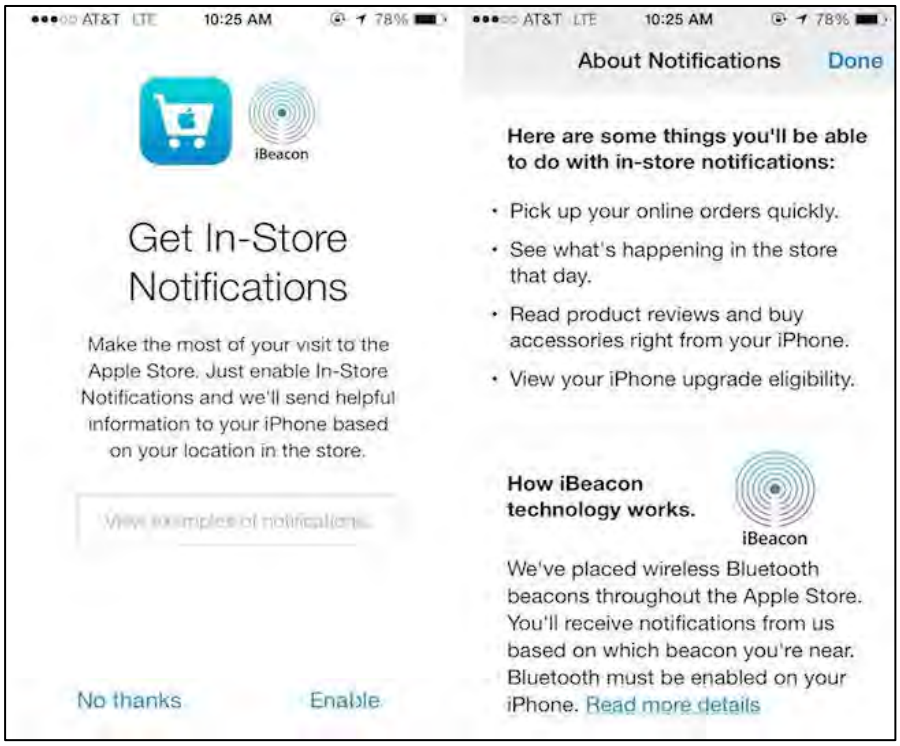

Figure 2.7: Official iOS Apple Store application interface [11]

Hillshire Brands have also implemented iBeacons to track the trip of a shopper through the lanes of a grocery store in order to send discount coupons or advertisements for their craft sausages when a shopper approaches the section of the store. The advertisements and coupons are delivered via smartphone applications such as Epicurious [11].

2.3 Related Work

The practicability of applying iBeacon technology in a museum is being discussed [12]. According to the finding, beacons can be placed easily at places nearby a collection or behind it or also placing it in the lobby between different exhibition halls. In addition, beacons can be used to provide an automatic guidance or notification to help visitors to start their trip in the museum. Lastly, auto-notifications and recommendations from the beacon can facilitate interactions between collections and visitors [12].

For the system, the data packets sent from iBeacons will be used to identify the different objects of a museum. The UUID will be used for the identification of a museum, Major to be used to show different museum halls while Minor to identify different artworks in a museum hall [12]. The structure of the knowledge pushing system based on iBeacon is shown in Figure 2.8.

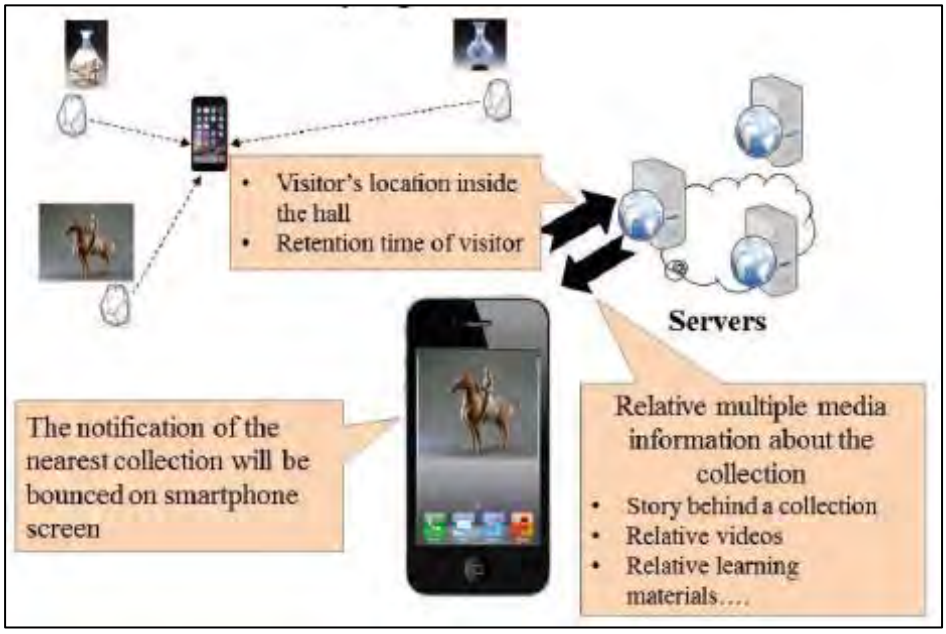

Figure 2.8: Interaction between visitors and collections in museum hall [12]

CHAPTER 3

METHODOLOGY

3.1 Introduction

Generally, an algorithm for iBeacons based indoor localization system is developed using Xcode and being applied into retail sales. This project has three main parts; the development, application and the experimental part.

This project begins with the development of an algorithm with Xcode IDE in the form of coding and simulation of the iOS device application. Next, the application of the iBeacon will be carried out to verify the algorithm and the system. Lastly, an experiment on the reliability of the beacon signal strength due to obstructions will be conducted. The overall framework of the project is summarized in Figure 3.1.

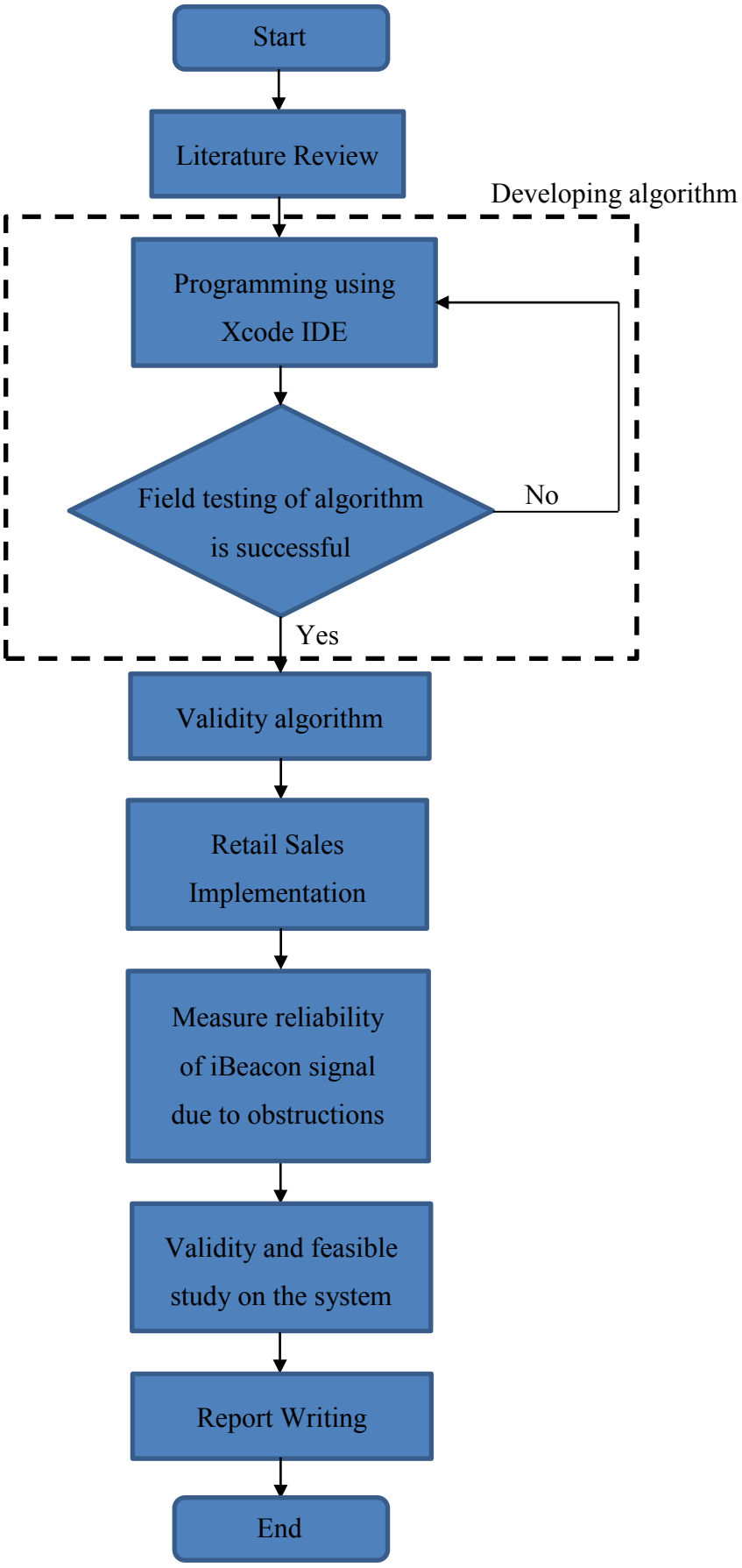

Figure 3.1: Framework of project