BeaLib: A Beacon Enabled Smart Library System

Monica Laxman Uttarwar[1], Arun kumar[2], Peter H. J. Chong[1]

[1]Department of Electrical and Electronic Engineering, Auckland University of Technology, Auckland, New Zealand
[2]School of Electrical and Computer Engineering, National University of Singapore, Singapore City, Singapore
Email: gqk9695@aut.an.nz, elearun@nus.edu.sg, peter.chong@aut.ac.nz

Abstract

Nowadays, Global Positioning Systems (GPS) receivers are used for outdoor navigation, which are the part of recent smartphones and tablet devices. However, GPS is not suitable for indoor navigations due to its signal limitations which are blocked by ceiling and walls. Indoor navigation can be achieved through a mobile phone using a recent technology that utilizes Bluetooth, namely beacons. Beacons are small transmitters, run on Bluetooth Low Energy (BLE) technology, used as a point of reference for mobile devices and they can detect a Bluetooth enabled device once it enters its transmission range. In this paper, we present BeaLib: a beacon assisted indoor navigation technique for smart libraries. The proposed indoor navigation technique can also be used for other applications such as offices, retails, airports, hospitality, and education. For experimentation, beacons are placed in a library and a Bluetooth enabled smartphone is used to install a digital library application (App) which communicates with the beacons. The result shows that when the smartphone comes in the range of a beacon, it shows the information related to the book on the smartphone screen.

Keywords

Bluetooth Low Energy, Beacons, Proximity Sensor, Indoor Navigation, Global Positioning System

1. Introduction

Recently, Bluetooth Low Energy (BLE) is gaining popularity as a convenient way of wireless communication due to its low power requirement and inexpensive characteristic compared with classic Bluetooth [1] [2]. Also, it does not limit the number of devices to be connected for information sharing. While Classic

Bluetooth is used for short-range (personal area network) communication, BLE provides fast and efficient handling of countless devices for similar applications [3].

Beacons are small transmitters, run on BLE technology, used as a point of reference for mobile devices and they can detect a Bluetooth enabled device once it enters into its transmission range [4]. In this work, for experimentation purpose, a beacon is linked with a book in the library which provides the basic information of the book to a reader/library user without even picking up the book. The prerequisite is that the reader should have the digital library App downloaded and installed in the smartphone or tablet. A user who has a Bluetooth turned on in the smartphone will receive the book information from the beacon if he/she is in the range of the beacon.

A Smart App is developed to provide easy access to library users with a Bluetooth-enabled smartphone or tablet. A user is able to see the basic information of the book on the mobile screen. This helps a library user to get easy access to the books without picking up individual books and it does not require an internet connection. As compared to GPS which is used for outdoor navigation [5], the proposed work is used for indoor navigation in the library.

Mostly, beacons have been used in marketing purpose for promotional offers. This paper explores another application of beacon as in indoor navigation. This work objective also includes the development of an Android mobile App using Java. The Estimote Bluetooth beacons and Android phones are used for the experimentations. Figure 1 shows a typical Estimote Bluetooth beacon available in the market.

2. Related Work

Bluetooth beacons are proximity sensors with small button cell batteries. They look like hockey pucks and are usually covered with a plastic case. The beacons are used to broadcast advertising services and information for publicity and promotional message or events [6]. Beacons have transmitters which work on BLE technology and can be programmed using a message. In a library, a user will receive the information about a book issued to him/her, return dates, fines etc. in the smartphone App.

Figure 1. A typical Estimote bluetooth beacon.

BLE is extensively used in health care applications where health sensors communicate biological readings and status to smartphones. Other healthcare applications built on BLE are monitoring systems of Electrocardiogram (ECG) [7], glucose [8], and blood pressure [9]. Few of the commercially available healthcare products are [10] [11]. BLE is a key enabler technology for The Internet of Things due to low power consumption and simple hardware implementation [12].
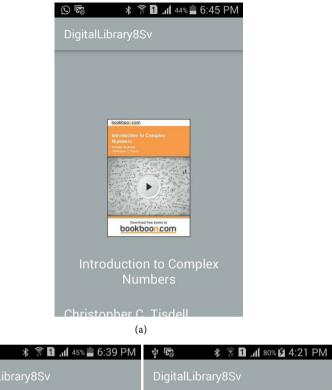
BLE is also used in hotels to inform the customers about the menu, prices and even the order can be placed using mobile App with the help of BLE and in that way, the customer does not have to wait for the waiter to come and take the order. This helps in cost cutting for expensive business. This also saves crucial time, for example, the waiter will take the orders and inform the chef and bring the food, by that time using the technology, and a customer can place the order and receive the ordered dishes. BLE can be used for jobs requiring accuracy like turning ON and OFF the lights and display on the different screen [13].

Magnetic beacons and receiver with magnetic sensors are attractive for a wide range of indoor events and applications, like pedestrian and robot navigation [14]. Mobile beacons in wireless sensor network (WSN) provide information of world-class applications like forest fire detection and animal tracking [15]. NFC is another contactless technology used for easy payment and paperless ticketing purpose [16]. NFC-enabled smartphone has helped to create a new application like mobile payment (m-payment) and mobile ticketing (m-ticketing). Authors in [17] have studied the contactless transport service using the SIM card as security element and NFC-enabled smartphone. The same application based on RFID is used in Auckland, New Zealand for bus, train and ferry ticketing which charges the users automatically once they reach their destination.
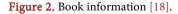
3. Proposed Solution

The aim of this work is to provide the indoor navigation to users in libraries like Auckland University of Technology library. In this paper, we present a beacon assisted indoor navigation technique for the smart library, BeaLib. A digital library App is created which displays the cover of the book, title, authors and a brief information about the book. Figure 2 shows an example of book information display on the Smart App.

The Estimote development kit is used for experimental purpose. The kit contains three Estimote beacons in different colours; lemon tart, candy floss and sweet beetroot. The beacons are enabled to broadcast not only Apple iBeacon packets but also Eddystone, an open beacon format from Google. The Estimote cloud can be used to manage the beacons. It allows the remote access to the settings of the beacons and location saved with Indoor Location SDK. There is information of the color, name, Identifier, and location of each of the beacon. It will display the information of the sticker beacon that is called as the "Nearables". It also provides the information of the applications that can be created using the "Apps" option. It also provides the information of the digital library App created as shown in Figure 3.

(a)

(b)

(c)

Figure 2. Book information [18].

It provides the information of the location and analytics like the number of visitors in particular time of the day and the location. The third floor of the Auckland University of Technology Library is chosen to test the BeaLib as it is a huge area full of books where Indoor navigation is difficult. It is also chosen to test the working of BeaLib in crowded areas as the signals of beacons get interfered and absorbed [20]. **Figure 4** shows the block diagram of university library. The beacons are placed 10 to 20 meters apart in the library. Using BeaLib, the students and Staff members are able to find the books easily. The proposed
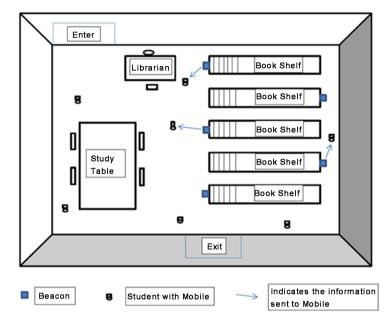
Figure 3. Created application [19].

Figure 4. System structure block diagram of university library.

solution is usually tested by the students of Auckland University of Technology. Three beacons are placed near the books as shown in **Table 1**. When a user reaches in the range of a particular beacon the information related to the book will appear on the smartphone.

The flowchart of the BeaLib App is shown in **Figure 5**. First, the user needs to install the digital library application. Then the beacons check whether the Bluetooth is on or off. If the Bluetooth is on then the student will receive the information of the book depending on where the student is. If the student is near Lemon color beacon then the smartphone will display Introduction to Complex Numbers and if the student is near the Candy colour beacon then it will display the basic information of the Automation and Robotics book. If the student is near the Beetroot colour beacon then it will display the basic information of Introduction to Electronic Engineering. If the student is not near any of the beacons then it will display the image not available. **Table 2** lists the features of Estimote beacons.

After that, if the user walks to another beacon then it will display the information of the book related to that beacon or it will just show no image available. If the user decides to leave the library or does not want any further information of the book then he/she can switch OFF the Bluetooth. In this way, the user can search the books without using the internet.

Table 1. Beacon and related book information.

Beacon	Title of the Book
Lemon	Introduction to Complex Number [21]
Candy	Automation and Robotics [22]
Beetroot	Introduction to Electronic Engineering [18]

Table 2. Features of Estimote beacons [23].

Properties	Specification
Battery Life	5 Years
Range	200 Meters
Thickness	24 mm
Built in Sensors	Motion, Temperature, Ambient Light, Magnetometer and Pressure Sensor

Figure 5. Flowchart of the digital library application.

4. Discussion

Once the Estimote beacons are linked to the Estimote account they can be programmed as per the required objective. An Android phone is required to run the
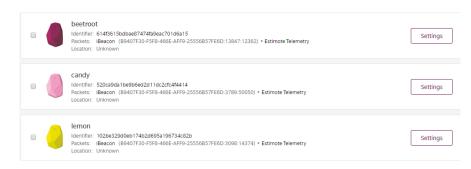
Figure 6. Beacon ID on the Estimote cloud [20].

Smart App and location of the beacons can be chosen as per the requirement of the project.

To run the Android App in a personal computer, Microsoft Windows or later version, Mac OS X 10.5.8 or later version with the Intel chip or Linux including GNU C Library 2.7 or later [24] is required. The Android Programming requires tools which are downloaded without any charges. The software required are Java JDK5 or later version, Android SDK, Java Runtime Environment (JRE) 6, Android Studio, Eclipse IDE for Java Developers and Android Development Tools (ADT) Eclipse Plug-in.

Each Estimote beacon has separate ID that can be changed, it is iBeacon format having three values that are UUID and Major ID and Minor ID as shown above (Figure 6) the beacon we have used in the project have the following. These IDs are identified by the mobile application and it makes them behave the way they show the output. The UUID is fixed and we can change the values of Major ID and Minor ID as per the requirement of the project.

The coding is used to give information about the Beacons and the ID. In the coding, the variables like title, author and a brief introduction of the book are declared using String Text and it uses variable name as "title", "author" and "intro". The image of the book is also stored and the background colour is stored. More variables can be introduced as per the requirement of the project.

5. Conclusion

This paper presented BeaLib: A Beacon Enabled Smart Library System. It is shown that Indoor navigation can be achieved through a mobile phone using a recent technology that utilizes Bluetooth, namely beacons. The proposed indoor navigation technique is for a smart library. BeaLib utilizes the Bluetooth Low Energy (BLE) technology. The proposed indoor navigation technique can also be used in other applications such as offices, retails, airports, hospitality, and universities. For experimentation, beacons were placed in a library and a Bluetooth enabled smartphone is used to install a digital library App which communicates with the beacons. The result shows that when the smartphone comes in the range of a beacon, it shows the information related to the book on the smartphone screen.

Acknowledgements

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