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An Implementation Study of Smart Library using Beacon Bluetooth Low Energy (BLE)

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ABSTRACT

An average number of books for a normal library is around 10,000. Finding books in a library is a cumbersome process and time consuming especially in a huge library. Besides, the cost to embed RFID tag on each book is too expensive. To overcome the problem, this paper proposed a solution for finding location of library books. The solution is using i) a smartphone application to navigate location of book, and ii) LED Blinker with Beacon Bluetooth Low Energy (BLE) technology on bookshelf. The case study for this research is Library of Jeneral Tun Ibrahim at Universiti Pertahanan Nasional Malaysia (UPNM) Library. This study also produces a new framework for finding books in libraries. The framework is a proof of concept that can be applied in the smart library system to assists library patrons in finding locations of books.

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Introduction

Library is one of the important places in any educational institution. Apart from books, journals, newspapers and magazines, library users or patrons can easily access a range of electronic resources to enrich their knowledge and studies. In a big and busy library, organizing books on shelves is a common routine by librarians and it is also a challenging task for them. Normally in a library, books are organized in shelves based on the categorization and classification of subjects. However, there is a lot of movement of these books in and out of the library's shelves [1]. So, there is possibility that these books become misplaced. When such misplacement of books occurs, it becomes challenging for both librarians and patrons to search books [1]. Although the OPAC or an online library management system provides book racks and access numbers, it is always difficult to find the rack or shelf, especially in huge libraries. This scenario can become worse if the books are misplaced [1].

Presently, many libraries have used technology such as RFID and barcode in managing their library system. RFID is a reliable technology that communicates through electromagnetic waves to exchange data between a reader and a tagged object such as a product, animal, or person for the purpose of identification and tracking [2]. Although, the traditional library management systems have already used the RFID barcodes in the various administrative processes, these systems are not considered as smart systems [3]. The limitation of the RFID technology in the traditional library management systems is in assisting the book borrowing and returning process only. The system does not assist the patron or the librarian to track the book up to its shelf. On the other hand, barcode technology had not featured a positioning capability and is restricted to identify the book through the identification number on the book.

With the emergence of Internet of Things (IoT), many services and innovation have emerged where IoT has become part of the network information system over the Internet. IoT is a system of computing devices, mechanical and digital machines, objects, animals or people that are interrelated and has the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT technology such as Beacon is a Bluetooth Low Energy (BLE) technology that is used for variety of purposes including location-based services. Beacons give more advantages over other location-based technologies such as RFID and Wi-Fi as they are small Bluetooth broadcasters and battery powered that can be attached to any location or object. It can also be configured with a mobile application. Thus, the development and production cost are kept low. There is also a limited number of applications using Beacon in the library of the world and none in Malaysia. Currently, the indoor navigation system using beacon technology provides the positioning and navigation systems linked to an application [4]. By using this technology, the system will integrate the conventional shelf library system with hybrid technology consists of Bluetooth and local positioning system to direct the user to book's location. Therefore, the book can be found at the exact shelf by only using smart phones. As almost everyone has a smartphone which directly connected to the internet, they can utilize their mobile phone's Bluetooth to communicate with the IoT sensors and connect to the library system. It will be able to find the book position through a local positioning system which prove to be very helpful.

With the full integration of IoT into the library management system would makes both the library patrons and staff's task easy, smart, convenient and practical. Locating misplaced books in the library using BLE Beacon along with smartphone is one of low cost yet effective and innovative solution. Acceleration of mobility and the increasing role and engagement of Information and Communication Technology (ICT) compared to the traditional operation will apply for the solution proposed. The mobile application is an Android mobile system that can scan and analyze the surrounding environment in the library for BLE beacons

This paper proposes the use of the BLE beacon in developing a smart library mobile application called Beasmart. The rest of the paper is structured as follows. The Beasmart library methodology is briefly explained in Section 2. Section 3 explains the survey analysis and the results. Section 4 shows proposed framework. The paper is concluded in Section 5 with some future research work.

Methodology

This research is using a Beasmart library methodology. The Beasmart library methodology as in Figure 1 is used to achieve objectives of this research. The methodology contains of 5 main phases: The first phase involved gathering of Beasmart Library specification based on analysis of current smart library literature reviews to identify the current technology used to develop the smart library application. This will also cover the specification of software and hardware. In this phase, a quantitative method is used to gather students' perspectives on the current library system. A survey of five questions of the current library services was distributed to more than 930 UPNM students to gather their input. The findings from Phase 1 were used to design the specification of the proposed Beasmart Library system. The analysis of the quantitative data will be discussed later in the Survey Analysis Section.

In Phase 2, the proposed Beasmart library application involved the integration of IOT sensor, beacon technology and local positioning system in UPNM's conventional library system. The specification design is used to develop smartphone application for the smart library using Android as in Phase 3. The specification design will be elaborated more in the Framework Design Section.

In Phase 4, the Beasmart library mobile application is integrated and tested at the UPNM's conventional library to ensure that the proposed system works well in a real library environment. Finally, as in Phase 5 the completed and free error system will fully deployed in UPNM's library to upgrade the conventional services to more effective service using a Beasmart library application.

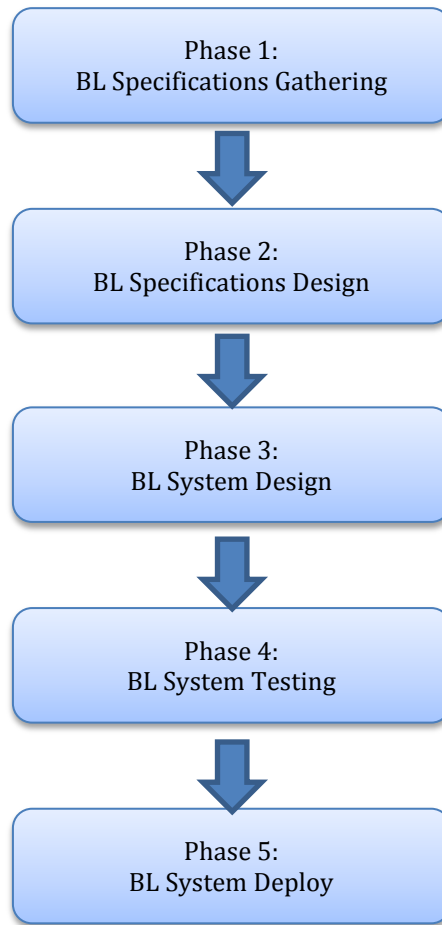


Fig. 1: Beasmart Library (BL) Methodology

Survey Analysis

A survey has been conducted to collect information regarding the current library searching book system. The survey was distributed to UPNM students. There were 930 feedbacks has been collected. Following are the quantitative analysis as the primary study of this project. Graph for each question listed in the questionnaire presents students' perspectives on the current library system analysed as follows:

a) How do you find the current method of searching books in General Tun Ibrahim Library?

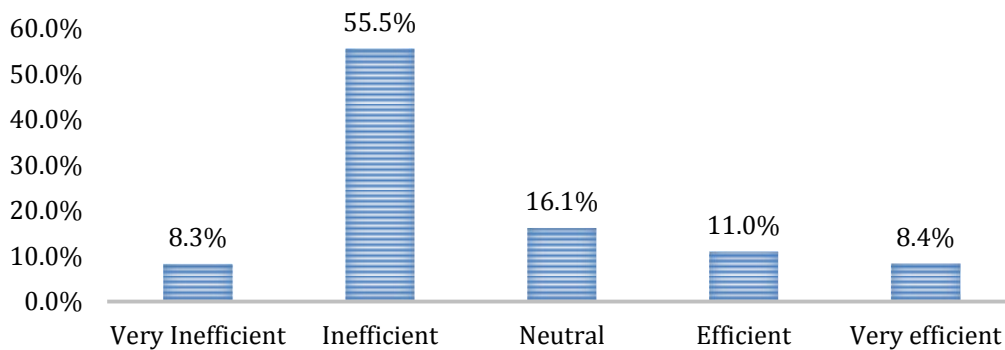


Fig. 2: Student Perspective on the Efficiency of Current Book Search Method

The graph in Fig. 2 presents the perspectives of students for the current practice of searching books in the UPNM's library. Majority of students (55.5%) described it as inefficient and 8.3% described as very inefficient. While 11% defined it as efficient, 8.4% very efficient and 16.1% described it as fair.

- b) Do you find this book searching method is very old and traditional?

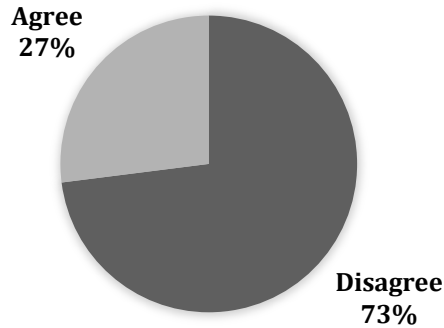


Fig. 3: Student Perspective on Current Search Book Method

The graph in Fig. 3 illustrates the students' view on the current searching book method. The graph showed the most of students (73%) agreed that the current system is very old and traditional. While 27% disagreed.

- c) Do you prefer alternative method using modern technology that will improve the current system?

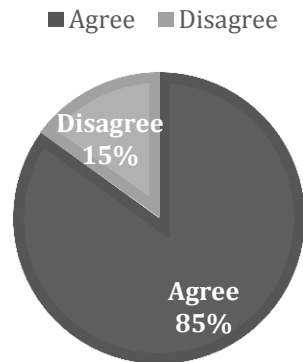


Fig. 4: Student Perspective on Improvement of Search Book Method

The graph presents in Fig. 4 shows that 85% of students prefer on alternative method using modern technology. While 15% of students did not prefer to have an alternative method.

As a conclusion, most students find the current method of searching books in the library is not efficient. They agreed that the current system is out dated. High percentage shows the current system should adopt a modern technology.

Proposed Framework

As library building and number of shelves or book racks grow larger and more complex, the requirement of indoor navigation system has increased. This project proposed to use BLE Beacon as navigation transmitting device for students and library patrons to find the location of exact shelf of books in a big library.

The proposed system comprises of indoor navigation system using BLE (Bluetooth Low Energy), mobile application and LED Blinker. BLE device is small, compact and powerful Bluetooth transmitter that has low power consumption wireless device. It could transmit information to Bluetooth receiver (smart phone) in the range of maximum 100m. Hence, this type of Bluetooth transmitter was proposed to be use as indoor navigation system for students and library patrons to search for the book shelf. Moreover, as the firmware of the BLE that will be used in this project is Arduino, the transmitter range could be customized as per end-user requirement. Fig. 5 shows the BLE that will be install to each book shelf in the library.



Fig. 5: BLE Beacon

BLE installed in each of book shelf was programmed to transmit the current location of the book shelf. Information transmitted by the BLE including the level and the shelf number. Users with smart phone will detect the BLE signal when in they are in the range. Using information transmitted by BLE, the user with smart phone will know their current location in the library. As the users move forward in searching location of desire book shelf, the BLE that was installed in every shelf will continue transmitting user's current location and nearest book shelves information. This system will help users to keep track their current location in big library and navigate user to their desire book location.

Smart phone used as illustrating device to navigate users in the library. Most of the smart phone nowadays equipped with Bluetooth module. Users need to enable Bluetooth in order to receive information transmitted from BLE. One application will be developed to assist user in searching available books and navigate them to the exact shelf. The mobile application is not for indoor navigation purposes only, but also to serve user in querying books using book's title and call number. Furthermore, the application will show user details of the book authors and book status. The status including availability of the book in the library.

When user start searching for a book, as the user approaching the book's shelf, the LED that equipped at the book shelf will blink. This feature was installed to help users alert that they have reached to the book's shelf.

Fig. 6 summarizes and illustrates the implementation of the proposed framework of BLE beacon and mobile phone application in library.

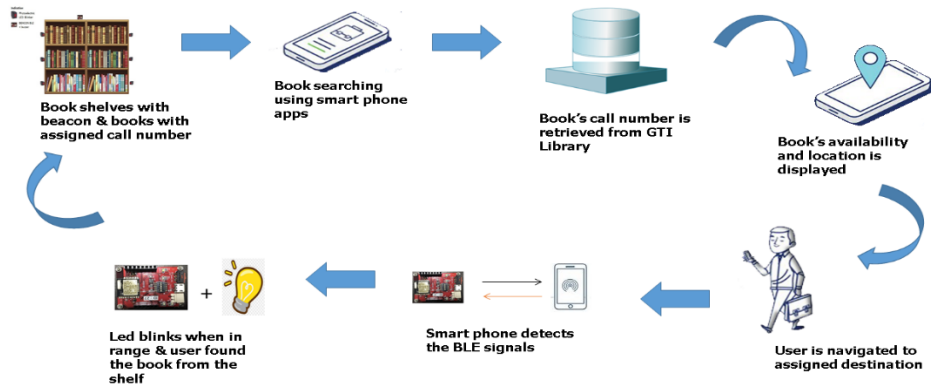


Fig. 6: Proposed framework of Besmart Library using Beacon Bluetooth Low Energy (BLE) Technology

Conclusion

In this paper, a smart range detector system named as Besmart has been developed to locate books in a library using prominent Beacon technology. Beacons are hardware transmitters in a class of Bluetooth Low Energy (BLE) devices that broadcast their identifier to nearby portable electronic devices. The proposed technology enables smart phones, tablets and other devices to communicate to a beacon using Besmart mobile applications; hence giving users the exact location of books on the shelves including the navigation features. The efficient smart library system is developed to enhance productivity of library patrons and users in managing and locating books with less manpower needed and promote a cost-effective system. In future, the proposed system can be extended to provide detailed information of the inventories on dedicated shelves by integrating OPAC databases to Besmart Databases. As a conclusion, the proposed method can be widely implemented in other storage premises as a smart inventory management system including warehouses, shipping ports, courier inventories rooms or filing rooms to replace manual inventory management system to locate items on the shelves.

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