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Book Searching Navigation in Libraries Based on iBeacon Technology

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Abstract With fast pace of life, quick service is in great demand. Accordingly, in libraries, managers are trying to find a balance between quick search for books and increasing volumes, which lengthen the searching time to some extent to achieve further development. Countermeasures are there from both the institutional level such as scientific layout or arrangement of items and the technological level, which has given birth to the concept of smart libraries. And in this paper, a design of Beacon-based system is described to solve the quick positioning and navigation problems for the library command. The key issues for the library command are solved in this system, including positioning of the targeted books and navigation for the corresponding shelves. The system is based on WeChat owning hundreds of millions of active users, in which way there is less worry about the system compatibility thus of high feasibility to promote for public use. Also, other functions of the system are introduced later derived from the message push based on Beacon-related technology, allowing for location-based services.

Keywords: *smart libraries, iBeacon-based system, quick positioning and navigation, WeChat*

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1. Introduction

In an era of information explosion, libraries keep expanding their size and stock of resources to satisfy readers' demands for knowledge of great scope and diversity. On the other hand, readers are often trapped in searching for the targeted books they are exactly calling for in such a large place with plenty of items. According to incomplete statics, college students spend approximately 10 minutes on average searching. As a result, sometimes it is of necessity to make a tradeoff between those above, fortunately, as to which technological means show promising prospect, putting indoor positioning and navigation into application of scenes in libraries. One of the technology is based on iBeacon of low cost and high accuracy.

iBeacon is a protocol developed by Apple based on Bluetooth 4.0 Low Energy BLE and introduced at the Apple Worldwide Developers Conference in 2013 [1]. Beacons are standalone devices that constantly send out a UUID (Universally Unique Identifier) using BLE.

Various vendors have since made iBeacon-compatible hardware transmitters – typically called beacons – a class of Bluetooth low energy (BLE) devices in a variety of form factors, including small coin cell devices, USB sticks, and generic Bluetooth 4.0 capable USB dongles that broadcast their identifier to nearby portable electronic devices. A Beacon's identifier can be picked up by a compatible receiver (mobile phones running iOS 7.x or higher or Android devices running version 4.3 or higher and having compatible Bluetooth receivers). iBeacon differs from some other location-based technologies as the broadcasting device (called beacon) is only a 1-way transmitter to the receiving smartphone or a receiving device, and necessitates a specific app installed on the device to interact with the Beacons. If the position of a iBeacon transmitter is caught, the information can be used by a suitable app to determine a receiver's (mobile phone) physical location, track customers, or trigger a location-based action on the receiving device. An iBeacon transmitter emits data packets at a specific interval consisting of its UUID and its broadcasting power. The broadcasting power is the Received Signal Strength Indication (RSSI) measured at 1 meter from the device. A smart phone with a suitable app can use the actual RSSI and the broadcasting power to calculate the approximate distance of the receiver from the beacon [2]. As the strength of the signal decreases predictably as a user gets further away from the Beacon. Obtaining the RSSI at one meter, and the current RSSI, it is possible to calculate the distance and can be presented as a range [near / immediate / far] or as a measurement

In the field of LBS, many previous studies about iBeacon have been implemented. Biehl et al. [3]

developed an indoor location estimation system for mobile devices using stationary beacons. Sruthi Menon et al. [4] designed a system called The Smart Workplace using iBeacon, which is energy efficient and economical. For the fire emergency demand, an indoor and outdoor integrated positioning system with a firefighter handheld device was brought out by Linjun Yu et al. [5]. providing real-time indoor and outdoor locations for the firefighters and the trapped people. For the medical demand, Xin-Yu Lin et al [6] implemented a mobile-based indoor positioning system using mobile applications with the iBeacon solution, showing enough accuracy for medical staff to track the locations of their patients.

2. Target

Libraries are of significance for college life, where there is a wealth of academic materials available for both faculty and students. However, in normal times, due to the limitations of management and equipment, there are still some deficiencies in the library, such as difficulties in finding or arranging books, making trouble in everyday use from the reader's side and management from librarians' side, in which case technological means can help a lot predictably.

Some tech means have come into use ever, among which the one based on RFID is relatively popular in some way. It is non-contact with automatic identification technology of high accuracy, depending on a hand-held reader of high cost which goes ill with promotion. Moreover, it is of bare expansibility in functions limited to positioning alone. On contrast, iBeacon is of high accuracy and its device is of low cost. Also, relatively speaking, it is much more propagable owing to the broad acceptability of BLE tech in smart phones and the flexibility with support platforms. Besides, it is of feasibility to achieve multi-functions and broader use when developing the system on the WeChat public platforms.

Therefore, the purpose of our work lies here to design a WeChat-based LBS System for Libraries via iBeacon. Through analysis of applications of iBeacon worldwide and the specific situation of Jiang'an Branch Library of Sichuan University, the system based on WeChat and HTML5 is aimed to achieve indoor positioning, navigation for resources on the first floor and message pushThe template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. Your paper is one part of the entire proceedings, not an independent document. Please do not revise any of the current designations.

3. Implementation Method

With WeChat Public account as the development platform, based on iBeacon technology, the system implements book searching in HTML5 interface. The hardware of the system is divided into three categories: ibeacon base stations, readers' terminals and the background server. The following diagram shows the basic architecture of the hardware.

- iBeacon base station: to send Bluetooth signal, communicate with readers' mobile terminals in one way.
- Readers' terminal: to receive Bluetooth signal, calculate real-time coordinates by the weighted fingerprint algorithm, calculate the reader's position according to the fingerprint database and send service request to the server to obtain the corresponding location.
- Background server: to store, manage, and forward data in the system.

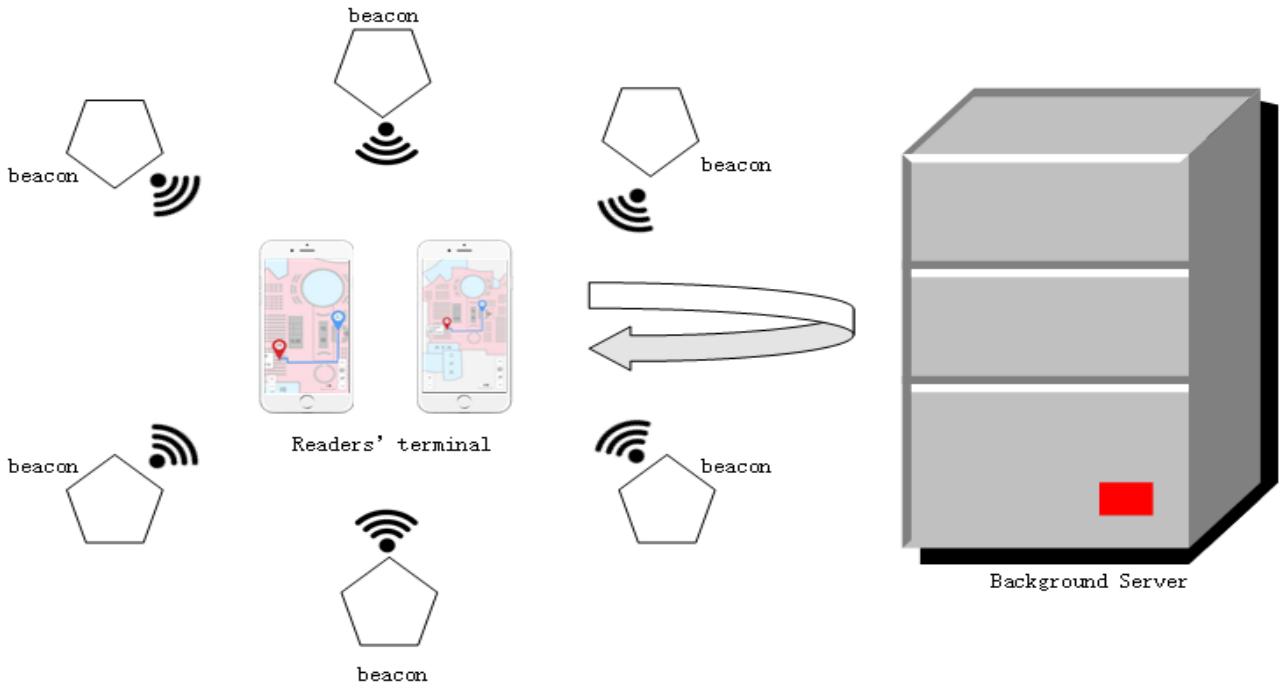

Figure 1. System Hardware Deployment Diagram

3.1. Preparation Work

In our design, the Jiang'an Branch Library of Sichuan University is taken for the targeted scene, with its first floor the core place.

• Drawing an isometric map

Taking the expandability of the project into consideration, we draw up a complete first floor plan of the library, marking the bookshelves in it in order to achieve the shelf-positioning. To ensure the applicability of navigation, the two-dimensional projection of the ground furnishings is marked as well. The sample map is as follows.

• Register WeChat public account

With WeChat, H5 pages as the implementation mediums, users don't need to download third-party applications. Their need for positioning and navigation of resources can be met in the following three ways.

a). the main menu. Click directly from the menu of WeChat public account to enter the positioning page.

b). WeChat "shake". Under the premise that the user turns on the Bluetooth, using the WeChat "shake" peripheral tab, the corresponding page will be shaken out.

c). Sharing in WeChat friends circle. The circle of friends binds the H5 page to the WeChat custom sharing function, and the user can get the entry page from the circle of friends.

Moreover, in order to complete design, debugging, measurement and optimization of the system, the corresponding interfaces and functional rights of the WeChat public account need to be obtained.

• Configure and bind the Beacon

To implement the functions through WeChat public account and H5, the system calls the corresponding interface of the JS SDK, requiring obeying the invoked protocols. The agreement stipulates that only when the beacons are bound to the WeChat public number, they can be monitored and accept signals. Therefore, in short, when adding a Beacon through the WeChat public platform, the unique set of device numbers for it are generated The configuration of the Beacon is completed by writing the device number provided by the WeChat public platform to the APP provided by the iBeacon device vendor.

3.2. Establishment of the Multiple Databases

The realization of the function of this project requires the establishment of multiple databases to store various types of data. In this paper, the fingerprint database-based localization algorithm is used to compare the collected data with the fingerprint database data, determine the current location and other information through certain strategies, and establish a fingerprint database. At the same time, in order to improve the database reading speed, this database is used. Simplified, established the base station database; in addition, in order to achieve the shelf positioning and navigation, the bookshelf database was established; in order to locate the books, a book database was established to correspond the book information with the bookshelf; to enhance the project's expandability and meet wider Demand, taking into account the potential value of the user's personal center, established a student information database.

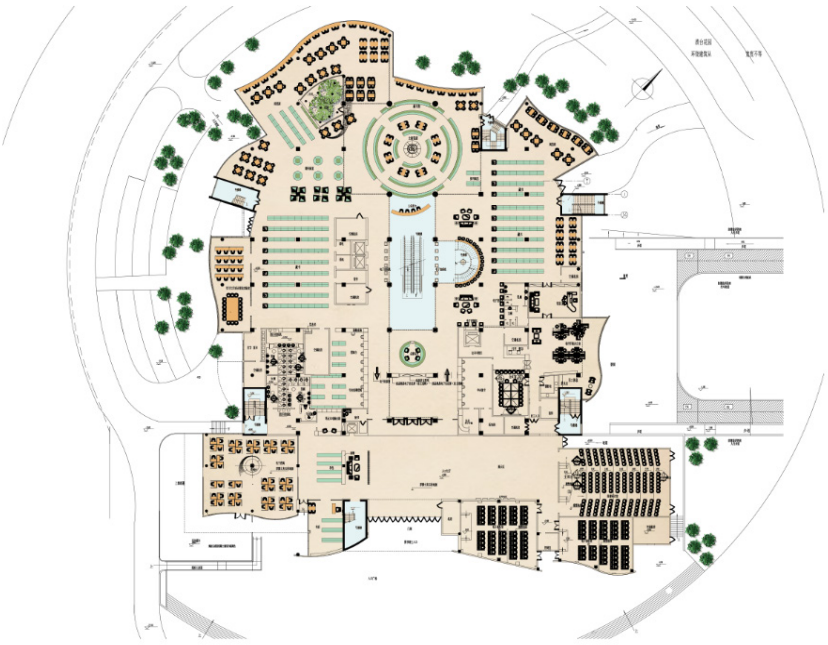

Figure 2. Library Equal Scale Plane

Table 1. Structures of Databases

Fingerprint Database	Location X	Location Y	RSSI X	RSSI Y	PX	PY
Base Station Table	Location X	Location Y	UUID			
Bookshelf Postion Table	Location X	Location Y	Tag	Shelf Number		
Book Table	Book Code	Title	Tag	Shelf Number		
Student Information Table	Duration	Time	Location	ID	Name	

3.3. Positioning and Navigation

This project uses H5 to call WeChat JS DSK to collect Bluetooth signal information and obtain the status of surrounding iBeacon devices. The WeChat interface requests the distance every second when requesting the Bluetooth signal. It is worth noting that the distance data will be greatly deviated at the beginning of the request for positioning, which may easily lead to positioning failure. Therefore, this paper judges this in the program. When the data is abnormal and the positioning point is not in the area, the positioning interface will be requested again until the data is stable, then the stop positioning interface is called, and the data is transmitted to the server through PHP. In order to ensure the friendliness of the user experience, when the positioning data requested by the system reaches 10 times and there is still no valid data, the system will prompt the positioning timeout and request relocation to ensure that the user has been waiting in the positioning interface. The specific process is as follows.

a). Load the WeChat JS SDK positioning interface.

b). Open the search for the iBeacon device signal.

c). Monitor the iBeacon device signal, calculate the map coordinates of the anchor point according to the positioning algorithm, and finally pass the plane map coordinates to the server-side code processing through ajax.

• Design location algorithm

Positioning is one of the core parts of the project. The paper has considered two types of positioning algorithms and summarized their characteristics.

1. Parametric positioning method based on geometric measurement. This method mainly calculates the distance between the user and the access point based on the time of arrival (TOA), the time difference of signal arrival (TDOA), the angle of arrival (DOA) of the signal, and the received signal strength (RSSI), and then uses the method of trilateral positioning. Positioning. Due to the complex indoor positioning environment, multipath propagation is very serious, and the parameterized positioning accuracy and effect are often poor.

2. Non-parameterized positioning method. This method is to estimate the location of the environment information as a coordinate function of the target to be located, which is an environment-aware positioning idea. In comparison, non-parametric positioning has higher positioning accuracy in the field of indoor positioning. Location fingerprint technology is a typical non-parametric indoor positioning method. It is completed by the establishment of offline fingerprint database and online real-time positioning. The RSSI fingerprint map database is built in the offline phase. The real-time positioning stage is obtained by fingerprint database matching. location. The indoor positioning process based on RSSI fingerprint library is as follows.

a). Uniformly divide the positioning area into M×N grid points, and determine the position of the reference anchor point.

b). Measure the signal strength indication (RSSI) value of the reference point from the reference node, establishing an RSSI fingerprint database.

c).When positioning, measure the RSSI value of the to-be-determined point in real time.

d). Use matching criteria to match the previously established RSSI database.

e). Fingerprint library matching algorithms are commonly divided into two categories. One type is based on deterministic positioning algorithms, such as k-Nearest Neighbor (KNN) [7], Neural Network (Arts) [8], Support Vector Machine (SVM)[9]; The class is a probability-based positioning method, and the representative algorithm has a Bayesian method.

Finally, considering the factors of positioning accuracy, computational complexity, positioning delay, etc., this paper adopts the RSSI fingerprint localization algorithm based on proximity classification and KNN. The flow chart is as follows.

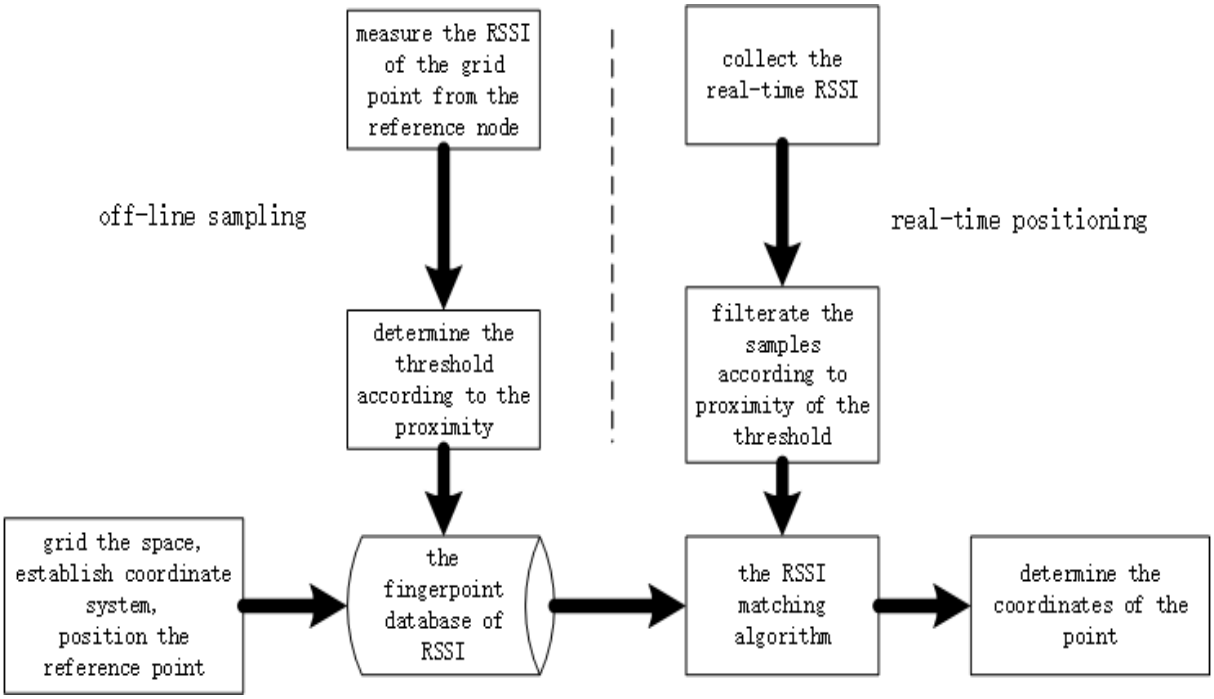

Figure 3. a flow chart of the RSSI fingerprint location algorithm based on proximity classification and KNN

The algorithm collects the RSSI fingerprint database during the offline training phase. According to the indoor RSSI propagation loss characteristics, the RSSI of each reference point is classified.

• Design navigation algorithm

The online positioning stage defines the search range according to the classification, and performs matching of the k-nearest neighbors to improve the accuracy and real-time of positioning. Navigation is one of the core parts of this project. At present, this paper adopts the k-based shortest path algorithm [10].

The basic idea based on k shortest path: According to the k-1 optimal path that has been queried, the Dijkstra algorithm is used to calculate the optimal path of all candidate deviation points to the end point, and the path is spliced with the path from the starting point to the candidate deviation point. The candidate path is formed, and the optimal path is selected from all the candidate paths as the kth optimal path, and the loop is performed until the number of found paths satisfies the given requirement K. In this system, the cost of each link constituting the path is determined by the length of the link and the congestion of the link. The calculation method is to first give all the segments the same size, and then adjust the cost through the following two steps.

1. Calculate the length of the road segment according to the position table. If the road segment is long, increase the cost of the road segment, otherwise reduce the cost of the road segment.

2. Calculate the user traffic of the current road segment by analyzing the user behavior record table. If the traffic volume is large, the road segment cost is increased, otherwise the road segment cost is reduced. Considering that the same level of library is basically not congested, in the actual design, this article ignores this step.

4. Result

This paper proposes a library self-guided and borrowing system based on iBeacon transmitter and WeChat applet. By arranging a simple Beacon network and designing a background database related to books and student information, a book addressing system based on WeChat and iBeacon can be established by using a high-precision RSSI fingerprint positioning algorithm and a K shortest path navigation algorithm. At the same time, this paper analyzes the preparation conditions, application process, key codes and algorithms for indoor positioning. With more and more interface permissions developed around WeChat, the rapid rise of HTML 5 technology, and more and more wireless network coverage, there is still much room for the application of WeChat in the library in the future. Students can take full advantage of the popularity of smart mobile terminals to complete self-help book inquiry, guide bookcase paths, borrow books, reduce borrowing time and improve borrowing experience.

In addition, this article introduces other personalized services as follows.

1. Information push (recommended scheme: 1. Default recommendation (no history or less history) 2. Recommended according to preference (based on: user's duration of each point, borrowing reservation history, number of arrivals)

2. Check-in interaction

The reader who enters the library scans the location QR code information through the mobile phone camera to obtain the check-in prompt box. The reader only needs to click the “confirm check-in” button to upload the fingerprint of the location and the QR code information to the reader through the iBeacon positioning system. On the server side, the result is returned to the client, prompting the reader to "check in successfully"

3. Welcome information

When the reader passes or enters the library, the library can use Beacons to automatically send a welcome message to the reader's mobile phone, which can include recent event information, new book recommendation, and so on. At the same time, the identification can also provide readers with personalized book recommendation service, book overdue reminder information, appointment event reminder and other information.

4. Design questionnaire survey

With Beacons, you can do some small surveys, such as whether you are satisfied with the series of activities launched by the library. In this way, the waste of paper questionnaires can be reduced, and the online version of the questionnaire survey can be eliminated, and the reader can also use the mobile phone to complete the survey.

5. Management seat

Everyone in the library has a position. Students can check the empty seat rate and vacancies of the library on the WeChat public account, which reduces the length of time the students are looking for a seat, and increases the utilization rate of the library.

5. Conclusion

With the rapid development of wireless communication technology and the acceptance and recommendation of new technologies by libraries, wireless communication technology will bring great changes to the library. The emergence of iBeacon will bring convenience to libraries and readers in many ways.

iBeacon is affordable and versatile. The library can use iBeacon to push information based on location and push information based on personalized characteristics. I believe that in the near future, the library will adopt this new technology to bring a new technical experience to each reader.

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