SHOP&NAV: iBeacon based indoor assistance and Navigation System

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Abstract- There have been various navigation and tracking systems being developed with the help of technologies like GPS, GSM, Bluetooth, IR, Wi-Fi and Radar. A shopping Mall is a vast place, & people often get confused with the direction of the nearest ATMs or even rest rooms. This paper presents the concept of an indoor assistance and navigation system for customers that leverages mobile devices. How to help customers to find the correct store location in a shopping mall, how to get to know about the promotions, discounts that are given by stores are issues that need to be solved urgently because time is the most value item in the present world plus in the future. Paper presents an iBeacon based Indoor Assistance and Navigation for shopping malls. It firstly analyzes the advantages of iBeacon compared with the common indoor positioning technologies; then design the indoor positioning system for shopping malls based on the three-layer architecture of Internet of things to have message-push-service through clients. Finally, the shortest distance algorithm Dijkstra's is used to recommend the nearest store to the customer and for the predicting the places that user might visit will be process with the use of K-Nearest Neighbor algorithm. Shown as result of the experiment, indoor positioning for shopping malls can be realized by the system. Expected benefits of the system are that people ought to find their way quicker and easier, being less distracted from their usual shopping experience.

Index Terms- iBeacon, BLE (Bluetooth Low Energy), Push Message Service, Dijkstra's Algorithm, K –Nearest Neighbor Algorithm.

I. INTRODUCTION

Navigation is the development of guiding and controlling the movement of an item from a source to a target along a path. Indoor navigation systems are designed to navigate the user within closed locations. There are varieties of indoor localization method and systems have been developed over the past years in an indoor environments positioning is mainly achieved through the use of radio technologies such as such as sensors, Infrared (IR), Ultra-Wide Band (UWB), Wireless Local Area Networks (WLANs), Wi-Fi, Bluetooth, Radio Frequency Identification (RFID), Assisted GPS (A-GPS), blue tooth, Zigbee and so on. At present, indoor positioning technology is increasingly perfect. It is commonly used famous museums while rarely used in large and medium-sized shopping malls. Indoor positioning is realized via WLAN, Bluetooth or radio frequency identification technology. Wireless local area network can realize the goal of positioning, monitoring and tracking target in a wide range. Self-location of network nodes is the basis and prerequisite for most applications. The Bluetooth technology is to locate object by measuring the signal strength. It has some merits. The greatest one of them is the small volume of the device, which makes it easier to be integrated in PDA, PC and mobile phone. Thus its popularization is easier. But it has some disadvantages. First, the devices and equipment of Bluetooth are expensive. Second, in the complex space environment, the Bluetooth system is unstable and vulnerable to be interfered by noisy signal. Radio frequency identification technology is to use radio frequency to achieve the goal of recognition and positioning by non-contact two-way data communication. On the one hand, it has advantages of big transmission range, low cost and getting information about the location in a few milliseconds. On the other hand, it has the disadvantages of short effect distance, and lack of the communication ability. Besides, it is also difficult to be integrated into other systems. In this paper, iBeacon-based indoor positioning systems for shopping malls, SHOP&NAV is introduced. The SHOP&NAV application will be a mobile application that runs in android platform that provides location finding and getting direction services at the shopping mall premises, using the newest technology, Bluetooth LE.

Unlike Global Positioning System (GPS) iBeacons has the capability of tracking the micro locations even in a limited geographical area in a very accurate manner. Since it works in long distance, it makes it more beneficial. With the aid of this device, SHOP&NAV will be able to locate the places in the shopping malls using a smart device. The SHOP&NAV application is a combination of android application and an online server and merged together, where the android application has the capability of accessing the online database which is stored in the server using application program interface (API).

Along with the navigation and hotspot detection there is a push message service which is used to send notifications regarding discounts, promotions, etc. by shop owners. Any device that runs the SHOP&NAV application will be able to receive notifications through the server. This project consists of designing and implementing an Android application for exploring the shopping malls. The authors have several objectives as follows.

A. General Objectives

To implement a flawless application for the users. It helps to increase revenue and customer loyalty which improve the marketing of this application.

The application should consistently guide users to their destinations within a reasonable distance. The application

should be used by any other person with a very simple knowledge of mobile applications. Develop highly user friendly application.

The application should have easy-to-use UI that displays navigation hints correctly based on the user's current state.

The application will be suing new features such as pop-up notification which helps to promote the products and brands. The application; it also affects the marketing approaches.

II. Literature Review

Yang J, et.al (2015) has discussed about an iBeacon base indoor positioning system for hospitals to help patients to find their departments or wards. The indoor positioning system for hospitals, has message-push- service through client. [1] Chakraborty A. et.al (2013) has developed an Embedded Linux based shopping assistance system. The system is implemented of location based touch screen modules with the centralized database can provide easy. [2] Tripathi J.P (2010) has developed an Algorithm for detection of hotspot of traffic through analysis of GPS data. It will present a method to detect traffic areas using the term "Hot Spot" with the help of GPS data. To detect the "Hot Spot" areas an algorithm used based on speed of the vehicle and clustering algorithm. [3]. M.Binsabbar (2014) has developed an iPhone Application for providing I-Beacon based service for student. This system mainly focused on taking attendance of the student, detects student's presence at a location and does not provide any navigation. [4]. Ozdenizci K. et.al (2011) has developed an Indoor Navigation System using Near Field Communication (NFC) Technology. This system used Dijkstra's algorithm and graph derivation algorithm to quickly compute the best route. [5] Narula H. et.al (2014) has designed a Smart Shopping Cart a Product Navigation System. This system displayed the User's location based on an Indoor Position System. [6] Winkler C. et.al (2011) have developed "NaviBeam: Indoor Assistance & Navigation for Shop-Ping Malls through Projector Phones". [7] Chen Z. et.al (2015) has implemented an I Beacon Assisted Indoor Localization and Tracking System. This system used I beacon and Pedestrian Dead Reckoning (PDR) technology for localization and tracking system. [8] Molteni R. and Perini F. (2010-2011) have implemented "WhAC: A Wi-Fi based application for indoor localization." This research based on an algorithms & applications for indoor Wi-Fi localization in noisy environment such as shopping malls, markets. [9]

III. Methodology

At the initial step the team conducted a literature review on the existing application to get an idea about the features of them, the usage, and the accuracy as well. At the same time, an online survey was also performed among a selected group of users and those results were evaluated accordingly. In order to identify the real situation in a shopping mall premises.

When considering the explained solution of SHOP&NAV, it can be described as a combination of two main components. They are the backend server, and the mobile application. The backend server is Go Daddy hosting server, while the mobile application is developed in Android Studio.

A. The Mobile application

The system has been developed based on three-layer architecture of Internet of things, as shown in Figure 01.

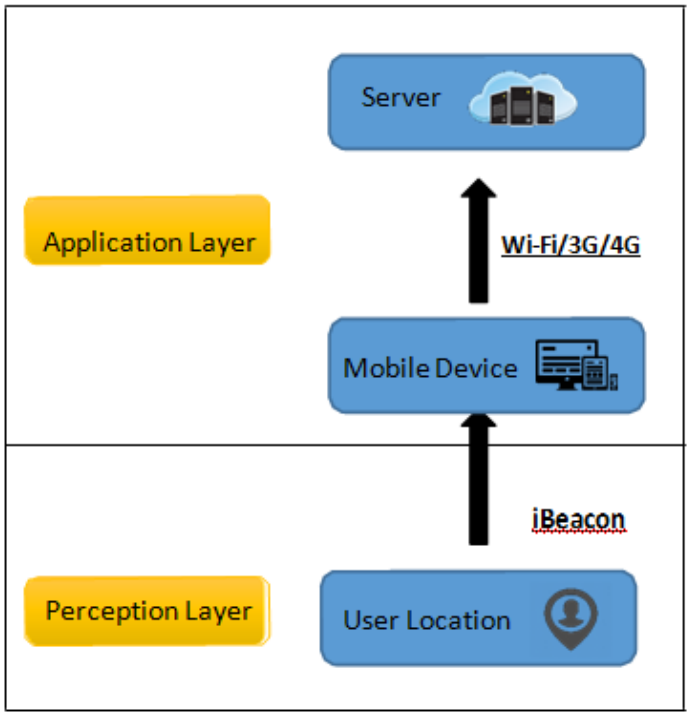

Figure 01: The Composition of the System

The network layer: Mobile data connection is selected, because direct communication between server and client, such as mobile phone, and tablet, is completed, through the indoor Wi-Fi, 3G, or 4G.

The perceptual layer: First iBeacon was configured. When a user enters this place, iBeacon will automatically send the specified information to the client, and the client forward it to the server. The server determines the location of the user according to information from the pre-configured iBeacon, and then sends the information processed back to the client. Application layer: It includes server and client. Server is responsible for processing information, while client is responsible for interacting with users. In the Application layer the direct communication between server and client.

As shown in Figure 2, the application layer is divided into three functional modules: the message pushing module, the indoor navigation module and the data (about visitors) collecting module. The message pushing module consists of shopping mall broadcasting message pushing, introduction of shops promotions and discounts. Message pushing service of client refers to the real-time delivery of information from server to directed mobile phone. It differs from the common polling mode mainly in two aspects: long networking and real-time delivery.

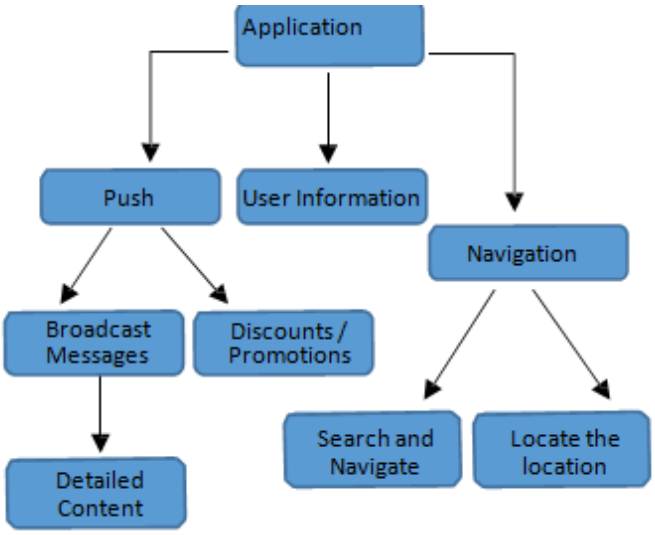

Figure 02: Architecture of Application Layer

The process of message pushing is as follows:

Step1. Client sends a request of http long connection, and then waits for response from the server. This request is asynchronous.

Step2. After the server receives the request, it does not immediately send the data, but hold this connection. This process is none blocking, so the server can continue to process other requests.

Step3. Only when the server has new data, the server takes the initiative to push out these new data, through good connections established before, to the client.

Step4. The client receives data returned which can be processed and then gives a new request of long connection again.

When a user enters an area covered by the iBeacon signal, client of the device which this user carries will receive iBeacon's ID, under the condition that the device's wireless network, 3G or 4G is opened. Client gives ID received to the server, and the server will compare the received ID with data put into database by technical personnel. If it exists, this user's location will be gotten.

When a user approach target area, the client will determine the distance between iBeacon module and user terminal. When this distance is less than a specific value, the client will take the initiative to request the server to push dynamic message of the area including the promotions and discounts. Furthermore, the client also can push detailed introduction of the range of the location. Figure 03 is the flow chart of message pushing.

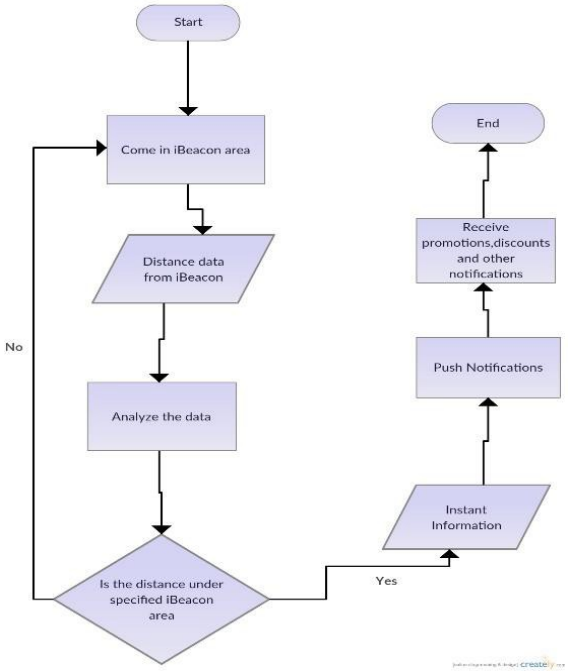

Figure 03: The Flow Chart of Message Pushing

iBeacon uses Bluetooth 4.0 connectivity. iBeacons broadcast their identifier to nearby portable electronic devices. This technology enables smartphones, tablets and other devices to perform actions when in close proximity to an iBeacon. In order to work in that manner, the iBeacons need to identify the co-ordinates of a particular user location, because then only it can direct the user in to the preferred destination. In pseudocode the algorithm can be described as follows (pseudocode may vary). Table 01 will illustrate the pseudocode for Navigational algorithm which is Dijkstra's algorithm. The flow chart description will provide how the Dijkstra's algorithm assist the user in Figure 4. When a user enters into the shopping mall, if he needs to go to one desire place or shopping mall who can simply enter the current location and destination location on the search page. The algorithm will calculate the distance from source to destination and User can easily navigate to the desire place.

1	Foreach node set distance[node] = HIGH
2	SettledNodes = empty
3	UnSettledNodes = empty
4	Add sourceNode to UnSettledNodes
5	distance[sourceNode]= 0
6	while (UnSettledNodes is not empty)
7	evaluationNode = getNodeWithLowestDistance (UnSettledNodes)
8	remove evaluationNode from UnSettledNodes
9	add evaluationNode to SettledNodes
10	evaluatedNeighbors(evaluationNode)
11	getNodeWithLowestDistance(UnSettledNodes)
12	find the node with the lowest distance in UnSettledNodes and return it
13	evaluatedNeighbors(evaluationNode)
14	Foreach destinationNode which can be reached via an edge from evaluationNode AND which
15	is not in SettledNodes
16	edgeDistance = getDistance (edge (evaluationNode, destinationNode))
17	newDistance = distance[evaluationNode] + edgeDistance
18	if (distance[destinationNode] > newDistance)
19	distance[destinationNode] = newDistance

Table 01: Pseudocode for Navigation Algorithm

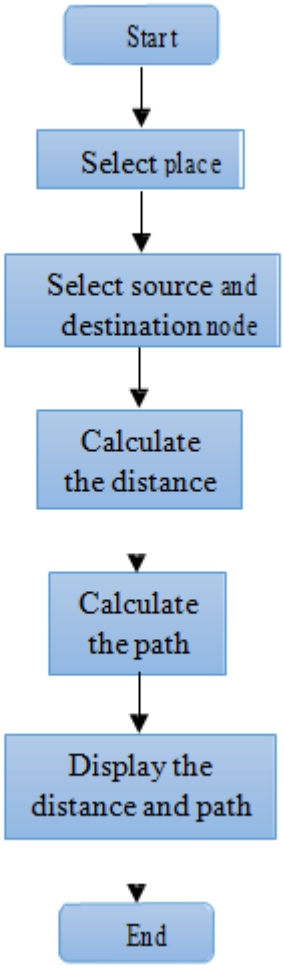

Figure 04: Navigation Flow Chart

For the hotspot detection the K-Nearest Neighbor algorithm is used. Table 02 will illustrate the pseudocode for the K- Nearest Neighbor algorithm.

1	Function KNN
2	Input: A finite set D of points to be classified
3	A finite set T of points
4	A function c: t - > {1…., m}
5	A natural number k
6	Output: A function r: D - > {1…, m}
7	Begin
8	Foreach x in D do
9	Let U < - {}
10	Foreach t in T add the pair (d (x, t), c(t)) to U
11	Sort the pairs in U using the first component
12	Count the classes labels from the first k elements from U
13	Let r(x) be the class with the highest number of occurrences
14	End Foreach
15	Return r
16	End

Table 02: Pseudocode for KNN

Figure 5 will illustrate the how KNN algorithm calculate the hotspot according the mobile application. When a user enters into the shopping mall, by analyzing the data according to user's previous visits the KNN algorithm will process the data and will select and suggest the nearest neighbor (Shops that visited most). The algorithm will calculate the no of visits user's history and. Therefore, User can select the desire place. K- Nearest Neighbor is a simple algorithm that stores all available cases and classifies new case based on a similarity measure.

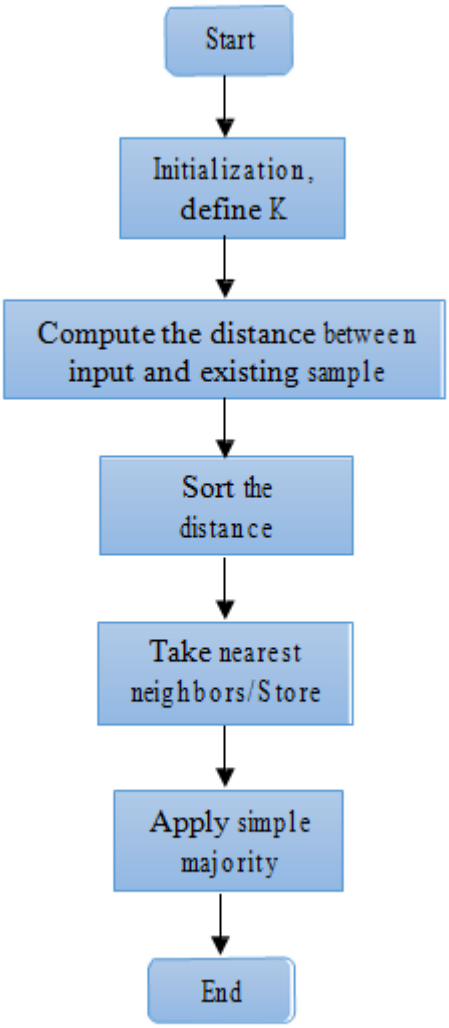

Figure 05: Flow Chart KNN

B. Backend server

Application layer consists the backend the which is Go Daddy Hosting server. The Server contains the online database which is MySQL database which contains all User's details, Device Details and Shop Details. The Server and the mobile application connected using API which is designed using PHP and JSON

IV. Result and Discussion

A. Result

Throughout this research the core finding that has been found was the possibility of using iBeacons to discover micro locations even in a limited area, using the two algorithms developed by the team based on the mathematical concepts that have been discussed in Section 3, under methodology.

Besides the algorithms the API is designed to connect the mobile application and the backend server is another finding that team came across within the SHOP&NAV project. It has most basic key words that can be found in PHP language plus in JSON. Since the mobile application is hosted the mobile application will be able to produce some information regarding the navigation and user and shop details.

B. Discussion

This Bluetooth transmitting device technology has opened up a new page in the book of indoor navigation and opening up micro locations in it. During the testing phase, the team noticed that there is an attenuation, which reduces the strength of the signals that comes to the mobile phone, from the iBeacons due to the obstacles in the surface, and as the beacons are designed specifically designed for IOC platform because of that the team has faced a problem with BLE connection with the Android stack which the testing mobile device is not connecting with the beacons accordingly. To overcome this issue, the team had to purchase the second generation beacons with the newly released SDK.

V. Conclusion and Future work

In a vast area like shopping mall, sometimes it could be hard to find particular locations even for a usual person who works at the shopping mall itself. The implementation of the SHOP&NAV has quite impact on the Shopping mall environment, given that the system allows visitors navigate in indoor, search for a place of interest, view availability of a person of interest with complete ease. The main intent of our system is customer relationship management by using dynamic navigation and pop up notification using hotspots detection. Therefore, by using our system customers can easily navigate through a complex to their destination and once they are travelling on an intended route and discover the prospective use of I beacon facility as an indoor positioning system in shopping mall. This system advances customer management services, business developments, as well as improve productivity and efficiency.

SHOP&NAV application currently has a limitation since it can only be used by the users with android devices. Therefore, this mobile application is to be modified to IOS platform as a next step beyond this research. The system currently uses 2D maps to view indoor floors of a building. Converting those maps to 3D, will be another better approach to be taken for guide users.

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