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Bluetooth Beacon Applications in Retail Market

Nikita Adkar, Akshata Talele, Chinmayee Mundhe, Anita Gunjal
MAEER's MIT College of Engineering,
Pune, India
nikitaadkar19@gmail.com*, akshata.talele@gmail.com, chinmayee.mundhe@yahoo.com, anita.gunjal@mitcoe.edu.in

***Abstract*—The retail market is wide and has a lot of prospects to offer, may it be in terms of revenue or meeting the customer demands. Albeit the pros it is losing its daily or regular clientele because of the unnecessary overhead of going through the various aisles and racks to find the necessary product and then proceed to a lengthy procedure to checkout. This paper addresses one such major issue in a way that the customers benefit from and the retailers can easily increase and analyse the sales. The solution is achieved using a low energy Bluetooth Beacon that communicates with other Bluetooth devices that are within the range and hence acts as a locator. In this paper we also discuss the various use cases which can be applied in retail store to address the problems faced by the customer. Our focus is on minimal power/ resource consumption in all of the scenarios. We also discuss various algorithms and communication protocols to satisfy all the aspects of the problem statement.**

Keywords—BLE, Eddystone, Internet of Things, iBeacon, Localization, Trilateration

I. INTRODUCTION

The proposed methodology is based on Indoor Localisation of the Retail shop so as to guide the customers to easily locate the required goods. This also includes the provisions to apply business logic layer that is to display the discounts on various products and to suggest different products based on basket analysis (already bought products) also to guide the customer to select the best product out of the lot. The solution also focuses on the retailer's point of view to analyse which products are popular among the customers or generate overall sales reports at one go. The idea is to take the input from customer what they want to buy further we calculate their location based on the received signal strength indications and guide them to the aisle where the product is located. The methodology also focuses on the display of suggestions and offers of the products to the customers.

Localization techniques using wireless networks have been an active area of research for the past two decades. The most common approach is using sensors or smart flooring. Bluetooth Beacon stands out from all the standard approaches. It is low energy and needs minimal maintenance and most importantly it doesn't require additional mechanisms since it uses Bluetooth to communicate which is inbuilt in smartphones. With the effective range in the order of tens of meters in indoor environments, beacon provides a very suitable "discriminating power" for accurate positioning with little training efforts, hence, making the solution optimal and efficient.

In this paper, we will deal with the implementation of Bluetooth Low Energy (BLE) technology in the form of beacons in retail markets. The key advantage of BLE comprises low energy consumption which allows the transmitters called beacons to be powered continuously from batteries from months to years. This also makes it possible to place the beacons in the spots where WiFi access points would be difficult to power.

The rest of this paper is organized as follows. We discuss related work in Section II. Section III describes the application of BLE beacons (iBeacons) in indoor navigation of retails stores. Section IV describes the technologies and methods that can be used for this implementation.

II. BACKGROUND INFORMATION

BLE beacons are more like proximity sensing hardware devices that notify nearby devices that are capable of receiving Bluetooth signals of their presence. Beacons use BLE (Bluetooth Low Energy) technology and continuously broadcast a signal to all smart devices in their range. They send unique location identifiers to applications on smartphones, which are programmed to respond in various ways based on the data received. Beacons enable personalized push notifications on just any smartphone as it enters a pre-determined location via these low-power signals received by smartphone applications. Since only Bluetooth Low Energy technology is used by the beacons, they do not need an internet connection to function. Beacons are often used for indoor spaces since the area covered by a single beacon has a limited coverage area[1].

Beacons are low cost palm-sized hardware devices that can be stuck to walls, ceilings, shelving units, etc. Beacons are battery friendly. BLE beacons provide a way for smart devices to communicate with each other in indoor spaces, where limited GPS receivers are available. When a user walks past a zone where an indoor positioning system using beacons is set up, the beacon sends a unique ID to the mobile device. This coded ID, which I shown as a form of notification, can only be viewed with a mobile application. The mobile application need not be running to be awakened by the beacon signal[2].

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Many applications on mobile phones use different inputs and techniques for indoor positioning. Indoor positioning provides better productivity and user experiences.[3] This paper tells how to accurately locate a device in a very light-weight framework using Bluetooth beacon technology. the framework explained in the paper uses iBeacon as indoor positioning technology, as it provides a significant advantages. A higher level of location awareness is provided by iBeacon in indoor positioning.

Further, iBeacon can be used in item tracking.[4] The solution proposed in the paper uses RSSI (Received Signal Strength Indication) for calculating the distance of the device and the beacons. The paper further discusses the restrictions using iBeacon technology while calculating the distances.

Beacon technology is ready and prepared to change the way consumers interact with brands. It helps in making the devices more helpful and transforming the way retail marketers measure the offline impact of online advertisements. Using beacons as a communication medium between the customers and retailers, it gives the customers an effortless shopping experience. It gives the ability to the retailer to reach the right person at the right time with the right message. For retail marketers, it provides with new and improved metrics to measure success. Beacon technology has proven to be effective as the bridge between retailers and the customers. It is the recently developed way to engage with customers and give them an opportunity to enjoy customized experiences and personalized recommendations.

III. APPLICATION IN RETAIL MARKET

Over the past few years, the market of beacon technology has been developing. During the period of 2016-2020, it is expected the global Bluetooth beacon market will grow at CAGR of 222.8% by volume [6]. It is predicted that, beacons will drive $44 billion in retail sales by 2019 [7]. Within 5 years, the retailers will invest $2.5 billion in IoT, and most of the investment will be for RFID tags and beacons. In retail shops the beacons are used to collect data which is available on the customers. Using beacons, 71% of the retailers are able to understand and track customers' buying patterns.

In the retail shop, beacons can be used for many purposes [7].

Advertising tool: The retailers have to rely on prints, TV, radio advertisements to attract the customers into their stores. Beacon technology can help to make the shopping experience personalized. The customers can be provided with the ads based on the proximity of the customer to the store. Based on the type of product the customer goes likely to, the advertisements of the related products can be triggered.

Personalization: Like the e-commerce businesses, the retailers can provide the customers with the personal shopping recommendations, using the individual customer preferences and shopping habits. Through the beacon technology, personalized shopping creates a bridge between the customers and the retailers.

Accessing data: For the retailers the data available on the customers is of utmost importance. The retailers can track shopping habits and preferences, through which retailers know how the customers behave which helps the retailers to plan their advertisements and give recommendations.

Providing location of the product: Many times the customers are confused and have lack of knowledge about the location of the particular product. Using the customers' location and the beacon ID which is near to the product, the product location can be provided to the customer.

IV. TECHNOLOGIES AND METHODS

A. iBeacon

Apple introduced the iBeacon, its trademarked technology, in 2013 Summer Worldwide Developers Conference[3]. The iBeacon protocol is considered as a next level development stage after Near Field Communication (NFC) technology or QR Code technology. iBeacon uses BLE (Bluetooth Low Energy) standard which is part of Bluetooth 4.0 technology. It is based on BLE proximity sensing by spreading a universally unique ID. This universally unique frame consists of a variable UUID, a major and minor pair[4].

The iBeacon data format has byte payload as seen in Fig. 1.

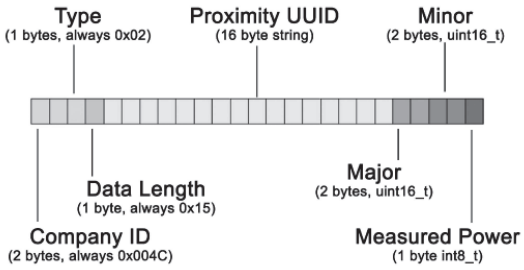

Fig. 1. iBeacon data format

UUID: This is a 16 byte string used to differentiate a large group of related beacons.
Major: This is a 2 byte string used to distinguish a smaller subset of beacons within the larger group.
Minor: This is a 2 byte string meant to identify individual beacons.

Following is an example frame for iBeacon:
fb0b57a2-8228-44 cd-913a-94a122ba1206 Major 1 Minor 2
where **fb0b57a2-8228-44 cd-913a-94a122ba1206** is UUID .
Fig. 2 shows the byte map of packets sent by iBeacon to the smartphones[5].

Byte 0-2: Standard BLE Flags

```
Byte 0: Length :  0x02
Byte 1: Type: 0x01 (Flags)
Byte 2: Value: 0x06 (Typical Flags)
```

Byte 3-29: Apple Defined iBeacon Data

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Byte 3: Length: 0x1a
Byte 4: Type: 0xff (Custom Manufacturer Packet)
Byte 5-6: Manufacturer ID : 0x4c00 (Apple)
Byte 7: SubType: 0x2 (iBeacon)
Byte 8: SubType Length: 0x15
Byte 9-24: Proximity UUID
Byte 25-26: Major
Byte 27-28: Minor
Byte 29: Signal Power
```

Fig. 2. i Packet Structure Byte Map

B. Limitations/ Restrictions of iBeacon

There are some limitations and restrictions while using iBeacon.

First limitation is that it is binding on the developers to use the data format provided by Apple in order to enable the usage of iBeacon functions in iOS.

The next restriction is the battery life [4]. Small coin-sized cell batteries can last up to a time span of two years. But with high signal strength and high advertising interval, this time span is reduced to one year. An effective solution to this problem is the usage of larger batteries e.g. AA batteries or an external power supply. However, these require power sockets which may not be available everywhere.

Bluetooth uses signals with 2.4GHz. Signals at 2.4GHz level have a problem with damping. In damping, the signal strength is reduced (i.e. amplitude of vibrations of the signal are reduced). Humans and walls are the main actors in the attenuation of the signals [4]. Fig. 3 shows the normal propagation of the signal.

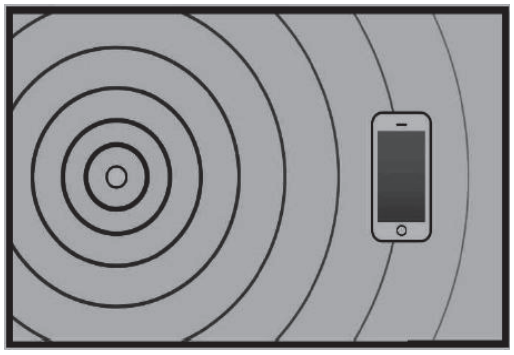

Fig. 3. Propagation of signal without barrier

Without any interference, the signal goes directly from the beacon to the smart device. This provides the highest accuracy. With a wall present in between the transmitter and the receiver, the accuracy reduces to a greater extent as seen from Fig. 4.

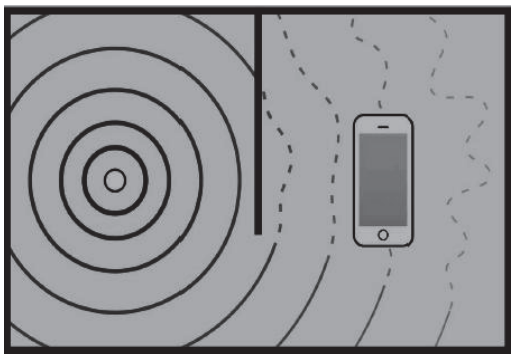

Fig. 4. Propagation of signal with barrier(wall)

A human body which consists of 80% water also affects the propagation of signal. The human hand also creates a damping effect which is evident from Fig. 5 [4].

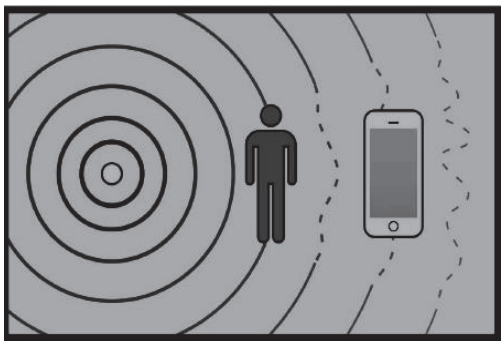

Fig. 5. Propagation of signal with barrier(human body)

C. Proposed Methodology

Using the Bluetooth technology, the mobile application listens for the signals from the beacons and acts accordingly. After the mobile receives the signals from beacons, the backend systems use data analytics and process information. The information gathered is then sent to the customers' mobile and the customer can enjoy personalized and customized in-store experience.

For using beacon technology in retail shops, we propose a solution which consists of a mobile application. The android based application will provide following modules,

1. Module to locate a particular product in the retail store.
2. Module to give suggestions based on the products bought by the customer.
3. Module to give push notifications about offers and updates regarding the products available in the store.

Eddystone is a protocol specification designed by Google [8]. It defines a BLE (Bluetooth low energy) message format for proximity beacon messages. It provides with several different message formats to create beacons that can be used for various applications. The message formats can be used individually or

can be combined. It has flexible architecture and is fully compliant with the Bluetooth core specification. Fig. 6. shows how the beacon technology can be applied in retail shops.

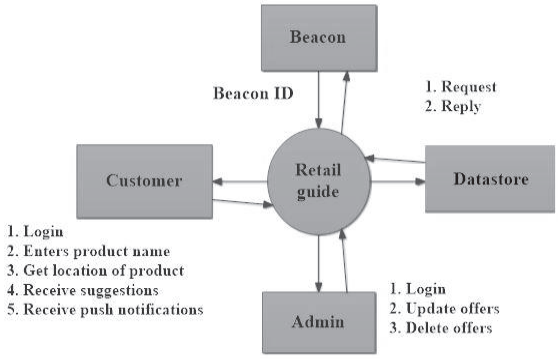

Fig. 6. Beacon technology in retail shops

D. Use cases

Locating a particular product in the retail store. So when the customer gives a product name that is to be searched, the mobile application searches the database and finds out in which beacon proximity the product lies. Once the beacon is been identified, the aisle number is displayed. Considering the user or customers' location that is to which beacon he/she is close to, the directions can be provided from customers' location to the destination beacon. Fig. 7 shows how the product will be located.

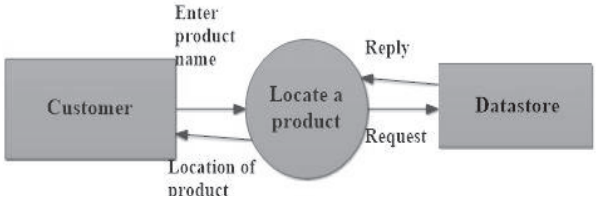

Fig. 7. Locating a particular product in the retail store

To find out the beacon to which the customer is closer, the value is calculated by measuring the strength of the signal (Received Signal Strength Indication) from the beacon (Fig. 8) [4]. The distance is provided in meters. The greater the strength of signal, greater is the accuracy.

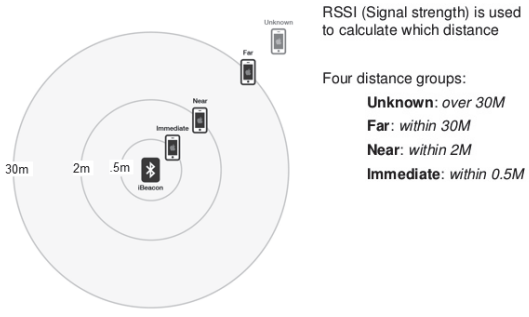

Fig. 8.

Distance calculation using RSSIFor calculating the distance, the formula is [10]:

$$d = 10 \wedge ((TxPower - RSSI) / 20)$$

Where, d = distance
Txpower = Beacon Txpower

RSSI reading are unstable and are highly dependent on environment and other factors [9]. Hence, it gives less accurate results. The obstacles between the beacons and customers' mobile, holding the mobile in different angle and the different mobile models (with different antenna) are the major reasons why the RSSI readings change and the accuracy for the distance calculations is not good.

After the customer enters the product name which is to be searched, the product name is then to be searched in the databases, to map with the respective beacon ID. To search the name in huge database is very challenging. The search should be accurate as well as fast. This will improve the system performance. Different search algorithms like, binary search, interpolation search, exponential search, or hashing can be used. Depending on the size of databases, the algorithms can be used. Like for small database, binary search can be used. But for huge database, like retail database, hash functions can be used.

Giving suggestions based on the products bought by the customer (Fig. 9). It is often being observed that the customer buying milk tends to buy bread or eggs. The customers' shopping highly depends on the previously bought items or it also depends on the time he/she spends in a particular aisle deciding whether to buy the product or how much quantity to buy. The relations between the items bought can be represented in the form of association rules. The association rules are very important part of data mining. It finds associations, frequent patterns and correlations between the data items. Different algorithms can be used to find the association rules like Apriori algorithm, FP growth algorithm, fuzzy transformations, etc. Specific algorithm can be used, to address different problems like memory constraints, database sizes and effectiveness [10].

Fig. 9. Giving suggestions based on the products bought by the customer

Giving push notifications about offers and updates regarding the products available in the store (Fig. 10). This requires the list of products and their associated offers. The

offers and updates regarding the products are given based on the customers' location. The offers regarding the products are sent when the customer enter a particular aisle. When the customer enters aisle A, then the offers related to the products in aisle A are sent to the customers. This will give customers a better look at the offers product wise and he/she is not confused with the offers.

Fig. 10. Giving push notifications about offers and updates regarding the products available in the store.

E. Requirements

It is important to know that, which product comes under which beacon ID. There are 3 main things which are required: Beacons, smartphone supporting Bluetooth, and an application which will manage all input beacon IDs and the display offers, location and notifications. The beacons should use Eddystone protocol with the required message formats.

CONCLUSION

It is safe to say that the world is under technological revolution and to survive all the industries must also revolutionize themselves to fit in. The retail world has transitioned over the years but this technology would bring the drastic change that is the society's need. The paper provides a method in which the customers can be provided with the location of the product with suggestions and offers related to the products. Moreover the retailers can get data on customers' behavior to increase sales. The paper has proposed a methodology to the unnoticed problem that the retail industry has been missing out on and the solution gives a way not only for the retailers to reap profits but also to the customers to benefit in more than one ways. The proposed methodology has some limitations like small battery life of the beacons, version specific requirement of Bluetooth 4.0 and above and the damping problem. Though it has limitations the proposed methodology can be implemented. Bluetooth beacon as a retail guide would give the market an edge that it deserves.

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