Distance Estimation Using Android App For BLE Beacon

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Abstract- *In wireless positioning systems, a lot of technologies for location estimation of devices have been emerged. Advancement in navigation technologies have enabled ubiquitous, accurate positioning for the outdoor environment but it falls behind in indoor and complex environment with high density walls. Due to its affordable cost and efficient energy usage as well as its availability in Smartphone devices, Bluetooth Low Energy (BLE) based indoor navigation is becoming popular. In this paper, we are proposing a model to estimate the distance between the android device and BLE beacon.*

I. INTRODUCTION

With the rapid advancement in mobile computing and location based services (LBS) in large public, indoor localization technologies have become popular. Till date, a lot of indoor localization technologies have been proposed based on various measuring techniques like ultrasound, infrared, light, magnetic field, and wireless signals. In addition to the diversified measuring primitives mentioned above, wireless signals, especially Wi-Fi signal, have become very popular in indoor localization due to their wide availability on mobile devices and indoor environments. Another localization technology used is Global Positioning system (GPS) which is associated with the satellite based technology of positioning, but the GPS signal fails to work in areas like indoor areas. But recently Bluetooth Low Energy (BLE) based localization became famous and has gained popularity in practical use due to its less cost, lower consumption of power, and availability in mobile devices everywhere.

A. Bluetooth low energy:

Bluetooth Low Energy has the aim to provide low cost and less power consumption and a similar type of communication range is maintained. The Bluetooth Low Energy supports wide range of mobile operating systems like Android, iOS, Windows OS, etc.

Bluetooth Low Energy is not compatible with the previous Bluetooth protocol. BLE is available above Bluetooth version 4.0 and above. Bluetooth Low Energy uses radio frequencies that is 2.4 GHz and is same as that of classic version of Bluetooth.

B. Eddystone:

Eddystone protocol is one of a Bluetooth low Energy (BLE) format that is developed by Google. Eddystone can be used with both iOS as well as android as it's open and multiplatform. There are four types of data a beacon can broadcast with Eddystone, described by three frames:

Eddystone has 4 frame types.

- A code known as identifying code is broadcasted by Eddystone-UID that retrieves information from app servers. The usability of this can be for interaction with apps, indoor location, identification of physical objects, and in any way depending on the developers usability or need.
- An encrypted rotating identifier is broadcasted by it in order to increase the security of the protocol, but otherwise it acts in a same way as the UID frame.
- The information about the beacons is broadcsted by Eddystone-TLM. This information may consist of battery level, sensor data, or other relevant information.
- Eddystone-URL is a protocol that broadcasts a URL that redirects to the specified website which is secured by using SSL. The corroborate of the Physical Web is that beacon.

We have proposed a system to estimate the distance between the mobile device and nearby BLE beacon based on Eddystone protocol, with the help of an android application. Our algorithm for distance estimation will calculate the distance between BLE beacon and the android device. This calculated distance will be displayed in the Android application.

II. LITERATURE SURVEY

As there are many types of research on BLE those are underway, we have classified the survey into 3 categories as follows:

A. Based on BLE indoor navigation

The BLE beacon uses the Received Signal Strength (RSS) based on which, different models have been proposed for distance estimation. AI-based deep learning model for BLE indoor localization is proposed, in 3D BLE Indoor Localization based on De-Noising Auto encoder [1]. Based on measured RSSI, reference locations in 3D space instead of a 2D plane are collected and robust fingerprint extraction is done. Using RSSI, De-noising auto-encoders are trained and weights of each trained de-noising auto-encoder are used as the fingerprint. At the last, the measured RSSI could be used to indicate distance between the output and the input of each of the respective reference locations. In Beacon Deployment for Unambiguous Positioning [2], the author has focused on a detailed study in BLE fingerprinting and the true potential of continuous BLE scanning. Various parameters like beacon density, transmit power, and transmit frequency are also studied in this. The main focus of enabling indoor object localization through Bluetooth beacons on the RADIO robot platform [3], is on the problem related to a RSSI value which can be very noisy and so single RSSI measurement does not provide accurate data. Thus, before extracting distance from the broadcasted RSSI, pre-filtering technique is used. Along with BLE beacons [4], different hardware tools like surveillance cameras can also be used for location tracking along with BLE beacons and RF information as an optimized input to image processing systems. It is strictly ensured that accuracy, as well as the performance of the newly hybrid system proposed, is significantly better.

B. Based on Beacon placement

In RSS Bias Compensation in BLE Beacon Based Positioning System [5], the author presents the first complete work of research on deployment of beacon. It focuses mainly on the positioning of the user with BLE beacons that is unambiguous. The model can localize accurately, the user by receiving coverage status of beacon from the user without using cloud or internet and respond accordingly. According to Beacon Controlled Campus Surveillance [6], BLE beacon has ability to automate and thus improve the management work of college campus. We can be then able to track the location of each student with the help of the system that is proposed here. It can help teachers to send text notifications and web page links to students as well as it will help in the automation of administrative tasks. In Location Fingerprinting with Bluetooth Low Energy Beacons [7], the author focuses on the deployment of the beacon and the model is formed combinatorial, instead of forming it geometrically. It is assumed that the range of each beacon, instead of simple geometric one, it is completely arbitrary. This method will be helpful in finding maximum-resolution sub-hyper graph. The proposed solution is based on greedy approach. In Beacon Placement for Indoor Localization using Bluetooth [8], an algorithm is provided for placing a large number of beacons in close proximity, by the author. It focuses on management of dense beacon network in smart building with the help of proof-of-concepts of dynamic beacon and simulation with the use of practical limits.

C. Based on Broadcast security

According to Secure Privacy-Preserving Information Beacons for Public Transportation Systems [9], the proposed system provides a solution that is secure, to the dynamic broadcasting of data via BLE beacon. Managing Large-Scale, Ultra-Dense Beacon Deployments in Smart Campuses [10], focuses on bias problem of RSS which is nothing but fluctuation or variation of RSS value. A method is proposed in this, to find bias level where the receiver is set arbitrary and RSS is obtained from the nearby beacons and this RSS is converted to distance. By using the trilateral technique, this distance can be then used for localization

III. SYSTEM ARCHITECTURE

To explain the scenario, complete system architecture is explained in figure (1).

BLE Beacons are placed in the vicinity which will be used to calculate distance between each android Beacon and Bluetooth supported device.

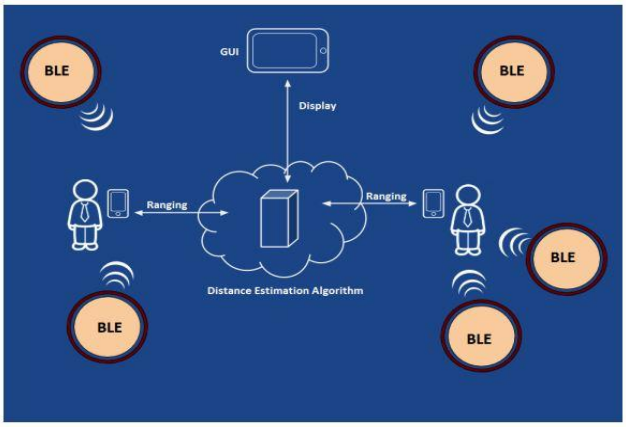


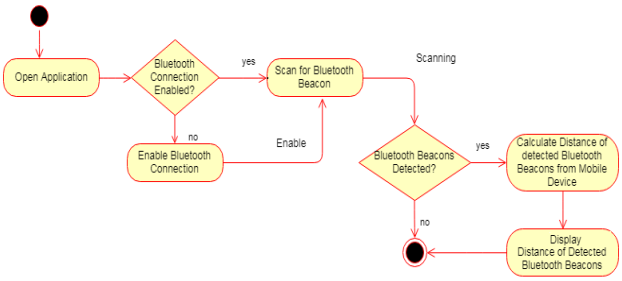
figure (1)

This beacon's setup will be done already which will then broadcast the RSSI and txPower (transmission power)

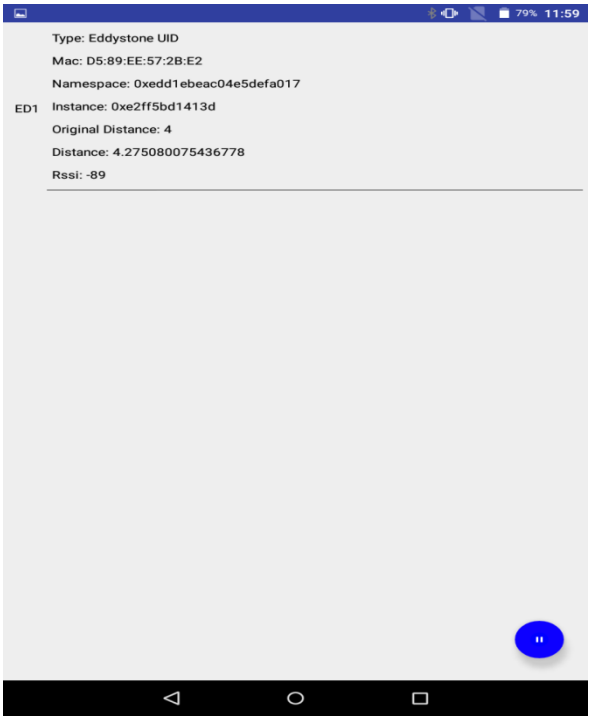
continuously after a specific time interval. The complete area will be connected by multiple beacons. To identify the beacon device from all beacon devices, it will use the Eddystone protocol. In this system only Eddystone UID supported beacons will be detected and depending on different format of protocols different information related to the Beacons will be displayed along with the estimated distance between Bluetooth supported device and BLE Beacon using our algorithm.

System Implementation

To implement the system, one beacon has been placed in the vicinity which will broadcast the packets. To show the complete system working, android app is installed on user's device. As BLE Beacons require Bluetooth, Android app requires user permission for Bluetooth and location from smart phone device.



As the app is opened, initially it checks for Bluetooth. The beacon will be already configured to broadcast the packets continuously on specific time interval. Our application will be used to scan the beacons in nearby area for a specific interval of time and then it will display the detailed information broadcast by the beacon. After launching the application, user will be able to see the scan button. When user presses the scan button the app will range beacons in the region and a distance will be calculated using our distance estimation algorithm between nearby beacons and android device which in turn will be displayed on android device.



The algorithm to detect distance works as follows:
The radio signal consists of RSSI or Measured Power:

RSSI:

RSSI stands for Received Signal Strength Indicator. It is the strength of the beacon's signal as seen on the receiving device.

Tx power:

Txpower is also known as the Transmit power with the help of which beacon can broadcast its signal.

RSSI is data sent by Beacon along with txPower(transmissionpower)and other parameters like MAC Address, UID etc.

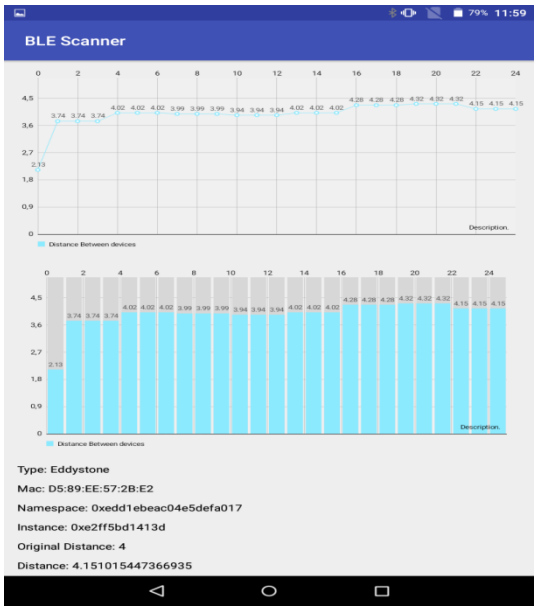
Distance Calculation:

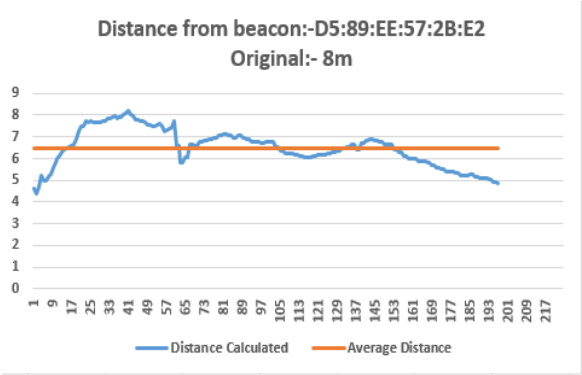
```
if( rssi ==0)
{
return -1.0 ;
// in case if we get cannot determine accuracy
}
ratio = rssi*1.0/txPower ;
if( ratio < 1.0)
{
return Math.pow( ratio,10) ;
}
else
```

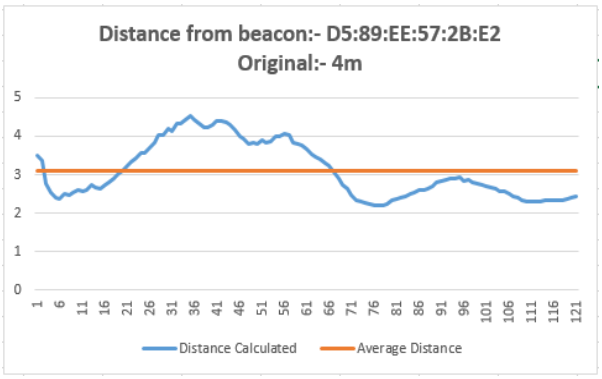
```
{
accuracy = (X)*Math.pow( ratio,Y) + Z;
//where,
// here constants calculated are based on power regression formula from values calculated based on rssi
return accuracy
}
```

The distance that is calculated, is the approximated distance, as for calculating exact distance, the loss factor (occurring from various environmental factors) will be made as zero.

After calculating distance based on above algorithm Graph is created in the end to check accuracy of estimated distance to actual distance.







IV. CONCLUSION

In this paper, we presented various navigation technologies and deployment techniques for BLE beacon. We also proposed a model for distance estimation. This estimated distance will be in turn, used in wide range of applications like indoor localization in large public places, shopping malls, hospitals, airports, etc. as well as in various health-care, security and robotic applications.

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