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A Survey on Distance Estimation for Bluetooth Beacon

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ABSTRACT: In wireless positioning systems, many technologies for location estimation of devices have emerged. Advancement in navigation technologies have enabled accurate, ubiquitous positioning for the outdoor environment but lacks in an indoor and complex environment with dense walls. Bluetooth Low Energy (BLE) based indoor navigation becoming popular due to its affordable cost and efficient energy usage as well as its availability in Smartphone devices. In this paper, we made a survey on various navigation technologies and deployment techniques for BLE beacon. We propose a model to estimate the distance between BLE beacon and the receiver.

KEYWORDS: Bluetooth Beacon, Bluetooth Low Energy, Indoor localization, distance estimation using BLE beacon.

I. INTRODUCTION

With the advancement in mobile computing, Location-Based Services (LBS) becoming popular nowadays. Most common technology among them is the Global Positioning System (GPS) which use Global Navigation Satellite System (GNSS). As these GNSS requires line-of-sight transmission between receivers and satellites, they are not useful for an indoor or urban area with the dense building. Hence the necessity of new technology, which should be low cost and energy-efficient, for the indoor environment has emerged. Research on RFID,Wi-Fi, and Bluetooth is underway. Among all the other technologies, Bluetooth Low Energy (BLE) based indoor localization becoming popular due to its affordable cost and efficient energy usage as well as its availability in Smartphone devices.

The Bluetooth 4.0 specification called Bluetooth low energy (BLE) has been introduced recently. BLE is a wireless technology designed for applications in the healthcare, fitness, security. This technology made Bluetooth more suitable for positioning systems. Compared to previous Bluetooth versions, BLE considerably reduced cost and power consumption.

BLE beacon devices that periodically emit signals using this BLE technology have been launched by several companies, and Bluetooth enabled device can be used to estimate the location of receiver or user with the use of the signal strength of BLE beacons. These devices have several advantages like they are small in size, affordable and power efficient enough that they can work for months and years without battery replacement.

We proposed a model to estimate the distance between the mobile device and nearby BLE beacon 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.

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II. LITERATURE SURVEY

As many types of research on BLE are underway, we have classified our survey into 3 categories as follows.

A. Based on BLE indoor navigation

For distance estimation in anindoor environment, based on the received signal strength (RSS) from BLE beacon, different models are proposed. In 3D BLE Indoor Localization based on Denoising Auto encoder [1], AI-based deep learning model for BLE indoor localization is proposed. It collects the reference locations in 3D space instead of a2D plane and robust fingerprint extraction is done based on measured RSSIs. De-noising auto-encoders are trained with RSSIs and weights of each trained de-noising auto-encoder are used as the fingerprint. At the end, the measured RSSI can beused to indicate distances between the outputs and the input of each of the reference locations. In Beacon Deployment for Unambiguous Positioning [2], theauthor focuses on adetailedstudy on BLE fingerprinting and the true potential of continuous BLE scanning. IT also studies various parameters like transmit power,beacon density and transmit frequency. The main focus of enabling indoor object localization through Bluetooth beacons on the RADIO robot platform [3], is on the problem related toa RSSI value which is very noisy and so single RSSI measurement does not provide accurate data. Hence pre-filtering technique is used before extracting distance from the broadcasted RSSI. Along with BLE beacons [4], different hardware tool like surveillance cameras are also being used for location tracking along with BLE beacons and RF information as an optimized input to image processing systems. It strictly ensures that performance, as well as the accuracy of the newly proposed hybrid system, is significantly better.

B. Based on Beacon placement

In RSS Bias Compensation in BLE Beacon Based Positioning System [5], theauthor presents the first complete research work on beacon deployment. It mainly focuses on the unambiguous positioning of theuser with BLE beacons. The model can accurately localize the user by receiving beacon coverage status from theuser without using internet or cloud and respond accordingly. According to Beacon Controlled Campus Surveillance [6], BLE beacon have the ability to automate the management work of college campus. The proposed system can track the location of each student which helps in the automation of administrative tasks as well as teachers can send text notifications and web page's links to students. In Location Fingerprinting with Bluetooth Low Energy Beacons [7], theauthor focuses on thedeployment of thebeacon and instead of forming it geometrically, the model is formed combinatorial.It assumes the range of each beacon is completely arbitrary, instead of simple geometric one. This method helps in finding maximum-resolution sub-hypergraph. The proposed solution is based on greedy approach. In Beacon Placement for Indoor Localization using Bluetooth [8], the author provides an algorithm for placinga large number of beacons in close proximity. 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 can provide asecure solution to thedynamic broadcasting of data via BLE beacon. The main advantage of this is the data validation does not rely on cloud and internet. Managing Large-Scale, Ultra-Dense Beacon Deployments in Smart Campuses [10], focuses on RSS bias problem which is nothing but fluctuation of RSS value. It proposed a method to find bias level where the receiver is set arbitrary and gets RSS from the nearby beacons and convert this RSS to distance. This distance is used for localization using thetrilateral technique.

III. PROPOSED MODEL

In this part, we have explained the model our system. Our model is a combination of hardware and software. BLE beacon is the hardware part of the system and the software system has been built on an Android platform. The

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distance estimation algorithm will be used to estimate the distance between BLE beacon and the device using the RSSI broadcasted by the beacon in the nearby area.

After the user starts scanning, 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 the android device.

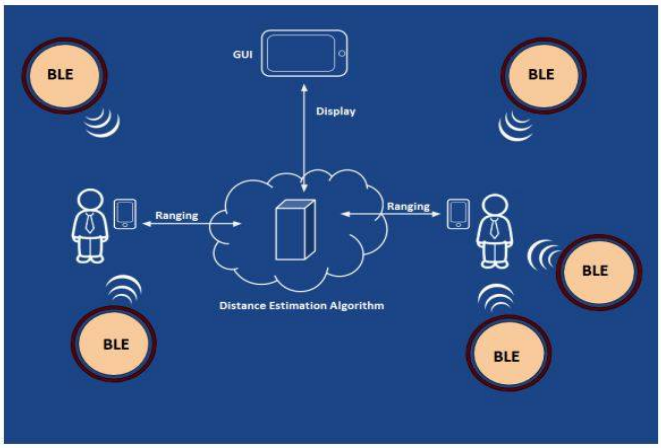

Fig. 1: System Architecture

To explain the scenario, the complete system architecture is explained in figure (1). This figure gives an explanation of working our application. Beacon device is placed in the vicinity which will be used to broadcast signals. This beacon device will already be set up to broadcast the packets continuously on a specific time interval. The android-based application will be used to scan the beacons in the nearby area for a specific interval of time and then it will display the detailed information broadcasted by the selected beacon.

IV. CONCLUSION

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

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