PREVENTING CHILD DISORIENTATION AND ENSURING SAFETY IN MULTI-STORY MEGA-STRUCTURES

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ABSTRACT:

Indoor structures such as walls and roofs weaken GPS signals, making it impossible to rely on conventional outdoor navigation methods in indoor environments because it doesn't produce reliable results. The use of Bluetooth beacons to determine the user's location and assist the user in navigating from one point to another is proposed in this paper. By strategically placing beacons inside large buildings like malls and hospitals, it becomes possible to accurately detect a Persons location and facilitate navigation from one point to another within the building. The paper also proposes a service that identifies crowd density inside the building, helping users navigate more efficiently through the complex. The location is determined using the trilateration technique, and suggested the route is calculated based on nearby points of interest or tenants. Dijkstra's algorithm is used for navigation. In this experiment, the sensors and wifi access points transmit signals to a cloud server, helping to prevent users, especially children, from getting disoriented in large multi-story buildings, thereby ensuring their safety.

KEYWORDS: Navigation, Bluetooth, Adapters, GPS, Location, Beacons, Wi-Fi

I.INTRODUCTION

Tracking systems, which monitor the location of objects or people, have become increasingly prevalent in modern technology. Locating and tracking individuals or objects offer numerous benefits in various scenarios, such as keep tracking of a child at a theme park, finding colleagues in an office, or following luggage through an airport. The most common methods for tracking people [1,2] involve the deployment of surveillance cameras. The CCTV footage must be centrally monitored by a human operator using these systems. Fatigue frequently causes a loss of concentration. Trackers with a Global Positioning System (GPS) technology are commonly used to monitor vehicles and other objects (GPS). The main issue with GSM is its location determination accuracy; particularly in densely populated areas where coverage is limited the ability to find and follow the movements of items becomes possible thanks to the wide array of personal gadgets [3] that support Bluetooth. The position of a communicating device can now be determined using the growing technology of Bluetooth both within and occasionally outdoors. Although Bluetooth technology does not specifically enable positioning services, it is nevertheless utilised primarily for signal strength measurement, link quality, and bit error rate, all of which rely on the services of the Host Controller Interface. As a result, the Bluetooth protocol's Received Signal Strength Indicator (RSSI) value is utilised to determine how far apart sender and receiver are in a network. The Golden Receiver Power Rank (RSSI value)[11] indicates the disparity between the received signal intensity and the ideal received power rank (GRPR).

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1.1 BEACONS

Beacon is a wireless network device that functions as a transmitter to find and locate cell phones using Bluetooth Low Energy (BLE). Push notifications and location-based services that utilize Bluetooth Low Energy (BLE) to automatically connect wireless devices can be delivered using the Apple iBeacon protocol. With the iPad third generation or later, iPad mini, and iPod Touch fifth generation or later, iBeacon is supported, which specifies how BLE connection requests should be delivered. Android phones and tablets can also use iBeacon. When near an iBeacon, smartphones, tablets, and other devices can now do actions thanks to the technology.

VERSION	YEAR	SPEED	RANGE	Features
1	1999	0.7 Mbit/s	10m	Communication between mobile and computing Devices
2	2004	2.1Mbit/s	10m	Enhance Data Rate & Secure simple Pairing
3	2009	24 Mbit/s	10m	High speed
4	2010	24Mbit/s	60m	Energy Efficient Protocol
4.1	2013	24Mbit/s	60m	Connection with IoT devices
5	2016	50 Mbit/s	240m	High speed with increase in Message Capacity

TABLE I: Overview of Bluetooth Releases

1.2 TRACKING

Bluetooth Low Energy (BLE) beacons are placed throughout the indoor space. In order for the system to track the user's location and deliver directions to their desired location, these beacons communicate a special identification to a user's device, such as a smart phone or tablet. The BLE beacons perform dual roles as Wi-Fi access points and navigation beacons, enabling users to connect to the internet [4] and use cloud-based applications. The information gathered by the beacons, including user location data and other pertinent information like the locations of shops or other points of interest inside the building, is stored using cloud server technology. This information can then be used by the cloud server to provide real-time maps and directions for users, which are displayed on their devices.

1.2 TRILATERATION

Trilateration is a technique used to determine the location of an object by measuring its distance from three known reference locations, or beacons, whose positions are fixed. The reference points used for indoor navigation are often Bluetooth Low Energy (BLE) beacons positioned in well-known locations all across the indoor environment. As a user reaches the area, their device can recognise the beacon signals [5,9] and calculate the separation between them and each beacon based on the signal intensity. The user's device can then utilise trilateration to determine the user's position within the indoor space using this distance information. This is accomplished by locating the intersection of three spheres, each with a radius equal to the separation between the user and each beacon and centred on one of the beacons.

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II. RELATED WORK

According to Markets and Markets, the indoor positioning market will reach $4.4 billion by 2019 thanks to a persistent demand from industries including healthcare, tourism, and hospitality. Currently, people spend more than 80% to 90% of their time inside buildings (Strategy Analytics). The fact that with rising smart phone penetration and changing client mobile purchasing actions, it is no sensation that start-ups and recognised organisations are swiftly hunting for strategies to give tracking-based applications to engage their users indoors. Indoor Positioning System [6] locates items and persons inside a building utilising many technologies via a smart-tracking or other smart manoeuvre. Businesses can build features for their tracking-based applications using indoor positioning systems. The most widely used way at the moment is Wi-Fi when it comes to the many Indoor Positioning strategies that are available for businesses to choose from. Less than half (50%) of the accused organizations have or intend to utilize indoor positioning systems via Wi-Fi, while slightly more than a quarter (26%) use indoor positioning systems via beacons. Solutions for Indoor Positing Systems that are scalable and accurate are desired in order to meet user engagement standards quickly and affordably. One of the biggest obstacles to progress today may be that the many respondents are simply unaware of the IPS alternative available on the market to address their business needs [7]. The cornerstones of indoor positioning are BLE beacons. With the use of this technology, the tracking gadget can detect when it is within range of a beacon and even determine its location when there are multiple beacons nearby. Placement based on BLE has grown in popularity recently. Initially, prototypes could only determine which beacon was closest to the user, but today, we can leverage position data and distance information from numerous beacons.

III. METHODOLOGY

The key components of a tracking system based on BLE beacons include ibeacons, BLE nodes, and a cloud-based server. IBeacons are strategically placed throughout a venue. The user builds a database of ibeacon identifiers scanning throughout the space. BLE beacons are mobile, while BLE nodes remain stationary. In this context, BLE receivers, referred to as BLE nodes are strategically positioned throughout a venue. This time, the Bluetooth Low Energy beacons are moving, attached to objects, or carried by people. Each beacon is programmed to recognise an object or person. Ibeacons move around promoting their unique identifiers. BLE nodes capture iBeacon advertisements and send them to the server. of a beacon When three or more BLE nodes detect a beacon, the system can triangulate its location The Server[8] then estimates the clients' position based on the known location of the BLE nodes. Beacons are a type of BLE hardware transmitter that broadcasts its identifier to nearby electronic devices. Each BLE beacon device must be configured with the following parameters: transmission power, UUID, Major/Minor values. At the fixed point, the application collects and compiles the RSSI readings.[10] Hence, the distance between each signal and the client is calculated using these data. The application uses both the whirligig and compass built into the cell phone[9] to determine the direction the user is going since the reference locations do not provide any information that would indicate their position in relation to the beneficiary. A guide will show the position of the client and the reference points as well as the distance between them.

DISTANCE BETWEEN USER AND BEACONS

The Friis transmission equation, a fundamental formula in Radio Frequency (RF) engineering, serves as the basis for the calculating the estimated distance between a user and a beacon using the RSSI value. The transmit power, frequency, route loss, distance, and received signal power are all related by the Friis equation. In the context of indoor positioning systems, we can calculate the

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separation between a mobile device (user) and a beacon based on the RSSI value using the Friis equation.

The equation is:
distance =10 ^((RSSI - A)/(10*n))
where:

RSSI represents the received signal strength Indicator in dBm.
A is the reference RSSI measured at a know distance, typically 1 meter.
The path loss exponent is n. (typically between 2 and 4).

The path loss exponent (n) represents the rate at which the signal strength decreases with distance, and depends on factors such as the environment, frequency, and antenna characteristics. The reference RSSI (A) is the received signal strength at a known distance typically 1 meter and is used to calibrate the path loss model. The formula works by first calculating the difference between the received signal strength (RSSI) and the reference RSSI (A), and dividing this by the path loss exponent (n) multiplied by 10. This value is then raised to the power of 10, and the result is the estimated distance between the user and the beacon in meters. It is important to note that this formula provides an estimate of the distance between the user and the beacon, and the actual distance may vary due to factors such as signal interference, multi-path propagation, and variations in the environment. However, the formula is widely used in indoor positioning systems and provides a reasonable approximation of the distance.

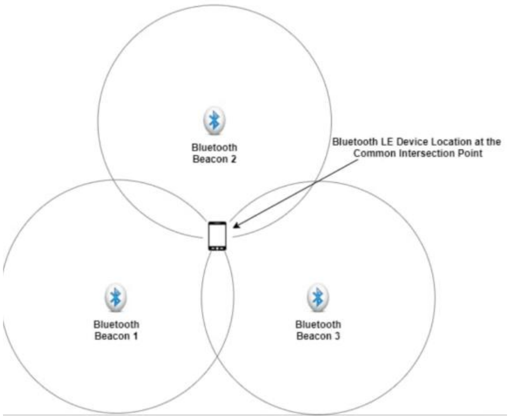

Fig 3.1: BLE Device location at Common intersection point.

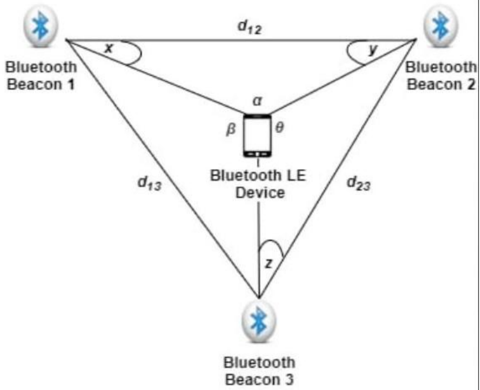

Fig3.2: Trilateration Based Location Estimation

CALIBRATION

In order to estimate the distance between a user and a beacon based on the RSSI value, calibration is a crucial step in the approach. At a predetermined distance (often 1 metre) between the user and the beacon, the reference RSSI (A) is measured as part of the calibration procedure. For a certain beacon and user, this reference RSSI value is utilised to calibrate the path loss model, which is crucial for precise distance estimates. Place the mobile device (user) a known distance from the beacon (typically 1 metre) and measure the RSSI value to calibrate[10] the path loss model. This can be done by physically moving the device to the known distance or by using a calibration app that provides a fixed distance between the device and the beacon. Once the RSSI value is measured at the known distance, we can calculate the reference RSSI (A) for the beacon and user using the formula.

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A = RSSI + 10 * n * log10 (distance)

The reference RSSI (A) can then be stored in the database for the beacon and user, and used in the distance estimation formula to estimate the distance between the user and the beacon.

IV. EXPERIMENTAL RESULTS

The accuracy and effectiveness of the system can then be evaluated based on the result of the analysis. Experiments done in a real-world indoor setting to gather data, and use of mobile device (such a smartphone or tablet equipped with a wireless receiver) to measure the RSSI values from the beacons. Based on the RSSI value, reference RSSI (A), and path loss exponent, we can then apply the method to calculate the distance between the user and each beacon (n). To locate the user based on the predicted distances, we can alternatively use trilateration or other positioning methods. Metrics such as accuracy, precision, and reliability Fig 4.1 can be used to assess the experimental results. The accuracy of the predicted distance relates to how near it is to the real distance between the user and the beacons. The estimated distance's precision is defined as its consistency throughout a range of measurements. The term "reliability" describes how well a system functions over time and under various circumstances. The accuracy of distance estimation using the method typically varies based on the environment, beacon placement, and device features, according to experimental results. In general, accuracy increases as the user gets closer to the beacon and diminishes as the distance between the user and the beacon grows.

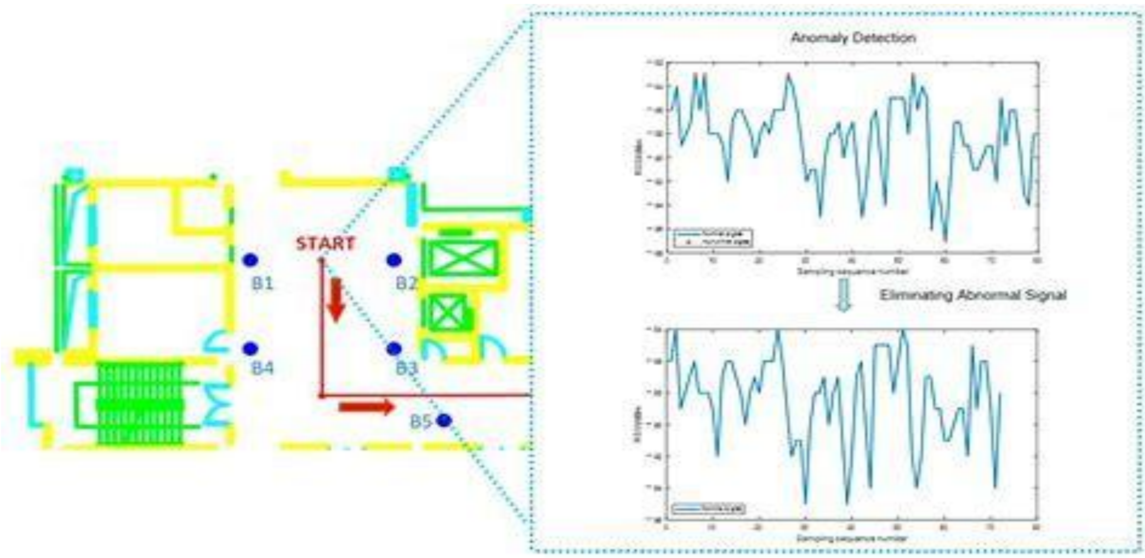

Fig 4.1: Detection of Signal

A variety of issues, including signal interference, multi-path propagation, and device or beacon malfunction, might result in anomalous signals in an indoor positioning project that uses beacons. The system's overall performance may be impacted by these aberrant signals, which might result in erroneous distance measurement and positioning outputs. Many strategies can be employed to get

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rid of erroneous signals and increase the system's accuracy. Many methods can be employed to get rid of erroneous signals and increase the system's accuracy, including, the signal can be filtered to remove noise and interference, which will increase the distance estimation's precision. Averaging, median filtering, and Kalman filtering are common methods for signal filtering.

Techniques for outlier detection can be used to spot anomalous signals and eliminate them from the dataset. Setting thresholds based on statistical parameters like the standard deviation or interquartile range can accomplish this.The ability to eliminate unusual signals and maintain precise distance estimation over time can be improved with proper calibration and routine device maintenance. Maintenance entails routine battery replacement, lens cleaning for beacons, and firmware updates.

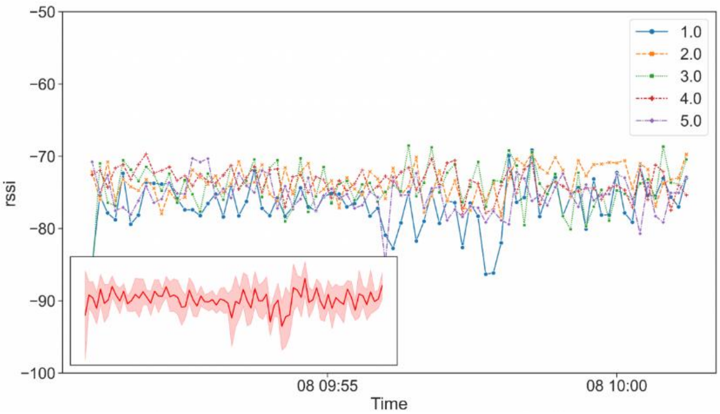

Fig 4.2: RSSI Time Series of 5 tags

The Bluetooth LE's variable channel (frequency) and environmental factors like obstructions, fading, and signal reflections, Fig 4.2 according to the researchers, are to blame for the significant variations in RSSI values they obtained for various tags. The Distance-based Proximity Method was used by the system to effectively identify the proper artwork with an accuracy of up to 95% as shown in Fig 4.3.

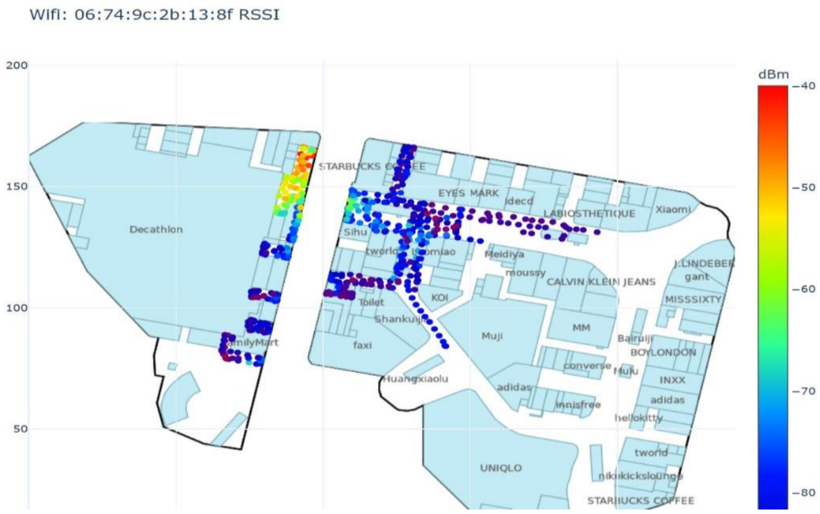

Fig 4.3: Final Output

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V. CONCLUSION

For interior locating, beacons provide a scalable and affordable solution, especially in locations where GPS is unavailable or unreliable. When paired with trilateration or other positioning algorithms, RSSI-based distance estimate formulas can offer reasonable accuracy for indoor location. Continual optimization is required to ensure accurate and dependable positioning because the interior positioning system's performance can vary depending on elements including beacon placement, ambient circumstances, and device characteristics. Overall, beacon-based indoor positioning can deliver useful location-based services for a range of applications, including asset tracking, navigation, and indoor analytics.

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