"Indoor Navigation for Blind Using BLE Beacon"

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Abstract - *One of the main constraints for people with visual impairment is the inability of unassisted navigation and orientation in unfamiliar buildings. Major disadvantages of the existing indoor navigation systems for the blind is the high price of hardware part. We are developing a low-cost indoor navigation system which is based on mobile phone, supporting technology Bluetooth Low Energy (BLE) Beacons, and running server. The proposed navigation system enables the users to navigate to desired room or place. The system guides user with help of audio output according to his location in building.*

***Key Words*: Indoor Navigation Systems for the Blind, Bluetooth Low Energy, Bluetooth enabled Mobile Phone, Express.js Server, React native application, MongoDB**

1. INTRODUCTION

The number of people with visual impairment is about 135 million, of which 45 million are blind. For people with visual impairment, navigation in unknown buildings is harder than outdoors, where they depend mainly on guide dogs and white cane [1]. We use GPS powered services for requesting directions, sharing our location with friends and family, for giving context to photos and videos, and to trigger actions based on location. Reliable outdoor navigation is however one of the most beneficial applications of geolocalization technologies and providing a similar solution to indoor environments has been so far a long-term goal. GPS is not a good choice for indoor localization because the walls and ceilings completely block the signal of the satellites employed by GPS. Moreover, the measurement error of GPS is too large for its usage in indoor environments where meters are significant and can place a user in the wrong room [2]. Wi-Fi and Electromagnetic Field have been tested to solve the indoor localization problem.

The main difficulties of visually impaired people in indoor navigation and orientation are: missing known sights, overcoming obstacles can be risky, not all blind can read Braille tags, the very price of existing systems for indoor Navigation. One of the biggest disadvantages of the existing indoor navigation systems for the blind is the high price of the hardware component. The indoor navigation system for the blind is proposed, that ensures widespread use, thanks to the integration of mobile phones from the middle price segments [3], BLE beacons that uses small lithium chip batteries and the battery life of the device is between 18 to 24 months.

2. RELATED WORK

There are two basic methods for indoor navigation:
1) Navigation based on information from sensors, which determine the position of the blind (piloting methods) and 2) Find the current position of the blind based on information for the previous position and an estimate of velocity and direction of movements (path integration methods or dead reckoning). Dead reckoning: For the realization of this type of navigation Micro-Electro Mechanical Sensors (MEMS) are used, which give an estimate of velocity, direction and height (electronic accelerometers, magnetometers and barometers). This type of navigation systems requires adjustment of the position after certain time interval. The correction is realized most often through (D)GPS, A-GPS or Wi-Fi positioning [4]. Piloting: This type of navigation is used by systems with infrared, ultrasonic and radio-frequency (RF) beckoning and systems, based on visual pattern recognition and visual and RFID tags detection. IR based navigation systems require special hardware part, which can receive signals from the IR transmitters which have a fixed position. The determination of position is based on the ID code of the nearest transmitter. Better results are obtained when using ultrasonic beckoning. For example, navigation system Drishti have 22cm position accuracy [5]. To calculate the position of blind metric Time Difference of Arrival (TDOA) is used. One of the major limitations in all indoor navigation systems described so far is the high price. Part of the existing indoor navigation systems are too complex and work with them requires long training.

3. METHODOLOGY

We offer a solution consisting of an React Native Android app, an Express.js server working on Node.js and beacon infrastructure in building. Server uses MongoDB Database to save data. The beacon infrastructure is designed to get a good distribution of beacons throughout the building. After the release of Bluetooth Low Energy (BLE) protocol many companies carry out research work on indoor localization for the main themes of Internet of Things (IoT) technology, such as tracking people and devices to determine their location, making brand advertisements etc. BLE technology is a wireless personal area network which provides new applications in daily life such as security, healthcare, beacons etc. In comparison to Bluetooth Classic, BLE consumes less power, it is cheaper and allows higher speed. BLE has 40 channels and three channels (i.e., 37, 38, and 39) are used for broadcasting advertisement messages. The received signal strength indicator (RSSI) from these three channels can be used for estimating the target's location [6]. Furthermore, some companies brought into market specialized devices called beacons which utilize BLE technology. Beacons transmit BLE signals to nearby devices. These beacons are named according to the protocols they use such as Eddystone developed by Google and AltBeacon developed by Radius Network. According to the Google website of the Eddystone: "Eddystone is an open tag format developed by Google and designed with transparency and robustness in mind". The purpose of the application is to read RSSI values of different Beacons and send the readings to the Express server for further processing and storage of data points.

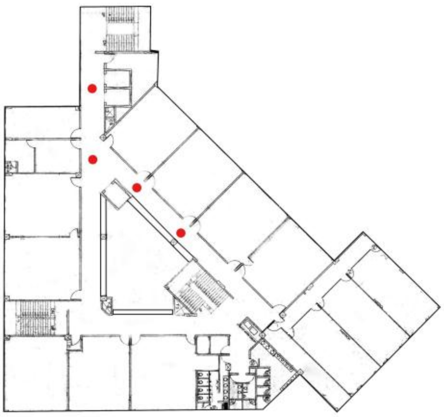

Fig -1: Position of Beacon in College.

The server is responsible for recording and processing fingerprints, so they can be used in a WkNN algorithm to predict a location in future development. For the beacon infrastructure, we used four beacons. The beacons will be placed throughout the fifth floor of our college building as shown in fig. 1. They will be placed on the wall at a height of 2.50 meters to minimize signal absorption, diffraction, interference and multi path propagation, caused by the materials and objects encountered through its path. The transmission power of the beacons is to be selected so the signal will able to cover the passage. The power of beacon will be set at -3dBm. According to manufacturer the selected powers for the beacons will be able to reach 15m [7]. The information was obtained from manufacturer's beacons configuration App.

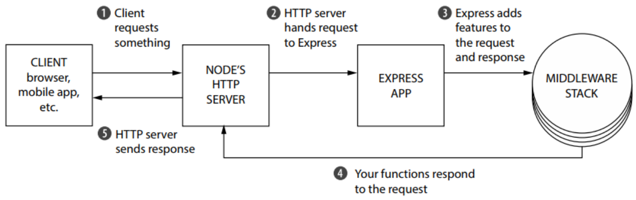

Fig -2: Request flow in express app.

The request flow in express is shown in figure 2. React Native App is our Client which communicates with server. Express app runs on Node.js HTTP server and MongoDB

Database is connected to it. It runs all logic and algorithms. We used fingerprints to estimate the position. The position estimator algorithm used is the Weighted k Nearest Neighbor (WkNN). Finds the k nearest chosen locations from unknown location based on Euclidean distance. Calculates coordinates of unknown location as the weighted average of the nearest k points. Weight is the inverse of the Euclidean distance. k can be considered as a tuning parameter in the algorithm. When k=1, algorithm acts as a simple look up table.

Table -1: The format of fingerprint database

Fingerprint in MongoDB				
Index	B1(dBm)	B2(dBm)	B3(dBm)	Region
1	-98	-83	-79	1
2	-78	-92	-78	2
3	-78	-94	-74	3
4	-73	-78	-89	4
…	…	…	…	…

Fingerprints consist of storage of RSSI values received from beacons for a specified region and processing each when they enter it, getting the values associated with each beacon, creating a message containing the RSSI value of corresponding beacons for a specified for location, and finally Logging of the collected information (fingerprint) to the server for further uses. The table I represent the format in which data is saved. In the fingerprint tracking stage, the application can use these fingerprints to return a prediction.

Comparing fingerprints sent to the fingerprint model used for learning. The fingerprint technique creates a map on the radio area based on data from multiple access points (beacons) and generates a probabilistic distribution of values for that location. Then the values are compared to the fingerprints, and they find the closest match and generate the expected location. The mobile application runs on Android 9 and makes use of the location, Bluetooth service Android Google Text-To-Speech. Audio messages will guide user accordingly.

4. SCREENSHOT OF APPLICATION

The application has three screens, containing Start screen figure 3, configuration screen figure 4 and Demo screen figure 5. There are two mode for this application, first configuration mode also known as fingerprinting mode and second is for demo or testing mode.

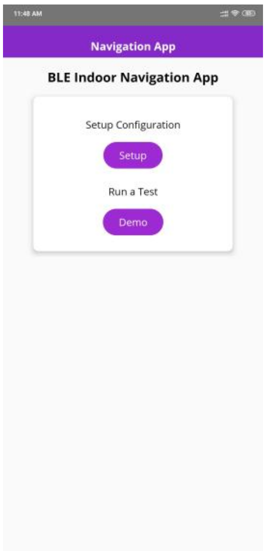

Fig -3: Start screen for App

In configuration screen figure 4, several positions inside a building are chosen and RSSI values from the different beacon recorded. This is done by first starting the scan for BLE beacons and then setting up region.
After setting the region we post the RSSI value received for region. This step is repeated for several times for different regions.

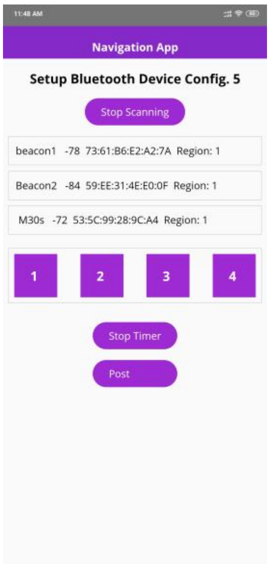

Fig -4: Configuration Screen.

Demo Screen figure 5, is divided into two parts form middle, upper screen is used for start locating user's location by press and holding on it and by tapping on lower screen user get current location based on latest RSSI value sends to server.

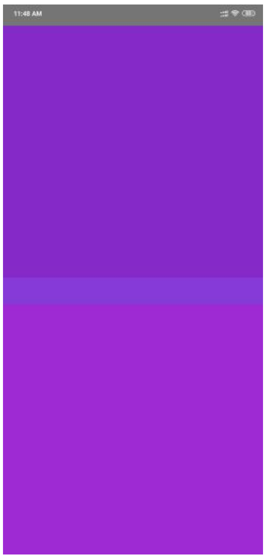

Fig -5: Demo Screen.

In Demo screen, the RSSI values are recorded in background from any unknown location and then send it to server intervalley and server sends back estimated location. As user is visually impaired, application gives estimated current location as voice output.

5. PRACTICAL DIFFICULTIES

Various factors influence the level of accuracy of the system in practice, these were identified and their effects were minimized to the possible extend.

• Fluctuating Received Signal Strength (RSS) readings: The readings taken from a particular location could fluctuate often and can result in errors. This could be rectified by using the average of several readings from the same location.

• Identifying reliable Access points: The access points considered for positioning purpose should be a permanent part of the structure and ideally be available at all times. Including temporary hotspots into the system should be avoided as they could negatively impact the calculations if they were relocated.

• Orientation of users: The orientation in which the user holds the smart phone can alter the signal strengths received at that location. This can be accounted to the user's body obstructing the signals from one particular direction. Orientation specific readings should be taken in the calibration phase to counter this factor

6. CONCLUSION

In this paper we presented a study of an indoor positioning system implemented using Bluetooth Low Energy beacons. In this implementation, we will use a fingerprinting technique for estimating location [4]. The location estimator algorithm will be used is the weighted k Nearest Neighbors Algorithm. A robust indoor positioning system is the backend of an indoor navigation system, the final aim of our work, and at this moment we are able to locate multiple users with 5 meters accuracy in the fifth floor of our college building. A* Search algorithm to find the best route between present location and destination. Voice outputs will lead to destination. Advantages of this application is simplified and intuitive user interface.

7. REFERENCES

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