Feasibility Report

Final Year Project

SmartGuide: A smart campus guide using BLE based indoor localization

Tooba Naseer (2016-CE-72)

Rida Mahmood (2016-CE-54)

Ayesha Jabbar (2016-CS-159)

Rabeya Hamood (2016-CE-81)

Supervised by: Dr. Sheikh Faisal Rasheed

Department of Computer Science and Engineering

University of Engineering and Technology, Lahore

Contents

1   Introduction

1.1   Overview of Project

The positioning of indoor and outdoor environments is the advanced field of IoT (Internet of Things) in this era of mobile computing. Also, indoor localization technologies have becoming so demanding in university departments, government small institutes, software houses, airports etc. So, our project will find the location of a specific person by using an android application which connected to the BLE (Bluetooth Low Energy) beacons by Bluetooth technology. This project will guide persons who are not much familiar with visiting place. It has an android application that will predict the indoor location of a person at room level and also gives information of current room location and nearby rooms in text, images, audio and videos form. In our case visiting place will be either university campus or a single department.[5]

A data-capturing application will be made which will capture the RSSI(Received Signal Strength Indicator) values that is the strength of the Bluetooth signal, then on the basis of RSSI values mobile device location will be predicted. This RSSI value will pass to the trained model (a model which is trained on a given set of input and output values by using machine learning algorithms) which gives the location of the device and his owner. After finding the location of the person, information of that certain room/area will be provided to the user on android application of his device.[1]

1.2   Background

Indoor localization can be done by using several technologies i.e. wireless localization, image-based navigation, sensor-based localization. In wireless localization, RSSI values determine the location of the device within a certain region and they can be found by measuring the distance between Wi-Fi access points and the mobile device. In image-based navigation, objects are navigating by process a series of image data and it can be recorded by passive sensors i.e. laser scanners and digital cameras. On the contrary, Outdoor localization has been formalized by using satellite-based technologies i.e. GPS, Compass, BeiDou, GLONASS, COMPASS, and GALILEO. It is hard for finding the indoor location by using conventional GPS technology because of no direct (Line of Sight) in indoors[2], so we cannot use these technologies for indoor positioning. Up to date, the methodologies used for indoor localization approach are: TOA (Time of Arrival), TDOA (Time Difference of Arrival), AOA (angle of arrival) but they have some limitations. TOA and TDOA require precise clock count and its synchronization and AOA-based systems require special antennas for their propagation. So, we are going to implement a system which use Bluetooth low Energy beacons to find the location of the visitor inside the campus and provides guide to that particular area to him.

1.3 Motivation

A visitor of a particular area i.e. Huawei Centre of UET Lahore, who does not know about the rooms/labs and its nearby rooms i.e. what happens in the room, what tasks to be performed in a certain lab/room, which people maintain and work in that particular area and much more. These problems motivate us to provide ease and leverage facility to users so that they can see the information of a particular indoor environment on his mobile application automatically. To provide information to users in multiform, we first have to find out the indoor location of the user by using BLE beacons. TOA, TDOA also used for indoor localization but they require precise clock synchronization.[3] We are using latest technology of BLE beacons because they work on battery and consume less energy than Wi-Fi signals.

2 Goal of the project

The main target user of our system is a visitor of a university campus. So, our goal is to provide ease and guidance to him regarding a particular lab and its nearby labs automatically via installed application on device by estimating his indoor location. The guidance involves the textual and pictorial information about that particular indoor environment.

3 Objectives of the project

3.1 Industry Objectives

- Implement a system that takes into account the demands of university campus exploration.

- This project leads to industrial workers save their time and cost by providing textual and pictorial information of their institute to their visitors.

- Industrial administrators seek advantage of their time by providing much information to their customers information in less time which automatically increase the sales and profit of their product.

- The huge investment of profit to the market will increase their market shares and they can advertise their industry specifications more and more.

3.2 Research Objectives

- To find the location of the user by finding the RSSI of his nearest Bluetooth beacons that will be connected to his android app via Bluetooth technology.

- To monitor and provide guidelines to user who is connected to the BLE beacon via Bluetooth and mobile application, we need to find fingerprints via data-capturing application.

- To develop an android application which provide textual and pictorial information of particular area and its nearby areas to the user who is located in that indoor environment.

- To predict the behaviour of people who are using indoor location-tracker by using previous technologies.

- To identify the problems visitors are facing while they go to a university campus or a new place first time.

- To provide the solutions of the problems that people are facing while they visit first time to a certain campus.

3.3 Academic Objectives

- This project enables us to understand the concept of Machine learning, networking as well as the use of Bluetooth beacons. The enormous work with RSSI will play the key role in understanding and connection between the android app and the hardware structure.

- To find the best Machine Learning algorithms which are used to train the model of fingerprints.

- To make an android application which use as an interface to provide guidelines to the user who is located in a particular indoor environment.

- To ensure the use of latest technologies in implementing the project which helps technical persons and students to enhance their academic skills via learning new features

4 Scope of the project

In this project, android application runs on a user's mobile device and this will connect to the BLE beacon via Bluetooth technology. Fingerprints (RSSI values between the device and nearby beacons) will be taken by data-capturing application at different times while doing our final year project and then captured-FPs will send to the trained model on the server which tells the indoor location of the user's device.[6] So, he could see the information (text, image, video) of that particular area on his mobile application. The placement of Bluetooth low energy beacons will be held in Huawei Centre UET Lahore.

5 Target Audience

Targeted audience will be the:

- Visitors of the University campus

- New Students and Staff of the campus

6 Possible Applications of work

The possible application of work for our project are as follows:

- Software house information (Development, QA, Frontier)

- Airport assisting system

- University Campus smart information system

- Government small Institutes

- Medical departments exploration in hospitals

7 Existing System

7.1 Comparison of Existing Systems

In recent years, indoor localization systems have been great significant research activity and of growing interest for their great expected social impact. In spite of the numerous research advances, no canned solutions have yet been defined. The diversity and heterogeneity of applications, scenarios, sensor and user requirements, make it difficult to create uniform solutions. There are multiple solutions present in research area for indoor localization. Here are the comparisons of few of them:

Sr. No.	System Type	Methodology	Weakness	Accuracy Achieved
1.	Image based indoor localization	Convolution Neural Network(CNN)	-Time consuming effort required to built data set -Low accuracy	74.09%
2.	By using Capacitive Sensors	Pressure sensing systems that detect presence	-Deployment of sensors in floor is expensive -Impractical	Average Accuracy
3.	By using Zigbee sensors	K- Nearest Neighbors(KNN)	-Expensive -Medium Scalability	Average Accuracy
4.	By using Wi-Fi	Deep Learning algorithms	-Consumes more power -Wi-Fi signals are not accessible to some areas	71%

Figure 1: Comparison of Existing Systems

7.2 Drawbacks of Existing Systems

There are many drawbacks in existing systems. In some systems, camera is required for indoor positioning which is obtrusive for some users. High cost and effort is required for the deployment of indoor localization infrastructure. Most of the existing systems have medium or low accuracy. In image based indoor localization, time consuming effort is required for built data sets. Wi-Fi fingerprinting is relatively better than other systems because of finding position by using already deployed infrastructure. But its main drawback is that it consumes more power. There are some spots where Wi-Fi access points would be difficult to power. There are some areas where Wi-Fi signals are not accessible. In our proposed system, we will find indoor location using BLE beacons. BLE beacons are small in size, light weight and cheaper then Wi-Fi. BLE consumes less power than Wi-Fi. BLE beacons are usually battery powered, which are more flexible and easier deployed than sensors used by existing systems. BLE RSS signals can have a higher sample rate than Wi-Fi RSS signals (0.25 Hz 2 Hz). Our proposed system will provide more accuracy than existing systems and also it is unobtrusive. So, our proposed system will overcome the shortcomings in existing systems. Furthermore, our system will not only predict location but also provide information of that location and nearby location in text, videos, audio and images form which is missing in existing systems because they find indoor positioning for different purposes.[4]

8 Problem Statement

Whenever a visitor goes to university campus or visits a new place, he does not know about the specifications of that area i.e. what happens in that specific room or what courses have been taught in a particular and its nearby labs. So, we are developing a system which assists them in determining the textual and pictorial information of a particular area and its nearby locations. For this purpose, we first find the indoor location of a user by using BLE beacons and RSSI values, and then provide information to him automatically on his android application.

9 Proposed System

In our proposed system, an android application provide guidance to university visitors and make them familiar with university. Application will not only tell the current indoor location of user but also the information about current indoor location and nearby rooms in textual,image, audio or video form.
Proposed system consist of these modules:

- **Deployment of BLE beacons**

BLE beacons will be deployed in the rooms. BLE beacons will be installed on the ceilings of rooms.

- **Data Acquisition**

BLE beacons broadcasts signals and these signals in the form of RSSI values will be captured at different positions by using android application and then csv file will be generated.

- **Data pre-processing and Training**

Data will be pre-processed and trained by using machine learning algorithm and then trained model will be deployed on server.

- **Room level prediction**

An android application for common users will be developed that capture RSSI signals and send to server. Then trained model will take these values as input for the purpose of prediction of room and then send back this information to application.

- **Information about location**

Application will fetch information data of current room and nearby rooms from server and then display these information to screen.

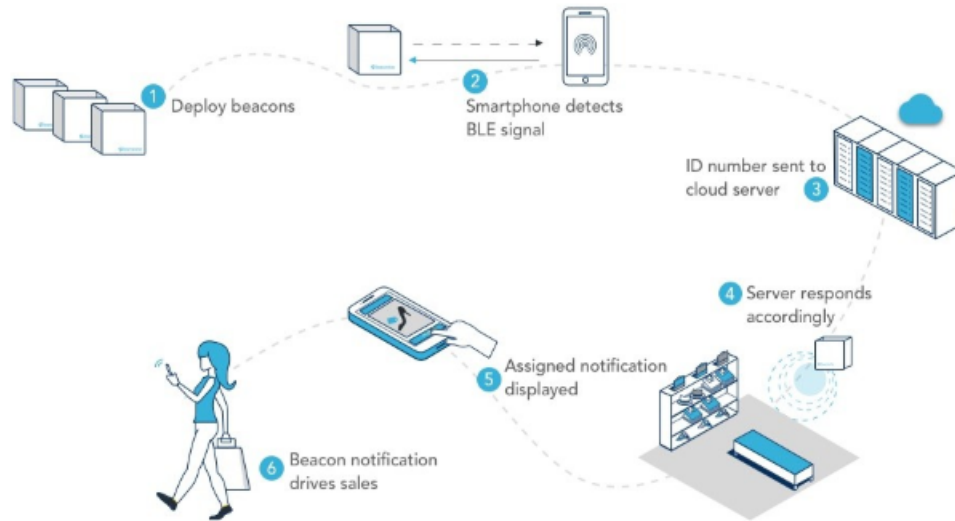Here is the similar kind of workflow of our project that gives basic idea about it:

Figure 2: Workflow of project

10   Feasibility Study

10.1   Technical feasibility

For the development of proposed system, we will use latest technologies. Android studio is used for development of android application. Weka API is used for machine learning. Weka is a machine learning library for Java[7]. BLE beacons are used for capturing RSSI signals. BLE beacons are small in size, light weight, cheaper and easily available. Android application connects with BLE beacons through Bluetooth. BLE RSS signals can have a higher sample rate than Wi-Fi RSS signals (0.25 Hz 2 Hz). BLE beacons can easily deploy as compared to other sensors existing in market. We have necessary skill sets for the implementation of this project. This project requires understanding of machine learning, development of android application and understanding of how application communicate with BLE beacons and server. We are all familiar with machine learning and recently we are trying to learn Android Application development. Our supervisor and co-advisor are very supportive and they have all necessary skill sets to properly guide us. So, considering all these things, it is clear that our project is highly technical feasible and higher chances to be completed.[8]

10.2 Operational feasibility

Operational feasibility means whether a proposed system is to be feasible at operational level. Our proposed system is basically a guided tool that not only tells room level predication but also information related to that room and nearby rooms. This project will guide person who is not much familiar with visiting place. In our case, visiting place will be university campus. Students who do not familiar with campus rooms and activities are much likely to use this application. For this purpose, we conduct a market survey, 83.3 percent people find difficulty whenever they visit the place first time (see Figure 3). 58.3 percent people are interested in knowing their current indoor location and information related to it (see Figure 4). 91.7 percent people are interested in knowing the information of certain lab in textual as well as pictorial form on their mobile application (see Figure 5). 91.7 percent people think that this idea will bring ease to them (see Figure 6).
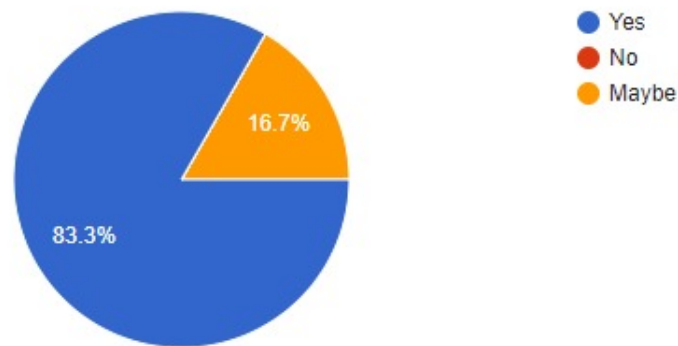

Figure 3: Problem

3. Do you want to know your current indoor location and information about that location?
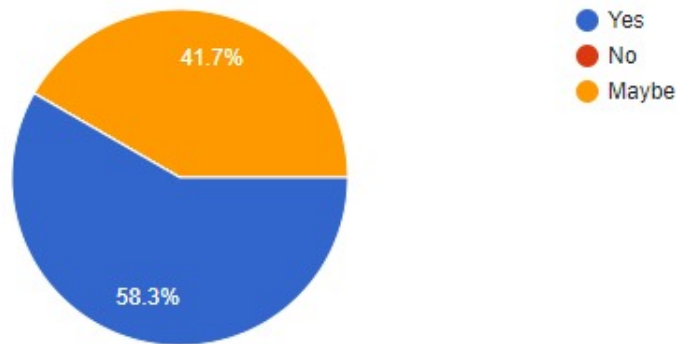
12 responses

Figure 4: Indoor location

4. Do you want to know the information of certain lab in textual as well as pictorial form on your mobile application?
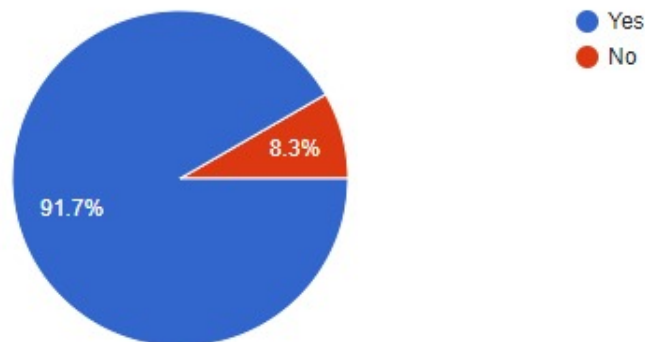
12 responses

Figure 5: Information on Mobile Application

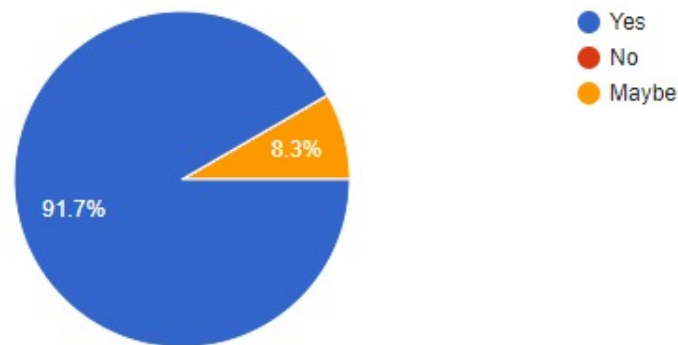## 6. Do you think this idea will bring ease to you?

12 responses

Figure 6: Bring Ease

10.3 Economical feasibility

Economical feasibility means whether a project is economically feasible by analyzing the cost required for developing and using this project. We will have to implement our proposed system in one department i.e. Huawei center. On average BLE beacons transmits signals upto 80 meters. So, we need almost 6 to 8 beacons which is sufficient for indoor localization in one department. The price of one BLE beacon ranges from 5 dollars to 30 dollars. Prices differ due to beacon signal range, typical battery life (which can be several years), and other factors. For deploying an android application on play store requires 25 dollars which is nearly equal to Rs 3,921. User doesn't need any cost for the installation of this application. For the purpose of machine learning we will use Weka API which is free and open source library. Android studio is used for development of application is also freely available. Only cost involving factor is the purchasing of BLE beacons and publishing of Android application on play store. According to estimation, budget of this project is nearly Rs 8,601 which is affordable for us. So, this project is economically feasible.

- **Budget Plan**

Sr. No.	Hardware Components	Price in Rs
1	BLE Beacons(6 Beacons)	4,680 (780*6)
2	Publishing of Android application	3,921
3	**Total**	**8,601**

Figure 7: Budget Plan

11 System Requirements

11.1 Hardware Requirements

- **Hardware requirements for Users**

Users just need a mobile device in which our application is installed.

- **Hardware requirements for Development**

Sr. No.	Component	Description
1	BLE Beacons	Range between 10-100 meters
2	Hard Disk space	Minimum 250GB
3	Processor	Minimum i7core@2.2GHz
4	RAM	4GB or above

Figure 8: Hardware Requirements

11.2 Software Requirements

- **Software Requirements for Users**

Installed android application and Bluetooth technology

- **Software Requirements for Development**

Sr. No.	Component	Description
1	Operating System	Windows10(64-bit)
2	IDE	Android Studio 3.5 and above with JAVA
3	API for machine learning	Weka (Java API for ML)

Figure 9: Software Requirements
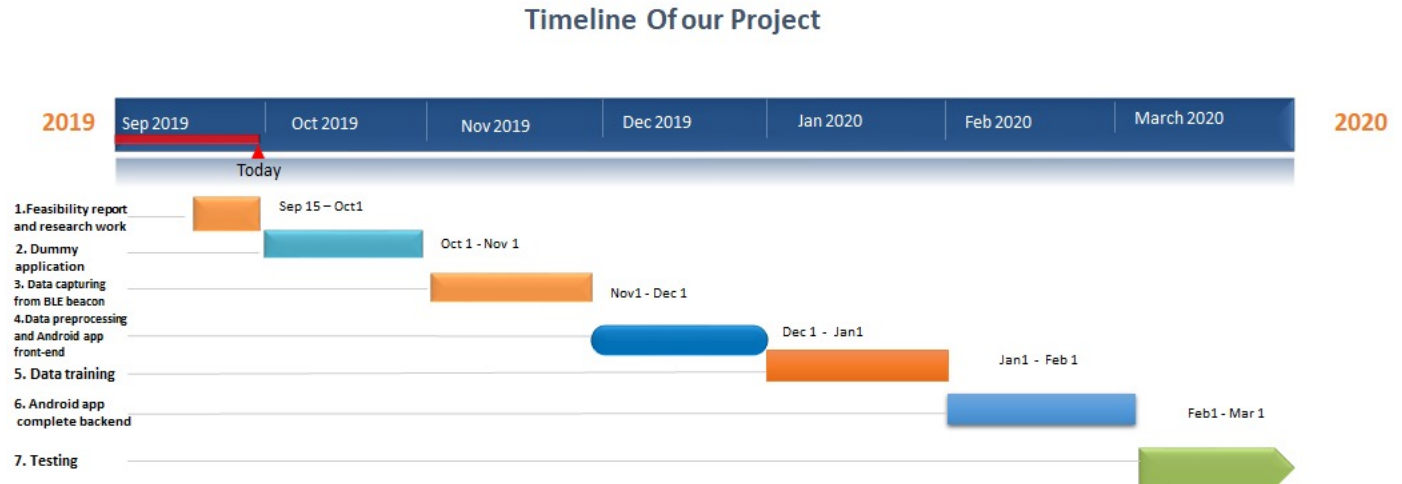
12   Timeline of the project

Timeline Of our Project

Figure 21: Timeline of the project

13   Roles and activities of Team Members

Team Member Name	Roles	Activities
Tooba Naseer (2016-CE-72)	Group Manager + Developer	Android application development backend and machine learning
Rida Mahmood (2016-CE-54)	Researcher + Designer	Android application development frontend and machine learning
Ayesha Jabbar (2016-CS-159)	Developer + Researcher	Android application development backend and data management
Rabeya Hamood (2016-CE-81)	Researcher + Quality Assurance	Research work and checking the quality of product

Figure 21: Roles and activities of Team Members

14 SWOT Analysis

14.1 Limitations and challenges

- **Deployment of BLE beacons for indoor localization**

BLE beacons is used for collecting finger print such as RSSI value by mobile device. So, we will deploy BLE on different locations to access the finger print. To deploy the BLE beacons is big challenge for us.

- **Using Android Studio**

Actually we are not familiar to android studio. We never worked on android studio before doing this project. So make the app development on android studio is also a big challenge for us.

- **Send mobile app data to server**

To send data to the server is also a big challenge for us. Actually we get finger print from android app such as RSSI values. This data is converted into CSV file and sent to the server. We sent the data to the server by http protocol.

- **Weka API is more compatible than MATLAB**

For this purpose, we apply KNN algorithm on MATLAB or using Weka API. We conclude that to apply machine learning algorithm on Weka API is compatibility easier than MATLAB. So to select a right software is also a challenge for us.

- **Send trained data to android application**

Actually, the purpose of this project is to guide the user about the place or nearby places where user is located. So after training the data, we sent the location of the person on android app in the form of text, video, image etc. To sent trained data in android app is also a big challenge for us.

- **Limitations**

Here are some limitations of our project such as :

  - Expensive

- Time consuming process

- Space constraints

- Short range technology

- To achieve 0.3m position accuracy

14.2   Strengths and Opportunities

- **Strengths**

Here are some strengths of our project:

- Bluetooth beacons are much more compatible than Wi-Fi for indoor localization.

- It supports mobile devices such as smart phones and tablets.

- Beacons are platform independent.

- We use Weka API which is more compatible than MATLAB.

- **Opportunities**

Here are some Opportunities of our project:

- User can easily find the location where he stands.

- Our app well-informed the user about that location.

- It also tells to the user about nearby places.

- User can know about the information which we provide in the form of text, video and images etc.

15 References

References

[1] Akram B.A., Akbar A.H., Wajid B., Shafiq O., Zafar A. (2019) LocSwayamwar: Finding a Suitable ML Algorithm for Wi-Fi Fingerprinting Based Indoor Positioning System. In: Boyaci A., Ekti A., Aydin M., Yarkan S. (eds) International Telecommunications Conference. Lecture Notes in Electrical Engineering, vol 504. Springer, Singapore

[2] @articlearticle, author = Akram, Beenish and Akbar, Ali and Kim, Ki-Hyung, year = 2018, month = 10, pages = 1-11, title = CEnsLoc: Infrastructure-Less Indoor Localization Methodology Using GMM Clustering-Based Classification Ensembles, volume = 2018, journal = Mobile Information Systems, doi = 10.1155/2018/3287810

[3] @ARTICLE8402208, author=B. A. Akram and A. H. Akbar and O. Shafiq, journal=IEEE Access, title=HybLoc: Hybrid Indoor Wi-Fi Localization Using Soft Clustering-Based Random Decision Forest Ensembles, year=2018, volume=6, number=, pages=38251-38272, keywords=decision trees;Gaussian processes;learning (artificial intelligence);location based services;mixture models;pattern classification;pattern clustering;telecommunication computing;wireless LAN;room-level;latitude-longitude prediction;hybrid solution;indoor localization system;Gaussian Mixture Model-based soft clustering;RDF;GMM-based soft clustering;natural data subsets;decision trees;hybrid location;room estimation;HybLoc performance;missing data replacement value;Hybrid Indoor Wi-Fi Localization;soft clustering-based Random Decision Forest ensembles;data dynamics;Wi-Fi fingerprints;Wireless fidelity;Forestry;Fingerprint recognition;IP networks;Meters;Floors;Big data applications;indoor localization;machine learning;random decision forest (RDF);ensemble learning;soft clustering, doi=10.1109/ACCESS.2018.2852658, ISSN=, month=,

[4] @articlearticle, author = Zhuang, Yuan and Yang, Jun and Li, You and Qi, Longning and El-Sheimy, Naser, year = 2016, month = 04, pages = 596, title = Smartphone-Based Indoor Localization with Bluetooth Low Energy Beacons, volume = 16, journal = Sensors, doi = 10.3390/s16050596

[5] Indoor positioning system. [online] Available at: https://locatify.com/blog/indoor-positioning-systems-ble-beacons/

[6] Loco guided video. [online] Available at: https://www.youtube.com/watch?v=bjbSwUveuXs

[7] Weka API. [online] Available at: https://www.cs.waikato.ac.nz/ml/weka/

[8] Indoor localization using mobile app. [online] Available at: https://medium.com/cuelogic-technologies/beacons-with-mobile-app-7a5e42590c36