THE DESIGN, DEVELOPMENT AND EVALUATION OF A SMART ATTENDANCE TRACKING SYSTEM USING BLUETOOTH LOW ENERGY BEACONS

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THE DESIGN, DEVELOPMENT AND EVALUATION OF A SMART ATTENDANCE TRACKING SYSTEM USING BLUETOOTH LOW ENERGY BEACONS

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ABSTRACT

THE DESIGN, DEVELOPMENT AND EVALUATION OF A SMART ATTENDANCE TRACKING SYSTEM USING BLUETOOTH LOW ENERGY BEACONS

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The Bluetooth Low Energy (BLE) signal is a wireless personal area network device that periodically broadcasts the signals of a BLE advertising. Smartphone devices take these signals and are used to locate users. This process will allow the provision of context-aware information to users' mobile devices and link the online virtual world to the online physical world. The main purpose of this study is to develop a system that allows students to register their participation in classes using BLE devices and implement this system on a university campus. This research is aimed to reach a set of key targets, including (1) The development of a system capable of polling students by using BLE beacons as an indoor positioning system; (2) Reduce the time for attendance registration; (3) To use more than one BLE device in parallel for students' attendance tracking. This study is also an attempt to understand the potential of using BLE beacons in educational institutions and the challenges in using BLE beacons. In this study, different topologies were designed to evaluate the accuracy of the measured powers from iBeacon devices, and a different number of iBeacon devices were used to do this. Based on measured power levels for iBeacon devices in the class using decision trees and random forest classifiers in each topology, the correctness of estimating the positions of the students were assessed. Power levels were achieved using software developed specifically for Apple iPhone devices; where three measurements were recorded for each location in the class to minimize the error. The results of this study show that students who are positioned close to the classroom walls have the highest probability of failure to register. Moreover, students outside the class can participate in the attendance without being in the classroom. For this reason, these regions are considered to be critical regions, and the signal powers are collected with a half meter resolution to increase the density of the collected measurements in these regions. To provide a useful method, it is essential to distinguish students who are physically located in the class from those who are not; so that the student should not be able to register for participation unless they are actually in the class. For this purpose, closed-field positioning technology based on Bluetooth Low Energy (BLE) devices is used in this study. Different distributions of BLE devices have been evaluated in this study to recommend a topology where students from outside the classroom are never allowed to participate in attendance. In this study, it was found that at least four BLE devices were required for each class to achieve 100% accuracy using random forest classifiers to classify students in and out of the classroom.

Keywords: BLE; Smartphone; Attendance; Random Forest; Decision Tree

ÖZ

BLUETOOTH DÜŞÜK ENERJİ BEACONLARINI KULLANARAK AKILLI BİR YOKLAMA TAKİP SİSTEMİNİN TASARIMI, GELİŞTİRİLMESİ ve DEĞERLENDİRİLMESİ

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Bluetooth Düşük Enerji (Bluetooth Low Energy -BLE) işareti, bir BLE reklamının sinyallerini düzenli olarak yayınlayan kablosuz bir kişisel alan ağı cihazıdır. Akıllı telefon cihazları bu sinyalleri alır ve kullanıcıların yerini tespit etmek için kullanılır. Bu süreç, kullanıcıların mobil cihazlarına bağlamdan haberdar bilginin sağlanmasına izin verecek ve çevrimiçi sanal dünyayı çevrimiçi fiziksel dünyaya bağlayabilecektir. Bu çalışmanın temel amacı, BLE cihazlarını kullanarak öğrencilerin derslere katılımını kaydedebilecek bir sistem geliştirmek ve bu sistemi bir üniversite kampüsünde uygulamaktır. Bu araştırmada, (1) İç mekan konumlandırma sistemi olarak BLE işaretlerini kullanarak öğrencilerin yoklamasını yapabilen bir sistemin geliştirilmesi; (2) Yoklama süresinin kısaltılması; (3) Öğrencilerin yoklamasını yapmak için birden fazla BLE cihazını paralel olarak kullanmak hedeflenmiştir. Bu çalışma aynı zamanda, eğitim kurumlarında BLE işaretlerinin kullanımının potansiyelini ve BLE işaretlerini kullanmada karşılaşılan zorlukları anlama girişimidir. Bu çalışmada iBeacon cihazlarından ölçülen güçlerin doğruluğunu değerlendirmek için farklı topolojiler tasarlanarak farklı sayıda iBeacon cihazı

kullanılmıştır. Her topolojide karar ağacı ve rasgele orman sınıflandırıcıları kullanılarak sınıfta yer alan iBeacon cihazları için ölçülen güç seviyelerine dayanarak, öğrencinin pozisyonunu tahmin etmenin doğruluğu değerlendirilmiştir. Güç seviyeleri, Apple iPhone cihazları için özel olarak geliştirilmiş yazılımlar kullanılarak elde edilmiştir; burada hatayı en aza indirmek amacıyla sınıftaki her konum için üç ölçüm kaydedilmiştir. Bu çalışmanın sonuçları sınıf içi duvarlarına yakın konumlandırılmış öğrencilerin katılım kayıtlarının başarısız olma olasılığının en yüksek olduğunu göstermektedir. Dahası, sınıf dışındaki öğrenciler, sınıfın içinde olmaksızın yoklamaya katılım gösterebilmektedirler. Bu nedenle, bu bölgeler kritik bölgeler olarak kabul edilir ve bu bölgelerdeki toplanan ölçümlerin yoğunluğunu arttırmak için güçler yarım metre çözünürlükle toplanır. Kullanılabilir ve etkili bir yöntem sağlamak için, sınıf içinde fiziksel olarak yer alan öğrencileri, olmayan öğrencilerden ayırmak önemlidir; böylece, öğrenci aslında sınıfta olmadıkça, katılım için kayıt olmak mümkün olmamalıdır. Bu amaçla, bu çalışmada Bluetooth Low Energy (BLE) cihazlarına dayanan kapalı alan konumlandırma tekniği kullanılmaktadır. Sınıf dışından öğrencilerin yoklamalara katılmalarına hiçbir zaman izin verilmeyen bir topoloji önerebilmek için BLE cihazlarının farklı dağılımları bu çalışmada değerlendirilmiştir. Bu çalışmada sınıfın içindeki ve dışındaki öğrencileri sınıflandırmak için rasgele orman sınıflandırıcı kullanılarak %100 doğruluk elde edebilmek için her bir sınıf için en az dört BLE cihazının gerekli olduğu ortaya çıkmıştır.

Anahtar Kelimeler: BLE, akıllı telefon, yoklama, rasgele orman, karar ağacı, sınıflandırma

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LIST OF ABBREVIATIONS

APP	Mobile Applications
BLE	Bluetooth Low Energy
CICO	Check-in-Check-out
CICO	Check-in-Check-out
FN	False Negative
FP	False Positive
GeoXACML	Geospatial extensible Access Control Markup Language
GPS	Global Position Systems
ID	Identification Number
IMU	Inertial Measurement Unit
IMWI	Indoor Mapping Web Interface
iOS	iPhone Operating System
IoT	Internet of Things
IPS	Indoor Positioning Systems
ISM	Industrial, Scientific, and Medical
MH	Mobile Holder
MsSQL	Microsoft Structured Query Database
MVC	Model-View-Controller
NFC	Near Field Communication
OSM	Open Street Map
PAP	Policy Administration Point

PDR	Pedestrian Dead Reckoning
PIP	Policy Information Point
RF	Radio Frequency
RFID	Radio-Frequency Identification
RSS	Received Signal Strength
RSSI	Received Signal Strength Indication
SSID	Service Set Identifier
TN	True Negative
TP	True Position
UID	Unique Identifier
URL	Uniform Resource Locator
UUID	Universally Unique Identifier
UWB	Ultra-Wideband system
WSNs	Wireless Sensor Networks

1. INTRODUCTION

The Bluetooth Low Energy beacon is a wireless personal area network device which regularly broadcasts the signals of a Bluetooth Low Energy advertising. The smartphone devices receive these signals, and they are used to detect the location of the users. This process will permit the provision of context-aware information to the users' mobile devices and make the ability to connect the online virtual world with the online physical world. The technology of Bluetooth Low Energy beacons has been introduced to provide the support for the main Bluetooth low energy techniques on the iBeacon market that has been launched by Apple in 2013 [1], and Eddystone which has been launched by Google in 2015 [2].

Another technique which is similar to Bluetooth Low Energy beacons is RadBeacon Dot that is entirely standalone Bluetooth Smart™ proximity beacon which uses iBeacon™, AltBeacon™, and Eddystone™ technology together. This technology has been executed in a lightweight and small package, which is powered by a battery. This beacon is considered the perfect one to be used in the exhibits, conferences, and trade shows and other different types of events. The location of the visitors can easily be detected with this device, since it is the industry's first multi-beacon, with simultaneous provision for the entire primary industry standard proximity techniques. The RadBeacon Dot allows concurrent closeness services via iOS, Android, and other developing mobile environments. For this reason, RadBeacon Dot beacons were used in this study. The supported beacon technologies in this study include the following technologies [3]:

- iBeacon
- AltBeacon

- Eddystone UID
- Eddystone URL

Apple Inc has issued the iBeacon protocol and this version from BLE devices class that broadcasts and receives a small amount of information inside short distances from the nearby portable electronic devices. When the smartphones, tablets and other similar devices are close to the iBeacon, they will be allowed to perform actions [4]. As well as, they have applications in the indoor positioning system where these devices can help the smartphones to find their expected position by delivering a comparative smartphones information from an iBeacon in an Apple retail store. Therefore, the device provides closeness based indoor localization solution/system based on the fact that iOS devices get signal’s strength from an iBeacon which is about its place to that iBeacon. There are studies, and researches that have been performed to develop indoor positioning system by the use of the available signal techniques such as Wi-Fi, ZigBee, Bluetooth, and UWB in the dependence of context and application scenario. The Bluetooth Smart or Bluetooth Low Energy was produced in 2010. This signal technology has been developed to have many features which differentiate them from other similar technologies regarding low energy consumption and low cost. Apple Inc presents the iBeacon technique by the use of BLE protocol that communicates with smartphones and delivers context- and location- cognizance.

It must be mentioned that all new smartphones and tablets come with built BLE protocol which can be used to help develop low cost, precise, energy efficient and accurate indoor positioning system by the use of iBeacon and smartphone [5]. The indoor position tracking and Indoor Navigation with beacons are considered the most common types of iBeacon and Eddystone where they offer significant benefits for the projects which depend on the high accuracy and aim to comprise Apple devices. In general, beacons usually consist of transmitters in the modes depending on the agent for example, the navigation inside the buildings enable the airline passengers to use the application across a platform and with accuracy reaches about one meter. The servers-based beacons of goods or people can be tracked only with the components of the external components (e.g., infsoft Locator Node, Cisco, Aruba) when the beacons are used for navigation inside the building or temporary installing operations, for example, with the exhibitions, and in unusual locations. The process of installing the beacons is so simple and straightforward that by providing where the housing is available with different colors the devices can be installed discretely. The Bluetooth Low Energy (BLE) technology works on operating the batteries during two years without the need to reach into the external energy source. Moreover, signal devices can be connected to the energy source or the use of energy source from the lighting. The thin-paper beacons with printed batteries are considered optimal for proper installations and save space. For example, the iOS batteries in the advertising materials have battery age extending from three to four days. The beacon management tool is integrated with infsoft systems that make beacon management and monitoring easy [6].

The Bluetooth Low Energy Beacons can send signals in a circle with radius 10-30 meters in the internal space, and they are effective concerning cost. Also, they can be installed with little effort and determine the position in approximately one-meter accuracy and are supported by many mobile devices and mobile operating systems. The BLE (Bluetooth Low Energy) standard is also efficient in energy consumption. Through the use of beacons, it is possible to use beacons for the most common use cases such as asset tracking and people flow.

1.1 Statement of the Problems

The following points summarize the problem that is intended to be solved in this study:

1. Decrease the required time to register the student’s attendance inside the classroom [7].
2. Avoid or reduce cheating to the lowest possible level which existed previously [8].

3. An attempt to expand the circle of using the electronic devices including the smartphones and avoid the existed problems through the use of traditional methods [9].

4. Decrease the pressure on the instructor to register the attendance of students through the traditional methods and give him an opportunity to focus on the lecture contents [7].

1.2 Aim of the Study

The primary aim of this study is to record the attendance of students using Bluetooth low energy beacon devices and apply it in a university campus. This research is aimed to reach a set of key targets, including (1) Developing a system that uses various operations for indoor positing system / using BLE beacons; (2) Reduce the time for attendance registration; (3) Use multiple devices in parallel to take attendance of students. This study is an attempt to understand the potential for BLE beacons within educational buildings and to understand the challenges involved in using BLE beacons.

1.3 Research Questions

In our study, the following research questions will be explored:

1. Is it possible to take attendance in the class within the University Campus by using BLE beacons?

2. What are the minimum and maximum ranges in meters that allow registering attendance by using student's mobile phones and BLE beacons?

3. What is the success rate of identifying whether students are in the classroom or not by using students' mobile phones and BLE beacons?

1.4 Structure of the Thesis

The thesis consists of five chapters and each chapter is interested in some part of our study, and we can describe each chapter as follow:

Chapter One: This chapter talks about the description of Bluetooth Low Energy beacons in general where it gives a review of these devices, importance, and use.

Chapter Two: It describes a model of the previous studies for a large number of studies in the same field where the researcher works and describes these studies accurately and covers all the study sides. As well as, it includes an in-depth review of the localization.

Chapter Three: It talks about the methodology of the study and the used technology in order to reach into the research results, which through the study are depended.

Chapter Four: It includes the results, which have been reached throughout the study, which is developing a system of student's registration inside the classroom by using Bluetooth Low Energy beacons. Also, it includes the machinery dependent on implementing this system. Moreover, it includes the discussion section that is reviewing a discussion about the study and the results.

Chapter Five: It includes the conclusion of the study in addition to a section of the future works.

2. LITERATURE REVIEW

2.1 Introduction

This chapter comprises a review of the literature associated with the topic under study, namely, the design, development, and evaluation of attendance tracking system using Bluetooth low energy beacons. In particular, the review includes the details of Bluetooth low energy technology with the applications as well as the localization. The trilateration and the indoor positioning system work on the same concepts where both of them use the distances in order to approximate the position. The inertial navigation can be accomplished through the use of accelerometer and magnetometer. To approximate, the movement is combined with the measurements of distances because the calculations of distances are inaccurate and noisy. The fusing of the data sources is the responsibility of the effective filter, and it can access numerous models to interpret the data.

A position can be calculated by using many different techniques, and these techniques may be sorted in different kinds by the dependence on the type of the available data. The outdoor positioning techniques are using outside information. For instance, angles of the camera can see the light or distance values in order to approximate the position. On the contrary, the internal positioning techniques use internal information including a gyroscope, accelerometer or magnetometer to approximate the existing position.

Section 2.2 defines the Bluetooth low energy technology. Section 2.3 reviewed the localization, then the indoor positioning and outdoor positioning has given in 2.4 respectively. Section 2.5 reviewed the related work in this thesis. Finally, a conclusion of the chapter is presented in Section 2.6.

2.2 The Bluetooth Low Energy Technology

Bluetooth Low Energy (BLE) is the smart, power-friendly type of Bluetooth wireless technology. It is already plays an important role in the process of transforming the smart tools to smarter tools by making them compact, reasonable, and less complex [11]. We can distinguish the Bluetooth Low Energy (BLE) from the previous versions of Bluetooth by its low energy consumption. We can achieve the low energy consumption when no paired connection is needed between the two BLE devices where one of them sends the frames, and the other receives them [12]. A BLE advertising is usually broadcasted at specific interval frames, which include a unique identifier. The Tadlys Wireless Communications Ltd.'s TOPAZ is considered an example to the commercial indoor positioning system that aims an average setting accuracy of 2-3 meters and can localize tens of tags concurrently that cover areas of thousands of square meters [13].

2.3 Localization

Merriam-Webster (an Encyclopedia Britannica Company) defines the localization as "to find or identify the location of something" (e.g., object or person) [6]. The localization can be thought of as the starting point of navigation in addition to the other location conscious services. Currently, the process of determining the localization of an object is an old problem. Many approaches and techniques were developed to overcome this problem. The current technology allowed the human being to localize and navigate by the use of many devices and software such as Astrolabe, Reflecting Circle, Traverse Board, Back-staff and The Sextant, Compass. The above devices have been invented to localize and navigate the ships in the sea and also some of them are used for many applications regarding navigation and localization in the land. For viewpoint in more modern time, tracking the position/location of vehicles can be seen similar to that of ships. The GPS system is the first device, which is developed for this issue. The rise of digitization and its entrance to our life require the needs of localization solutions for each person and not to be restricted to ships and cars only. The rules of this game have changed by the age of smartphones. Currently, the GPS technique is installed on most of our smartphones, and they are rapidly used in our daily life. The fact of existing a powerful mobile digital device in our hand allows us to personalize the context and location-aware applications. Figure 2.1 illustrates the flowchart of the localization types.

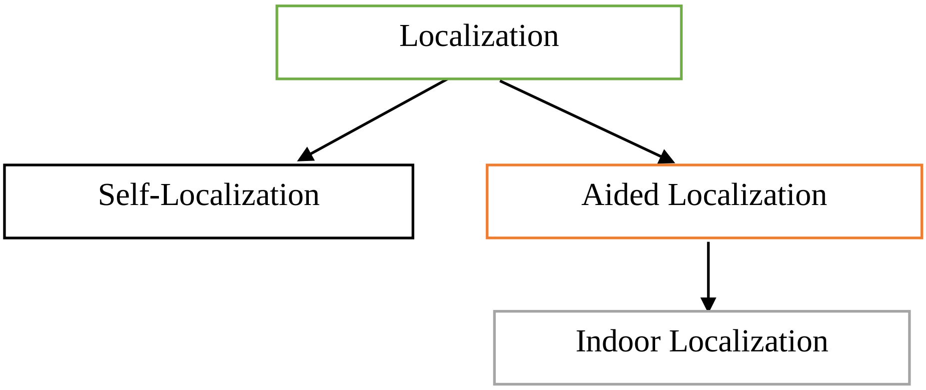

Figure 2.1: Localization types

2.4 Indoor Positioning Methods

There is a broad group of the indoor positioning systems, which have been performed, evaluated, and commercialized depending on the approaches used, these systems can be classified into three classifications including beacon-based systems, pedestrian dead reckoning (PDR) based systems, and vision-based systems. The system which is based on the beacon, the user convoy's device that listens to an optical or radio frequency (RF) signals from beacons in the environment. The power, stage, or time-of-flight of the (Wi-Fi, Bluetooth, infrared) signals is dignified and is used to regulate the person's position. A PDR-based system needs knowledge of the initial location, and then uses the direction and number of steps taken by a person to compute the next location. The system based on the vision will capture the images taken by the cameras worn by the user. Then, it will analyze the images to recognize the position of the user. A distinctive vision-based invention is Easy-living by Microsoft [14]. In our study, we implemented a beacon-based system through the use of Bluetooth technology where the current smartphones are equipped with Bluetooth interfaces, and it is easy to reach the received signal power. In contrast, PDR is not considered because the weak sensors applied in smartphones do not deliver exact data that can cause a massive amassed mistake. The analysis of vision was not considered because of its difficulty. In a unique vision-based system for instance [15], to distinguish a location, an image database and location model has to be pre-constructed, which includes the positions and path between positions of an indoor environment. Then, a wearable mobile device seizures images and sends them to the remote server to implement the location appreciation. The difficulty and cost of generating the large image database, the server, and the need for real-time communiqué between the mobile devices and the server are adverse. Because of that we are confident to perform a beacon-based system, the approaches used in such systems will be deliberated in the next subsections of these, the most common approaches are fingerprinting and triangulation. We can compare different types of indoor positioning systems as shown in Table 2.1.

Table 2.1: Comparison of different types of indoor positioning systems

Indoor positioning system	Nature of Work	Advantage	Disadvantage
WI-FI	It works on locating and monitoring the active wi-fi devices including smartphones, tablets and wi-fi tags.	Tracking solutions where analysis of motion profiles is desired for all Wi-Fi-enabled devices, ability to monitor visitor behavior and wide range (up to 150m)	Difficult to achieve the level of precision afforded by BLE or RFID and high latencies and use of randomized MAC address when the device is not connected to Wi-Fi network
BLUETOOTH LOW ENERGY (BLE) BEACONS	It works on broadcasting the signals by the use of Bluetooth Low Energy	Flexibility cost efficiency and enables indoor tracking solutions without near-perfect precision needs	Attenuations in the signal dispersion within buildings, instability with layout changes and radio interferences
ULTRA-WIDEBAND (UWB)	It is a short-range radio technology works on tracking solutions in an industrial environment with high precision needs and a modest number of assets	High accuracy, low latency times with position updates up to 100 times/second and almost no interferences	Higher cost and shorter battery life as compared with BLE beacons
RFID	It is a form of wireless communication that uses radio waves to identify objects	Very high accuracy, very immune to interferences and no battery needed	Short range (less than one meter), installation requires significant planning and infrastructure can be expensive

2.5 Related work

In this section, the literature on the design, development, and evaluation of attendance tracking system using Bluetooth low energy beacons have been reviewed. The applications of these techniques based on indoor positioning and outdoor positioning for Bluetooth low energy beacons are reviewed as below:

Sharhan and Zickau [16] provided a study, which aimed to present a graphical web interface depending on Open Street Map (OSM), which is called Indoor Mapping Web Interface (IMWI). It is designed to use the indoor maps and floor plans of many projects in the real world including universities, hospitals, and other buildings. The aim of this work is extending the Policy Administration Point (PAP) by extending its abilities to produce policies depending on GeoXACML and BLE beacons in the indoor locations. The focus of this work will be on the tasks, which are implemented before the access control systems are in place and are used. This means that the focus is on the setup of the indoor environment with BLE tokens and its incorporation into an LBAC framework. The proposed approach uses three phases: (I) to appeal the indoor strategies, and they will be added to an Open Street Map (OSM). (II) The BLE beacons are bright on the indoor maps and placed at the particular locations in the real world. (III) The rest of API is designed to amount information for the policies generation depending on the Geospatial extensible access control markup language (GeoXACML) standard to the Policy Administration Point (PAP). In case of an access control, utilize, the Policy Information Point (PIP) delivers information regarding the indoor user positions that will be organized to the rules in the policies, which are stored in the Policy Decision Point (PDP). The Bluetooth Low Energy (BLE) beacons will be placed inside the buildings by labeling them on to digital indoor maps. Then, the back-end of the web interface will deliver the stored location inside the access control environment. The solutions of this system will depend on BLE beacons as it determines the locations of the smart devices. We concluded that BLE beacons are used to determine the locations of the smart devices. The interaction occurs between insertion of beacons in the real environment and stores the identifiers, which belong to it in the database and then is connected to the back-end of the policy.

Shota et al. [8] have a study on proposing a scientific system to decrease the time by scanning the cards of ID above many android devices equivalently. The Android smartphones, which have been used, are those owned by the students. The device that is used by this study is the BLE (Bluetooth Low Energy) beacon to send a magic number that is necessary for the proper registration inside the classroom. The study methodology has been implemented in two parts where the first one is the Android application of the students and the second one is the web-based management system of the teachers. The process requires installing the application on the Android devices of the students. The teacher on the web system as follows should create a set of class ID, name, and a magic number:

1. Before starting the class, the teachers must prepare a set of ID and class name on the web-based management.

2. Later, the teacher runs the BLE beacon to send the magic number to the Android devices inside the classroom.

3. Next, the application will be run by the students in the class and scan their cards above the NFC reader. As well as, the nearby classmates can use those devices.

4. The BLE beacon sends a magic number and is received by the Android devices of the students inside the classroom.

5. Finally, the Android devices will send the scanned ID and name together with the magic number that is received by the server.

The primary results that are obtained through the implementation of this system are the process of managing the attendance of the students through their own or their classmates' Android devices. The BLE beacon device is employed to transmit a magic number to the Android devices within the classroom not to allow students to cheat by submitting attendance from outside the classroom.

Wu et al. [17] provided a scientific study on developing a novel CICO system depending on the developing technology of Bluetooth Low Energy (BLE) proximity.

The Technologies, which are used in the study is CICO technology which is varied and extensive where they range from the most straightforward technologies to the Web and Wireless Sensor Networks (WSNs) based systems. The educational organizations especially the universities are widely using the Check-in-Check-out (CICO) measurement to track the participants' attendance in their registered events, for instance, the courses. If we compare the CICO system with other types of systems concerning high accessibility of terminal medium, easy-going identification, the progressive and spatial correctness in real-time proximity pursuing, we can find that it is superior on these systems by all of the features mentioned above. The methodology of the Study: the CICO detection uses four components and designs the BLE proximity depending on CICO system firstly components in the client sides and secondly two server-side ones. The procedure of this system can be summarized by many steps. Step 1- the Beacon advertiser that broadcasts the BLE Proximity data packages, which can be received by the receiver of the Beacon when arriving at the actual geophone of the Beacon advertiser. Step 2- The Beacon receiver is used by the smartphone application that is programmed inside it, sends the received BLE proximity data packages to the receiver side. Step 3- The BLE Proximity data packages are received and stored by the Proximity Log Server. Step 4- The Proximity Log Analysis Server examines and envisages the participants CICO status. They present solutions and technology of CICO tracking is compared and a new system depending on the BLE proximity technique has been developed. The proximity measuring development will be continued during the future work.

Assissi et al. [18] provided new location awareness possibilities for applications by the use of Beaconholic are an iPhone operating system (iOS) application, which delivers a link between the Reminders on phone and Beacons in the real world. The technology, which is used in the study, is iBeacon technology which delivers new location responsiveness prospects for the applications. The methodology of the study is that Leveraging Bluetooth Low Energy (BLE), an iBeacon technology allows the device, which can be used to create a region around the object and find the device when entering or getting out from the region. The iOS application that is used, is Beaconholic, and it helps the user to assign the personal task remainder. The remainder will pop up in a time-based or location-based task.

This iOS application works on iPhone and iPad. As well as, there is authentication that protects the reminder application. The user depending on his location can classify the task. IBeacon allows the iOS application the capability on determining its proximity to iBeacon with the core location where it enables the software developers to create mobile applications conscious of location setting delivered by beacons. The signal of broadcasting is the Bluetooth smart 4.0 BLE (Bluetooth Low Energy Signal). The main result of this work is developing an application to discover the location by the use of BLE signals of different sensor such as temperature sensor, pressure sensor, proximity sensor, and position sensor.

Varshney et al. [19] developed an application in order to construct an application to user positioning in the indoor environment to exploit the characteristic of Wi-Fi signal recognition from Android smartphones. The technology that is used in this study is the Bluetooth Low Energy (BLE). BLE Beacons became common in indoor positioning and navigation because of their broad range, low power consumption and ease of using with advertising added abilities. The methodology of this study is that when the beacon devices are installed in an indoor environment, it becomes extremely easy to detect stable Bluetooth signals that the beacons advertise periodically, and location estimation becomes fast and simple. Another area to be explored could be a use of hybrid technologies and combination of algorithms to analyze the results of location estimation in indoor environments. They developed an Android application for indoor positioning in their department that depending on RSSI measurements of Wi-Fi access points pre-installed in the department. The result of this study is that the algorithm application in the Android and above the department map provides the results in real analysis circumstances. The achieved accuracies propose that the location estimate in sensor networking by the use of Wi-Fi signals provide many trade-offs. To achieve higher accuracies, more access points must be deployed, and many signal samples must be used. They used pre-installed Wi-Fi access points and Beacon devices based on Bluetooth Low Energy (BLE) technology for the testing issues in their department in the indoor positioning.

Anil Kumar et al. [20] provided a study in order to produce a fault-tolerant smart system that can reduce tracking and monitor the attendance process of students. The technology that is used in this work is Bluetooth Low Energy (BLE) technology that inhibits fraud and favors in the attendance system by the use of Bluetooth smart beacon. The methodology of the study is that when the students enter the range of the beacon, the application automatically registers the time, transmits a message to the server and checks the information of students that present in the database, creates the attendance and then the system will enter in freeze mode until the next lecture time. Also, it starts the process again automatically to create the attendance. If the information of students will not register in the database, the students will not obtain the attendance. Also, the student will not obtain the attendance if the registered student device is not detected during the predefined time-out period. The attendance information of students will be updated after each lecture, and the attendance can be verified in the management system by the professor. At this study, they produced a Bluetooth Low Energy based Beacon attendance system where the students can send their attendance by the Android devices which decrease the consumption of time and attendance of fraud if compared with the conventional handwritten approaches and other recent RFID, NFC, Barcode, Biometric methods. As well as, the proposed system can be enhanced in the future by executing it on another operating system such as Windows and.

Ozer and John [21] has a scientific paper to implement and develop a simple IPS Android application by the use of BLE beacons and the application of Kalman filtering to enhance the accuracy. The technology which is used in this research is the Kalman filter to decrease the noise in the raw RSSI signal. They have used a Kalman filter due to its lightweight implementation which permits filtered RSSI values to be getting in real time that helps for real-time tracking.

The methodology of this study includes two modes of operation where the first one is tracking mode and the second one is a watching mode. In the first mode, the application scans for the nearest beacon and uses the values of filtered RSSI of beacons to determine the nearest beacon to the user. At this paper, they have successfully proved the Kalman filter application in enhancing the indoor BLE IPS accuracy. The Kalman filter is used at this work as it allows on minimizing the difference of the received RSSI values and allows fast calculations, which assist a real-time, tracking. This helps in making this filter implementation suitable for the applications with low power including tracking the mobile devices. Decreasing the variance in the accuracy of RSSI, the accuracy of IPS is expressively enhanced which help on better tracking and expectable results.

Blas and Lopez-de-Ipina [22] provided a series of post-processing filters to improve the result of the expected position applying the trilateration as the key and straightforward technology to determine someone inside the building. The technology, which is used in this study, is the Bluetooth Low Energy1 (BLE) beacons (either iBeacon or Eddystone formats). The methodology of the study is to test the system application of trilateration as the leading internal localization technology. The number of approaches which have been tested is two: 1) the first one is only vanilla trilateration. 2) The accuracy is on the top of the trilateration in addition to the corrective function which also applied that give a result the best technique to the real location in the present surrounding circumstances and inside their technological research Centre. Despite the value itself, the vile thing here is to represent the difference between the real and the assessment location. Meters outline the mentioned difference by the use of Euclidean distance (error margin) columns. They also calculated the mean value and the standard deviation are helped to determine which evaluation is regular. The values, which have been captured in the taken sample, are captured during a short period, and in general, they are very close to each one of them with small difference but significant at the end. The used technology enables the indoor localization. Any person who uses this application in the future may be desirable to be clear about the unexpected distance evaluation calculated depending on the RSSI values of the broadcasted signal from beacons. In this research, they presented post-pressings filters series to improve the results of the evaluated position by applying the trilateration as the primary and straightforward approach to determine the position of any person inside the building.

Barapatre et al. [9] proposed a scientific paper where its goal is to develop an application, which connects within the IOT beacon device, and then it will be connected to cloud to that many operations including the indoor positioning system. As well as, it is possible to mark and implement the attendance and management of the event. Analyze the collected data from this device will assist the staff and students in the development and growth of this system. The technology, which is used in this study, is the Bluetooth Low Energy and Eddystone beacons. The methodology of their system is implemented by using NFC (Near Field Communication) card reader for attendance and scanning their card one after another that consume much time for registering all of the students. The application, which they developed, is merely a smart college system that allows the students to mark their attendance automatically, search exam halls and events by their android devices. The developed application provided reliability, easy control and timesaving where it can be used to create related applications to track the events, attendance, and location of the offices and colleges in any workplace.

Lin et al. [23] proposed a mobile indoor positioning system that its goal is to implement a mobile-based indoor positioning system. The technology, which is used in this work, is the mobile applications (APP) with iBeacon solution depending on the Bluetooth Low Energy (BLE) technology. They used iBeacon technology due to its low price, lightweight and comfortable to be deployed as compared with other wireless technologies. The system methodology is divided into four primary elements, which are iBeacon deployment, patients' mobile applications (APP), system server side and the monitoring side. The medical information of the patient can be collected by these elements in addition to the staff information and patient location information. The main findings of this system are accomplished by employing a mobile indoor positioning system to help the doctors and nurses to find their patients efficiently. Moreover, the system is designed to help the patients themselves**.**

Şengül and Karakaya [24] proposed a scientific paper that deals with using Bluetooth low energy beacons to be used for indoor localization. The technology which they used during this work is Bluetooth Low Energy (BLE) Beacons due to its excellent characteristics and features which characterize by this technology as low energy consumption and thereby long lifetime. Their methodology includes two stages including the Initiation and Service. In the initiation stage, BLE beacons are placed in their position, and they used the BLE device to record the received signal power level for each cell grid. Then, the received readings will be stored in the database. While in the Service stage, any BLE enabled the mobile device visits the grid reads the received signal power level of the BLE beacons and sends them to the server of application. The application server will compute the estimated grid cell, and the results will be returned to the mobile. The exact location information of BLE beacons is not necessary to be known. Furthermore, there is no need to perform any calculations on the mobile. The primary results of this study pointed out that it is possible to employ several BLE Beacons to increase the success of prediction technique significantly.

Şengül and Karakaya [7] proposed and developed a smart classroom application to monitor the attendance of students in the classroom environment. The design phase included the use of a low-energy Bluetooth device that is located in each classroom. Besides, there is a central database that matches and store the Identification number (ID) of the low-energy Bluetooth device and the name/number of the classroom. At this work, they used low-energy Bluetooth devices and attendees' smartphones/smartwatches to obtain the attendance. Moreover, they designed a central database to keep track of the students list their course and courses' timetables, attendance periods of the students for each course. They developed a mobile application, which works on both the smart watches and smartphones. In addition, they developed two pieces of software, and each one of them differs from the other where the first one for the smart devices and a second one for the central server. The findings of this study are to test the proposed system for three consecutive weeks in two lectures, and they got encouraging performance. However, to measure the strength of the system, it must be tested in more complex environments with a higher number of courses and students

Zou and Chen [25] proposed innovative indoor localization and tracking system, which fuses PDR method by the use of smartphone built-in IMU sensors, Wi-Fi fingerprinting and adaptable iBeacon corrections depending on a particle filter. In this study, they used the Pedestrian Dead Reckoning (PDR) method that influences smartphones equipped accelerometers, gyroscope, and magnetometer to evaluate the distance between walking and user direction. The methodology of this system can be explained as follow:

1) Initialization: it supposes that we have an initial position.

2) Prediction: With the IMU sensor capacities.

3) Updating: Supposing the position assessment by Wi-Fi at a time.

Through the use of the proposed method and compared it with PDR, Wi-Fi and incorporated PDR and Wi-Fi using a unit filter. The proposed and developed system allows the substantial progress to deliver accurately, applied and large-scale indoor position-based services.

Yang et al. [26] provided a scientific study to differentiate between the three-movement types and accurately modifies the counter when there is an MH (Mobile Holder) going to or out of the room. The technology, which is used at this work, is the iBeacon novel technology has been used at this work to create an intelligent detection system to be used inside the room. The methodology of the study is that the iBeacon RSSI readings will be collected upon stimulation, and then, the record will be sent to the remote server across a wireless connection. The whole process can be summarized as follow:

A- Double iBeacons Approach: the motion sensor, which is reading from iBeacon when the door is opening, instigates the process of RSSI recording.

B- Single iBeacon Approach: they believe that it is possible to spend efforts to enhance their system and make it as original iBeacon implementation. Throughout this study, they made an investigation and development of iBeacon based intelligent in-room attendance detection system to record the users in the room. Moreover, they analyzed the possibility density function, the rate of error detection in addition to the other metrics by the use of empirical measurement results.

Cay et al. [27] have a study to develop a system to track and control the disabled people or elderly inside the indoor environment. The technology, which is used in this work, is the iBeacon type beacons as the Android and iOS devices can easily detect them. The receiver that is used in this work includes the Android smartphone and an Arduino Mega microcontroller board equipped with a BLE receiver module. The signals can be used to categorize the unique id, subgroups and individual ones in subgroups. The methodology of the study is to determine the path loss index, which was the critical point at their work. To calculate the index, they spent extensive measurement. The procedure, which is used for this purpose, comprised carrying out the repetitive measurements at the grid points by the use of smartphone and microcontroller board. The results refer that the system is capable of transmitting an alert message if the targeted person move to the forbidden area or stay at one location for an extended period. Since the non-ideal impact, their system offers better results to estimate the location than the precise positioning. In conclusion, their work is shown that the software and hardware can be joined to implement this work. Whereas regarding the future work, they suggest developing more useful and accurate measurements by controlling the levels of the signal of the transmitter.

2.6 Summary

In this chapter, works on Bluetooth low energy were reviewed. There are two main directions considered in this chapter. First direction works on the indoor positioning and the second direction works on the outdoor positioning. This chapter discussed and reviewed related works that either applied or improved the indoor and outdoor positioning problems. This section shows the most critical challenges that previous studies encountered related to the indoor and outdoor positioning.

3. METHODOLOGY

3.1 Introduction

This chapter presents information about the research methodology used in this study. This study follows the standard research methodology in computer science where the primary goal is to develop and improve the mobile indoor positioning performance system at the Cankaya University. It also provides the required steps to implement a mobile-based indoor positioning system using mobile applications (APP), with the iBeacon solution based on the Bluetooth Low Energy (BLE) technology. The phases in which the proposed methodology of this research is to be applied are also described in detail in this chapter. The research method conducted in this study consists of the following phases: Literature review (problem identification and understanding), design, data collection and preparation, implementation, testing and evaluation.

This chapter is organized as follows: Section 3.2 presents the problem identification phase. Section 3.3 provides the implementation phase of our study. Section 3.4 reviews the data collection and preparation phase. Section 3.5 presents improvement and measurements phase. Section 3.6 reviews the evaluation and testing phase. Finally, Section 3.7 presents classification algorithms used in the study. Figure 3.1 shows the diagram of the research method used in this thesis, which is presented in the following subsection.

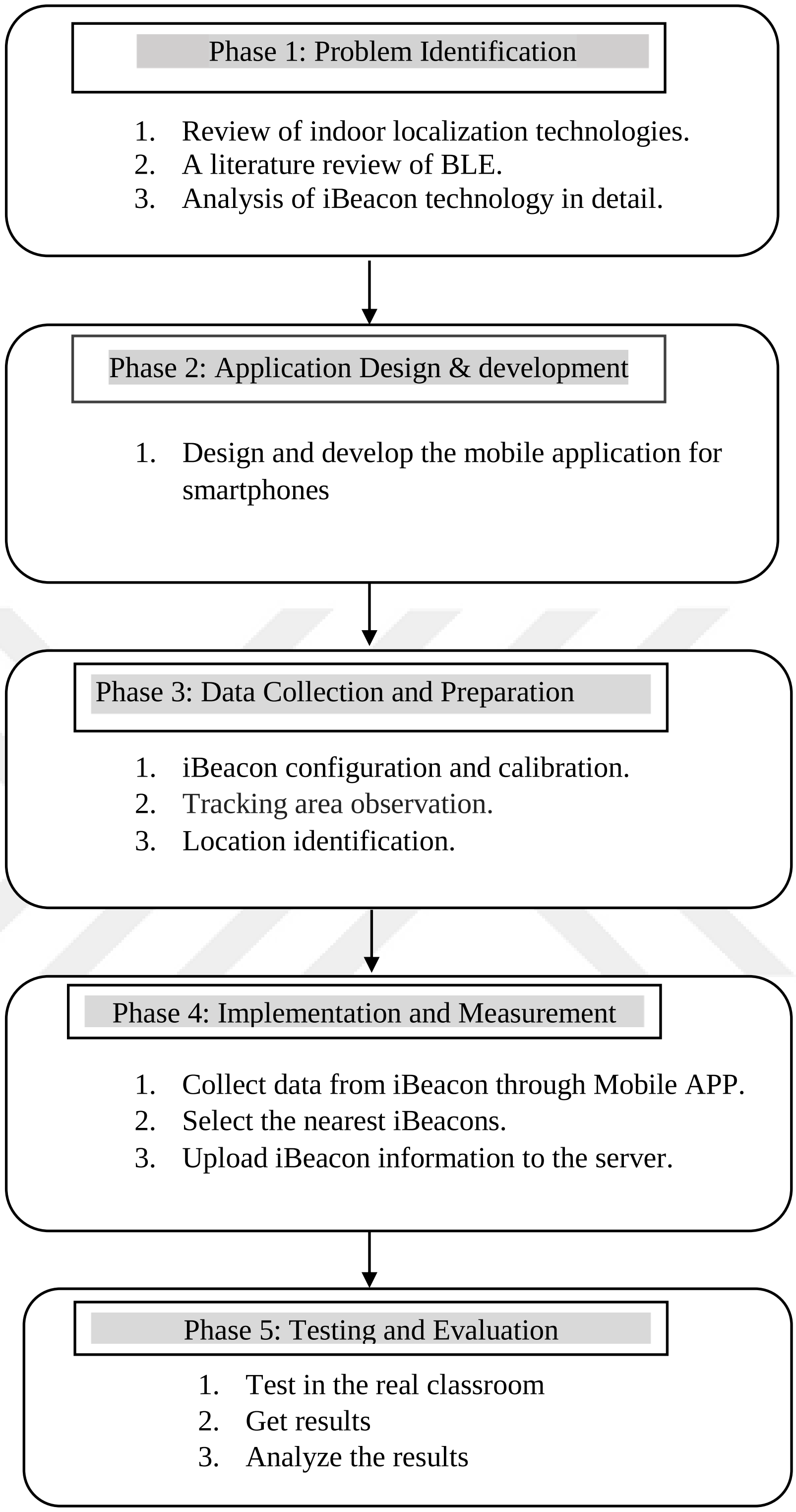

Figure 3.1: The Research Method

3.2 Problem Identification Phase

This phase begins with identifying the most relevant work, and is concerned with understanding and determining the central concepts in the feasibility of Bluetooth Low Energy (BLE), as a viable information source for localization in an indoor environment, which is an interesting question. With the help of iBeacon, a positioning service for smartphone localization can be developed based on BLE-protocol. From the literature review of the iBeacon localization, indoor localization and BLE-based indoor positioning systems being developed, the fundamental problem is identified and discussed in Chapter II.

The iBeacon is an example of technological innovation from Apple. It is designed to work with Bluetooth Low Energy and come with characteristics of low energy consumption, low cost and longer battery lives. This technology is primarily designed to extend the location services in iOS applications. When users approach or leave a location where there is an iBeacon, an action can be initiated in their smartphones.

3.3 Implementation Phase

A web application is implemented for the proposed method using ASP.net C# Model-View-Controller (MVC) hierarchy, so that, smartphones measure the power transmitted from iBeacon devices in range with the smartphone, and sent to the server. The server then compares these major and minor values of the four-iBeacon devices with the highest power measured by the smartphone device to those stored in the database for each class. Based on the results of this comparison, a course that the student is enrolled in is searched in the opened sessions at that classroom. If such course exists, the student is required to provide a real-time picture using the smartphone’s camera and save it to the server alongside with other information of the registrations attempt. As the C# is an object-oriented programming language, classes are created for the main objects in the implemented method. Entity framework is used to store some of the classes that have information that is required to be stored in the database.

3.3.1 Implemented classes

A class is implemented to represent classes in the university, where as shown in Figure 4.5, each class has a name, type, and four iBeacon devices. A class type has a name attribute as well as two dimensions that describe the class, while its Major, Minor, and Power values, as shown in Appendix (A), describes a Beacon as well. Using such topology, all information required per a class can be easily retrieved from the classroom.

Another important class in the implemented model is the Course class, which represents courses being given in the university. A course class consists of four main properties, which are the Instructor Id, the name of the course, a Boolean to whether it is open for students' registrations or not, and the classroom that it is being given in, as shown in Appendix (A). Using such topology, it becomes easy to retrieve courses given by a specific instructor, so that, the instructor can open them for registrations in a particular class after authenticating into the server.

When a course is opened for registrations, a session with a unique identifier is created, so that, students can register their attendance using this session. A session's class consists of the date and time the session is opened and closed for registrations, the course given in that session, the classroom that the course is given in and the status of the session, whether it is open for registrations or closed, which is also illustrated in the source code in Appendix (A).

When a session is open for registration, students can use the application developed for this purpose to register their attendance in the course, by opening the application and providing their credentials. A class is created for these registrations that hold the username of the student, the session that the student used for the registrations, the time of those registrations, and a Boolean whether the registration is finished or not and the extension of the image provided by the student, as a proof of attendance. A registration is created after the student provides the required credentials with the status unfinished, and is marked finished when the student provides the image required from the smartphone's camera. A list of Beacon objects is included in this class, so that, the details of all the iBeacon devices included in the registration are stored in the database for further analysis. This information includes the major, minor and power measured by the smartphone, according to the definition of Beacon object shown in Appendix (B).

3.3.2 Implementation procedures

The application implemented for the iPhone smartphones, using Xcode development environment and Swift programming language, collects iBeacon devices in the range of the device, with the SSID specified for the University and creates a web request that is used to retrieve the web page responsible of registering students to the session. As shown in Appendix (B), the application searches for any iBeacon devices in the range and checks whether the number of these devices is more than three, as the minimum number required for registration is four. If so, the Major, Minor, and power values are arranged is the request, without a specific order, and the request is sent to the server.

Upon arrival, the request is processed by the server, as shown in Appendix (C), where the iBeacon devices in the range are extracted, arranged and compared to those in the database, to detect the class that the student is located in. By arranging the iBeacon devices according to their power measured by the smartphone and taking the first four devices, these iBeacons are compared to the iBeacons of each classroom in the database, if a match is found, the login credentials are requested from the student to accomplish the registrations, and otherwise, the student is redirected to the home page. When a matching classroom is found, the open sessions in the database are searched for a course being given in this classroom, so that, a new registration object is initiated for that student.

3.3.3 Users interfaces

Upon opening the application in the iPhone, the student is requested to take a real-time picture using the smartphone’s camera, after validating the received iBeacon information, as shown in Figure 3.2. By setting the capture attribute in the file upload controller to ‘capture="camera,"' the application only accepts real-time images to be taken instantly from the device's camera and does not allow uploading images from the gallery of the device. This feature allows more flexibility in the web application and ease of implementation in many other operating systems, such as Android or Windows phones.

Figure 3.2: Student registration interface

Another interface is implemented for the instructors, where they can add courses, open and close sessions for the students to register their attendance, as shown in Figure 3.3. Upon closing a registration session, a summary is displayed for the instructor including the number of students registered into that session, as well as all the registrations’ details, such as the uploaded images, the students’ names and the time of the registration.

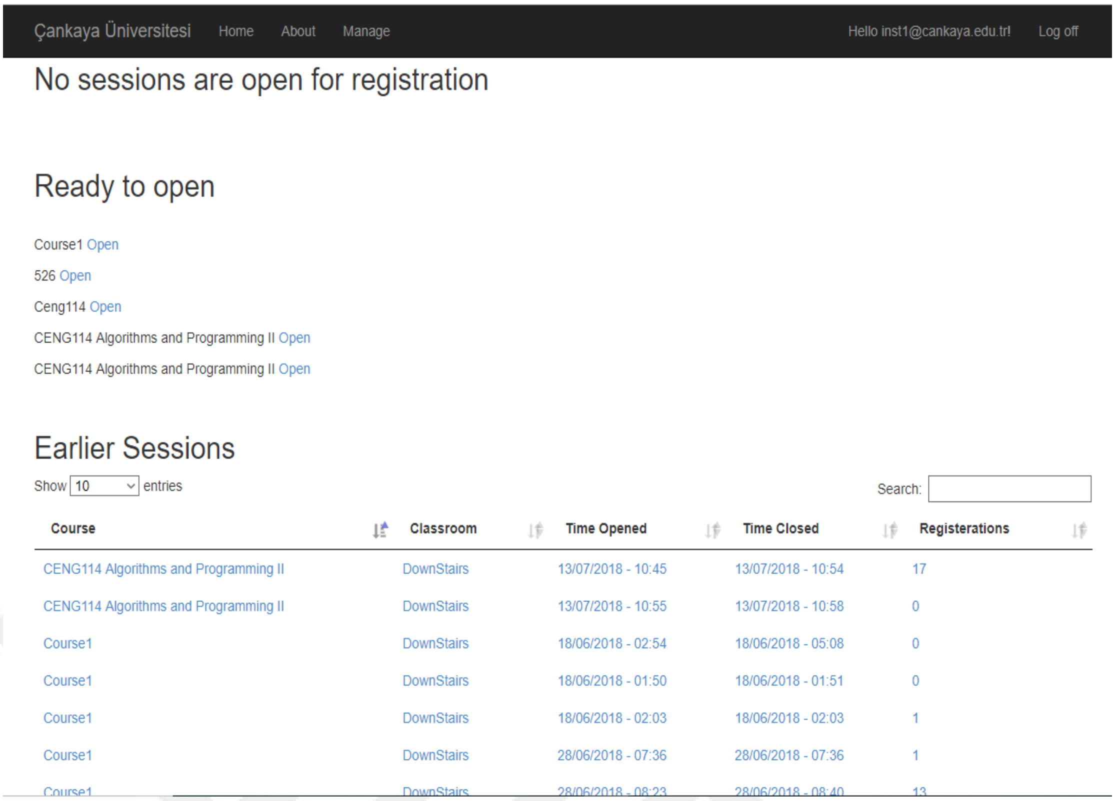

Figure 3.3: Instructors' Interface in the Implemented Model

As it is essential to maintain the roles of the users of the implemented models, so that, users in the "Instructor" role can open and close sessions, an "Administrator" role is added to the model, where administrators can modify whether a user of the web application is an instructor or a student, as shown in Figure 3.4.

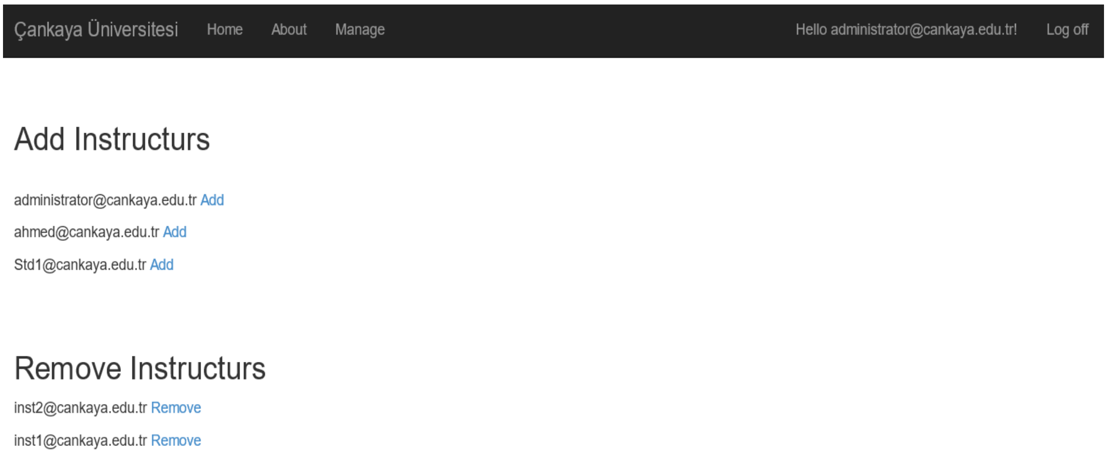

Figure 3.4: Administrator interface in the implemented model

3.3.4 Database

The information required to be stored in the database is managed by utilizing tables, as shown in Figure 3.5. According to the structure of the corresponding classes illustrated earlier, the Entity Framework was used to structure each table.

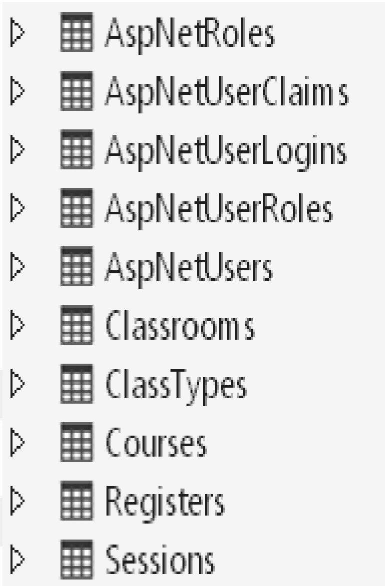

Figure 3.5: Database Tables to Store Classes Information

3.4 Data Collection and Preparation Phase

This phase concentrates on designing the logical sequence of the proposed BLE-based indoor location frameworks. More precisely, this phase focuses on modeling the parts of the problem that can be expressed mathematically, such as the evaluation and the problem definition. To collect the Received Signal Strength Indication (RRSI) measurements from each of the reference nodes, an application for iOS devices is developed and used. This application scans for Bluetooth-Low Energy devices nearby (iBeacon in the surroundings of the smartphone) and log data packets received and write them in a text file. This text file would then be fed into the web application to perform localization processing.

The position of the device is calculated based on the information collected from the nearby iBeacon devices. Then, the mobile device captures an image and transmits it to a remote server to perform location recognition. The complexity and cost of creating the robust image data at the server, and the need for intensive real-time communications between the mobile device and the server are undesirable. A suitable solution representation is also identified in this phase. This phase is also concerned with the transfer of information about each problem instance (benchmark instance or the input file) to a suitable matrix, which is used during the solution generation processor improvement stage.

3.4.1 iBeacon configuration and calibration

The technology used in this study is the iBeacon technology. iBeacon is a new technology developed by Apple to provide location services in iOS applications. This technology is low power based on Bluetooth technology. iOS can detect iBeacon's and simple devices that are in range with the connected devices, and the evidence is then transferred from those devices to the server. The presence of the addressee represents the lecturer or teacher who receives the absence and attendance data from the server, after the students complete their attendance registrations. The iOS operating System contains the primary framework that has ways to record alerts when the user enters or exits specific areas defined by the presence of iBeacon devices. According to measurements, the length of the classroom from which the measurements were taken is 7.80 meters or 5.21 meters. We divide the classroom into vertical and horizontal and then measure distances in meters. We specify a threshold that represents the strength of the device so that, if the power of that device is greater or equal to the threshold, it indicates that the student is inside the classroom; otherwise, the student is outside the classroom and does not accept the registration process. We assume that the student has a username and a password when he or she enrolls in the classroom. Many technologies, techniques, and programming languages are used to accomplish this work, including Asp.net, C#, Swift, and MS SQL Server. Figure 3.6 shows the Beacon inside nodes run on AAA battery or Micro-USB and are used for long-term deployment due to their excellent battery lifetime.

Figure 3.6: iBeacon inside a Node, a Clone of iBeacon

The students must install the program on their devices through the XCode program that is used by us, and the same steps are be applied. The strength of the signal will be measured when recording the attendance and comparing it to the threshold we specified if the power is higher than the threshold limit. Then, the student is considered in the classroom, and the registration process is accepted. Otherwise, the students are denied entry because they are considered outside the classroom.

3.4.2 Location identification

For positioning, model classroom (2) is used as "2Nolu Sedam" Near the Department of Registration and Student Affairs at the Cankaya University, which applied the experience of the program and the iBeacon devices used in this work, where this classroom is the place of our current study and where the results are tested. This classroom is where the measurements and process took place at Cankaya University as it is the university where the researcher studies. The university is located in the city of Ankara, which includes many scientific and social departments and studies a mixture of international and Turkish students. International students come from Middle Eastern countries. Figure 3.7 shows the pilot beacon locations is an outdoor space location relative to existing sectors.

Figure 3.7: Location Relative to Existing Sectors

Figure 3.8 shows the outdoor site where the experiments are conducted for BLE-based outdoor localization system. The propagation model and measurement setup used to build a BLE-based outdoors positioning system. Here, we discuss the measurement setup; a “2Nolu Sedam” Near the Department of Registration and Student Affairs at the Cankaya University was selected as the experimentation environment.

Figure 3.8: The Outdoor Site Where the Experiment was conducted for BLE-Based Outdoor Localization System

Figure 3.9 shows the indoor site where the experiments are conducted for BLE-based indoor localization system. The propagation model and measurement setup used to build a BLE-based outdoors positioning system. Here, we discuss the measurement setup; a "2Nolu Sedam" Near the Department of Registration and Student Affairs at the Cankaya University was selected as the experimentation environment. In the field of pervasive computing, it is one of the very first indoor positioning systems developed. They are advantageous due to their small size, being lightweight and thus easily portable. However, they also have issues like security and privacy and require expensive hardware and maintenance cost. Finally, the significant research is being done in the field of indoor localization. This has led to the development of several indoor positioning systems (or solutions) using different signal technologies for both research and commercial purposes. Therefore, when developing an indoor positioning system choice has to be made. A mind map is presented here to distinguish between different indoor positioning systems based on the signal technology used as an information source in these systems for localization.

Figure 3.9: The indoor site where the experiment was conducted for the BLE-Based indoor localization system

The other model where the dimensions are taken and the experiment has been implemented is the New Campus of Cankaya University where the room that used has the number of L-113 as shown in Figure 3.10. this site is used in order to increase the accuracy of the results where the size and the structure of this campus and room differ from that used in Balgat Campus of Cankaya University.

Figure 3.10: The Indoor Site Where the Experiment was conducted for BLE-Based Indoor Localization System in the New Campus

3.5 Improvement and Measurement Phase

The primary goal of this phase is to improve the Received Signal Strength Indication (RSSI) from the iBeacon reference which has been used to associate the presence of smartphone (user) in one of the three regions (Near, Far and Very far). Multiple Beacon nodes are used to record RSSI measurements over distance distribution from 5.21-7.80 meters. This way an attempt is made to establish a clear threshold, based on the recorded mean RSSI measurements over multiple distances from the reference nodes. The characterization of each region with a certain RSSI mean value threshold for a reference node can be seen in Table 3.1.

The mean value for an associated range of RSSI to each distance is created from the calculated standard deviation over the points in those range of iBeacon. The used indoor localization system is based on BLE.

Table 3.1: The Distance Range Associated with Each of the Three Regions

Proximity Intimation	**Distance Range Based on Smartphone**	**Estimated RSSI Threshold Value from Reference Ibeacon**	**Associated RSSI Threshold Value from Reference Ibeacon**
Near	0 -5 *meters*	-68.51	-70
Far	5 -20 *meters*	-82.18	-70 to -85
Very Far	20+ *meters*	-87.63	< -85

A detailed explanation of this framework is presented in Chapter 4. BLE-based indoor positioning system with proximity approach can be easily implemented. It is the simplest localization algorithms, and iBeacon is designed to provide such localization solution. With the help of an Application, users can quickly calibrate the threshold values for their chosen indoor environment and implement the system faster.

The smartphones collect the received signal strength (RSS) value of the advertisement broadcast. The distance between the sender (beacon) and receiver (smartphone) is calculated by using the RSS. Many beacon manufacturers supply an API that calculates the distance. Otherwise, it can be calculated by the following equation [7], [28]:

$$RSS(d) = RSS(d_0) + 10n\log_{10}\left(\frac{d}{d_0}\right) \quad (3.1)$$

Where n represents the propagated path loss exponent while d represents the distance, d_0 represents the reference distance.

Since the propagation path loss exponent n is unknown, it can be calculated from the equation below:

$$n = \frac{RSS(d_0) - RSS(d)}{10\log_{10}\left(\frac{d}{d_0}\right)} \quad (3.2)$$

When RSS(d_0) is a set on the beacons to -60 *dBm*, and d_0 is equal to 1 *m*.

$$d = d_0 * 10^{\frac{RSS(d_0) - RSS(d)}{10 * n}} \quad (3.3)$$

The accuracy of the RSS values is usually defined using the mean distance error, which is the average Euclidean distance between the estimated location and the correct location.

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN} \times 100\% \quad (3.4)$$

Where True Position (TP) refers to the number of positive samples, True Negative (TN) denotes the number of negative samples, False Positive (FP) often referred as false alarm, it refers to the number of negative samples and False Negative (FN) sometimes known as miss, it is determined by the number of positive samples.

Also, a measurement of the number of correctly and incorrectly classified records is calculated as follow:

$$Correctly\ classified\ records = TP + TN \quad (3.5)$$

$$Incorrectly\ classified\ records = FP + FN \quad (3.6)$$

Precision is a measure of exactness, which is the proportion of observations from actual class correctly classified as positive. It describes how well a classifier removes the negative class from being misclassified as positive class.

$$Precision = \frac{TP}{TP + FP} \quad (3.7)$$

F-measure is a combination of precision and recall or a harmonic mean of them. It is the average value of precision and recall when they are close, for the case where the two values coincide with the square of the geometric mean divided by the arithmetic mean. The traditional F-measure or balanced F-score can be denoted as:

$$F - measure = 2.\left(\frac{Recall\ precision}{Recall + precision}\right) \quad (3.8)$$

3.6 Evaluation and Testing Phase

The tests have been performed in a static environment in order to realize a probable increase in the performance without any intervention that may affect the results. Thus, there is no any dynamic environment is assessed, and according to that, it is not possible to calculate how the existed design may perform when it is compared with the performance of existed people. The reason to not consider this issue through the testing period is according to the difficulty of regulating the environment and perform the testing process repeatedly. Although, by looking at the results from the executed test, it is clear that it is correct to assume that the dynamic environment does not worsen the map-based method performance relatively the map-less method. Nevertheless, in order to solidify this assumption, the real test requires to be performed in a dynamic environment. Many use cases are considered to validate the positioning systems. Depending on the use cases, there are many test cases, and assessment standards that are proposed to check the positioning system performance. The test is implemented inside a public building which includes many adjacent rooms and hallway that connect then to each other. The building is spaciously furnished because it is widely used for meetings and conferences. Many uses cases have been identified in order to perform a correct assessment of the system. Many tests cases are helped with related assessment standards have been proposed. 1) Routing, which is considered as a perfect example to the service that may benefit from the positioning system without the dependence on the user to deliver the starting position, the positioning system provides the starting position instead. 2) Proximity is considered one of the simplest localization algorithms where it is designed in order to deliver “symbolic relative location information”. The proximity approach for localization is used for the purpose of finding the position of a mobile device only by its existence in a special area in range of a reference node nearby. This approach works by forwarding simply the location of an anchor (reference node) point, from which the maximum signal strength is received, as the position evaluate the mobile device. This approach enjoys by ease implementation. However, it is not good in terms of localization system’s performance. Accuracy of this approach is from 5-10 meters. The more critical metric here is integrity which means how much confidence can be placed on localization systems’ ability to correctly inform about the position of smartphones with the correct distance range.

In order to have the ability to deliver the right service, it is necessary that the positioning system can reveal the correct location of a specific user. The first evaluation standard in the system evaluation is the accuracy where it examines how far the evaluated position from the real position. The second standard is to estimate the room correctly where Boolean decision is provided to describe the position of the device, inside or outside a certain room. This standard is considered as a complement to the accurate position where the error of the evaluation may be minimal. An iOS application is developed by using the Swift programming language to detect the position of the user by measuring the strengths of the signals taken from the BLE beacons.

3.7 Classification Algorithms Used in This Study

In this study, classification algorithms are used to determine whether students are in the class or not. Two classifiers, namely decision trees and random forests are used to evaluate the accuracy of predicting the position of a student, based on the power levels measured for the iBeacon devices located in that classroom.

3.7.1 Decision trees

The decision tree works on building regression or classification models and has a tree-like structure. Also, the decision tree classifier breaks down a dataset to smaller and smaller subsets whereas at the same time a related decision tree is developed incrementally. The final result of this form is a tree with decision nodes and leaf nodes. Moreover, the decision node (e.g., Outlook) has two or more twigs, for instance, rainy overcast and sunny. Leaf node (e.g., Play) signifies a classification or decision. The topmost decision node in a tree which relates to the best analyst called root node. Decision trees can handle both definite and numerical data.

3.7.2 Random forest

Random forest classifiers are also based on decision trees, where a forest consists of a group of decision trees. Each tree in the forest is trained using a different set of training data, where the data objects in that set are selected randomly, so that, each tree extracts different knowledge from the dataset to reach the same results. When a prediction is required from the random forest classifiers, the attributes values of the new data object are forwarded to all the trees in the forest, where each tree provides a prediction depending on the knowledge it has extracted from the random samples used in training. Finally, the random forest classifier selects the dominant class as the predicted class for the new data object.

3.7.3 Differences between random forest and decision trees

A random forest can be considered as a collection of Decision Trees, but there are some differences. If we input the training dataset with labels and characteristics in a decision tree, it expresses some set of rules that can be used in order to make the predictions. For instance, if it is required to predict whether a person is going to click on an online advertisement, information about advertisements the person has clicked in the past is assembled and some characteristics which describe the user's behavior. If we put the characteristics and labels in a decision tree, it creates some rules, so that, we can forecast whether the advertisement will be clicked or not. In comparison, the Random Forest algorithm randomly chooses observations and characteristics in order to construct many decision trees and then means the prediction results from these trees.

The other notable difference is that "deep" decision trees may suffer from overfitting. Random Forest avoids over decent most of the time, by generating random subsets of the characteristics and constructing smaller trees by the use of those subsets. Then, it blocs the subtrees. It must be mentioned that this does not work all of the time and that it also generates slower computations, depending on how many trees are in the random forest. How the random forest works is illustrated in Figure 3.11 [30].

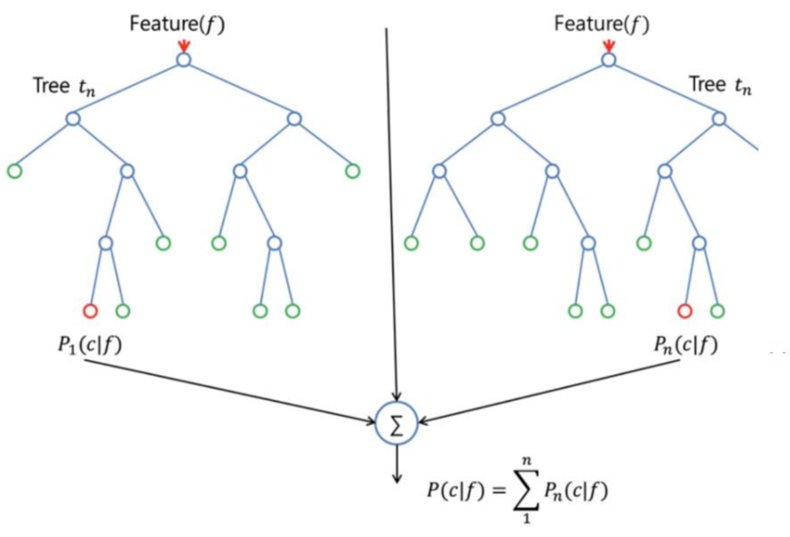

Figure 3.11: How random forest works

3.8 Summary

This chapter has presented the research method used in this thesis. In particular, this thesis uses an experimental methodology to develop a mobile-based indoor positioning framework to solve various combinatorial optimization problems. An experimental methodology is used instead of an analytical approach due to the stochastic elements in the proposed hyper-heuristic frameworks. The descriptions of the considered methodology phases, i.e., problem identification, preprocessing, constructive algorithms, improved algorithms and evaluation and comparison, have also been discussed in this chapter. The next chapter presents the preliminary setups for the subsequent chapters and the experimental result for this thesis.

4. RESULTS

To evaluate the accuracy of the powers measured from iBeacon devices, different topologies are implemented using a different number of iBeacon devices. Per each topology, two classifiers are used to evaluate the accuracy of predicting the position of a student, based on the power levels measured for the iBeacon devices located in that classroom, which are the decision tree and random forest classifiers. All experiments are conducted using Weka data mining software [30] running on a Windows operating system using an Intel® Core™ i7-4500U CPU @2.40GHz and 8GB of memory. The power levels are logged using specially developed software runs on an Apple iPhone, where three measurements are logged per each position in the class. Students inside the classroom positioned close to the borders of the classroom have the highest probability of failing attendance registration. Moreover, students outside the classroom, positioned close its borders, to have the highest probability of registering attendance without being inside the classroom. Therefore, these regions are considered to be critical regions and powers are collected with a half meter resolution in order to increase the density of the collected measurements in those regions. These measures are collected for two different classes in Cankaya University with different dimensions, where 2Nolu Sedam has a width of 5.2 meters and a length of 7.84, while L113 has 7 meters width and 7.2 meters length, so that, the selected topology can be applied to classes of any dimensions.

4.1 Using One iBeacon Topology

In this experiment, a single iBeacon device is located at the center of the classroom, by dividing the length and width of the classroom by two and position the device at the calculated coordinates. Measurements are collected from inside and outside of the classroom, where the entire internal area of the classroom is scanned while only up to one meter far from the border of the classroom is collected from the outside. The classification results for both classrooms using the decision tree and random forest classifiers are shown in Table 4.1 and Table 4.2. The length and width of the classroom have been taken, and the iBeacon device is located in the center of the classroom as shown in Figure 4.1.

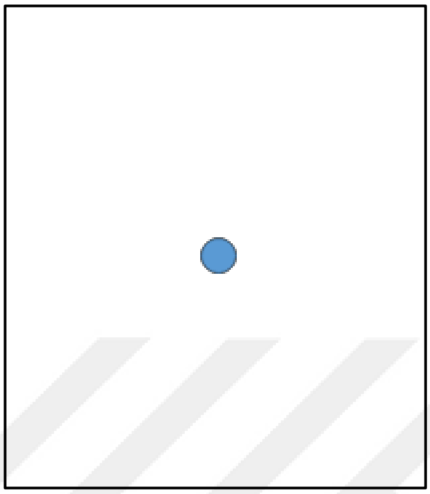

Figure 4.1: The Location of iBeacon Device in the one iBeacon Topology

Table 4.1: Classification results using one iBeacon device

Classifier	Classroom A			Classroom B		
	Accuracy	False Acceptance Rate	False Reject Rate	Accuracy	False Acceptance Rate	False Reject Rate
Decision Tree	64.04%	13.02%	59.25%	60.18%	40.07%	49.86%
Random Forest	65.35%	28.13%	41.27%	62.31%	41.52%	53.18%

Table 4.2: Summary of the average performance using one iBeacon device

Classifier	Accuracy	False Acceptance Rate	False Reject Rate
Decision Tree	62.11%	26.55%	54.56%
Random Forest	63.83%	34.83%	47.23%

4.2 Using two iBeacons Topology

In this experiment, the length of the classroom is divided by two in order to calculate the position of the two-iBeacon devices. Each device is located next to a wall with a distance between the devices equal to the width of the classroom.

4.3 Using three iBeacon Topology

The longer wall of the classroom is divided in half, where an iBeacon device is located on one wall at the calculated distance, while the remaining two are located on both corners of the opposite wall, as shown in Figure 4.3.

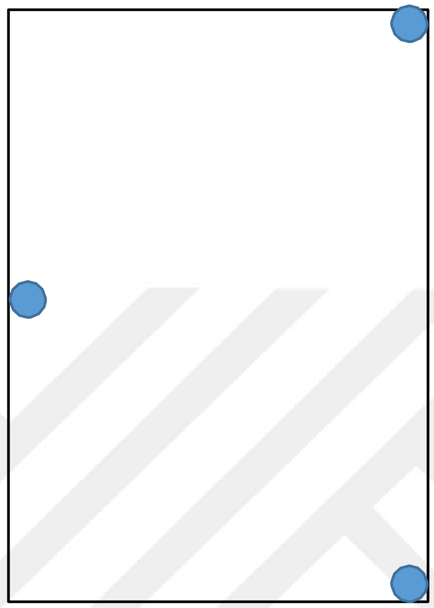

Figure 4.3: Distribution of iBeacon Devices in the three iBeacons Topology

Similar to other experiments, measurements are collected from inside and outside the classroom, where the entire inside area of the classroom is scanned while only up to one meter far from the border of the classroom is collected from the outside. The classification results of this experiment are shown in Table 4.5 and Table 4.6.

Table 4.5: Classification results using three iBeacon devices

Classifier	Classroom A			Classroom B		
	Accuracy	False Acceptance Rate	False Reject Rate	Accuracy	False Acceptance Rate	False Reject Rate
Decision Tree	89.90%	7.60%	13.49%	88.22%	12.51%	16.21%
Random Forest	99.66%	0.58%	0%	97.98%	0.87%	0.79%

Table 4.6: Summary of the average performance using three iBeacon devices

Classifier	Accuracy	False Acceptance Rate	False Reject Rate
Decision Tree	89.06%	10.06%	14.85%
Random Forest	98.82%	0.73%	0.40%

4.4 Using four iBeacon Topology

Four iBeacon devices are installed inside the classroom for this experiment, where every two devices are located in the middle of opposite walls, by dividing the length of those walls in half, as shown in Figure 4.4.

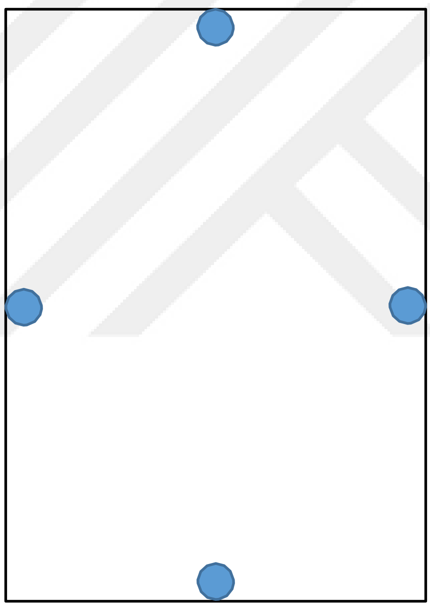

Figure 4.4: Distribution of iBeacon Devices in the four iBeacons Topology

Measurements are also collected for the entire classroom from the inside, with one-meter step size, except positions close to the borders, where measurements are also collected for a half-meter as well. From the outside of the classroom, measurements are collected with a half-meter resolution, up to one meter away from the border of the classroom. The classification results for this topology are shown in Table 4.7 and Table 4.8.

Table 4.7: Classification results using four iBeacon devices

Classifier	Classroom A			Classroom B		
	Accuracy	False Acceptance Rate	False Reject Rate	Accuracy	False Acceptance Rate	False Reject Rate
Decision Tree	98.43%	0.71%	0.03%	95.33%	0.93%	0.88%
Random Forest	100.00%	0.00%	0%	100.00%	0.00%	0.00%

Table 4.8: Summary of the average performance using four iBeacon devices

Classifier	Accuracy	False Acceptance Rate	False Reject Rate
Decision Tree	96.88%	0.82%	0.46%
Random Forest	100.00%	0.00%	0.00%

4.5 Evaluation of the Implemented Method

The implemented method is evaluated in one of the classrooms of the University of Cankaya (L112), with real case scenario, during a CENG114 Algorithm and Programming class, with the attendance of the supervisor of this thesis. The iBeacon devices are distributed in the class as shown in Figure 4.4. Students who have smartphones with the iOS operating system have installed the application implemented for this purpose, while a computer running the web application that receives the information from these devices in order to log them in the database is connected to the network, so that, it becomes reachable from the students' smartphone. The environment, where the experiment is conducted, is shown in Figure 4.5.

Figure 4.5: The classroom where the experiment is conducted.

Five students have registered new students’ accounts on the system using their smartphones, where the instructor of the class has created an account, where the system’s administrator assigns instructor role to that account. The instructor, then, has created a new course, with the name “CENG114 Algorithms and Programming II” and the instructor opens a registration session for the students. By the end of the class, the session is closed by the instructor and the registration summary, shown in Figure 4.6, is displayed to the instructor.

The information about the iBeacon devices, which are the minor, major and power values are also stored in the database, to make them available for any further investigations, in addition to all the attendance registration information, such as the students' IDs, date and time of the registration and a picture of each student in the class. The iBeacon devices have shown a very stable operation, and the server easily recognizes where the classroom those students are in, so that, the session opened in that class is used to register the attendance of the students. Moreover, none of the students have faced any challenges registering new accounts in the system, as well as registering their attendance in the class.

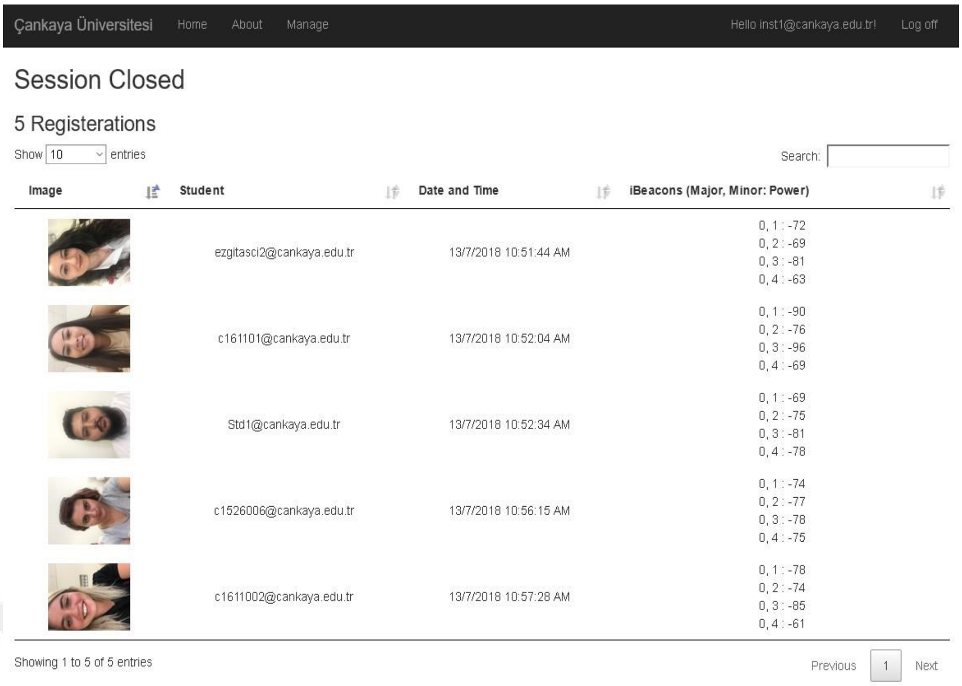

Figure 4.6: Registration summary shown to the instructor of the class after closing the session.

The power of the iBeacon devices collected by the students' devices is illustrated in Table 4.9. Classifying those students using the classifier trained with the data collected for the same classroom has shown 100% accurate predictions, where all students are predicted, by the classifier, to be inside the classroom. This results also support the hypothesis concluded earlier, that the use of four iBeacon devices per a classroom could produce 100% accurate predictions. A Comparison between similar studies associated with our study is shown in Table 4.10.

Table 4.9: The power of the iBeacon signals collected by the students' devices

Student Number	iBeacon Devices			
	1	2	3	4
1	-72	-69	-81	-63
2	-90	-76	-96	-69
3	-69	-75	-81	-78
4	-74	-77	-78	-75
5	-78	-74	-85	-61

Note: The numbers (1, 2, 3 and 4) refers to the iBeacon devices which existed in our study while the negative numbers refer to the iBeacon power which ranges between Major and Minor: Power

Table 4.10: Comparison between similar studies associated with our study

Study	**Feature**	**Explanation**	**Comparison**
S. Barapatre, et al. [7] **Zou, et al. [23]**	The use of web application to interact with the application installed on the smartphone.	The use of such approach eases the implementation of smartphones application regardless of the operating system they use, where the application is only required to access the web application in order to display the web pages related to required	The same approach is used in the proposed method, so that, implementing applications for smartphones that use an operating system other than iOS can be achieved easily in the future.
Lin, X. Y. et al. [21]	The student is notified about the result of the registration process after completing the entire process, regardless of the results of the operation to be	This approach increases the time required for students to achieve a successful registration, where the entire process is repeated in case of a failed attempt. Moreover, such an approach increases the load on the server, which requires more resources to handle all students.	In the proposed method, the registration is blocked directly if the student is detected to be outside the classroom, so that, the time required to complete a failed attempt is eliminated, which increases the efficiency of the proposed method on
Kumar, et al. [18]	A magic string is displayed inside the classroom in order to eliminate any fraudulent registrations.	The time required by students to capture the magic string and pass it to the server is time lost from the session. Moreover, the magic string can be forwarded by any student inside the class to other students to assist in fraudulent registrations. This approach	The use of four iBeacon devices has allowed the proposed method to distinguish the student inside the classroom from those outside it. Thus, no time is required to display such strings, which improves the time efficiency regarding the instructor's and students'
Lin, X. Y. et al. [21] **M. Hall, et al. [28]**	The reports displayed about the registrations include the students that have not registered in the class	Although such a report may not provide valuable information for the instructor at the classroom, these reports can be used to calculate the number of classes that a particular student has attended or missed.	As the proposed system works as a standalone service, the information about the students and the courses each student is enrolled in are missing. Thus, such reports cannot be generated, as the absent students are not known to the method because the enrolled users in a particular course are

5. CONCLUSION

The average performance of the classifiers in both classrooms using a single iBeacon device show that both classifiers have low performance, where the decision tree classifier scores accuracy of 62.11%, and the Random Forest scores 63.83%. Moreover, the ratio of the number of students that are able to register to the class, without being in the classroom, is 26.55% for the decision tree classifier and 34.83% for the Random Forest classifier, which show that it is possible to register from outside the classroom especially when students are very close to the borders of that classroom. The high ratio of students that are actually in the classroom and are not able to register to the class is extremely high, where the decision tree has 54.56% of legitimate registration attempts blocked, and the Random Forest has a ratio of 47.23%. Thus, such topology cannot be used to implement a method for that purpose.

Moreover, the average performance of the classifiers using two iBeacon devices show that the addition of the second iBeacon device has improved the performance of both classifiers, where the decision tree classifier has scored an accuracy of 76.41% and 89.61% for the random forest classifier. Although a significant improvement to the ratio of students that can register from outside the classroom has been seen in the random forest classifier, which has 10.57% false acceptance rate, this ratio is still high as specific behavior from the students may be employed to increase such rate.

The false rejection rate, which represents the ratio of legitimate registration attempts that are rejected by the classifier, has also improved and can be employed in such method, as students may find the most appropriate positions to accomplish their registrations. Furthermore, the results show that both classifiers, when three iBeacon devices are used in the classroom, have significant improvements in their accuracy, where the accuracy of the decision tree has improved to 89.06% and random forest to 98.82%. However, there is still a ratio of students, from outside the classroom that can register for the class, exists. Although this ratio is quite low in the random forest classifier, with only 0.73% of the collected measurements have gained access to registration, finding the exact spot that a registration can be achieved from outside the classroom increases that rate, where most of the students with the intention to register without attendance are going to register from that spot.

Finally, the use of four iBeacon devices has a perfect classification score with 100% accuracy, using the random forest classifier. Such accuracy indicates that none of the students from outside the classroom are going to be able to register their attendance to the class without being physically inside the class, which is a fundamental measure to the performance of the proposed method. Moreover, the 0% false rejection rate indicates that none of the students in the classroom are going to face any challenges registering their attendance, as long as they are physically inside the room, which increases the usability of the proposed method.

The rapid growth in smartphones usage, where the number of such devices per each person on the globe is rising, has allowed the employment of these devices in different applications. Students' attendance registration is one of the applications that may have benefited from such devices, where the traditional methods require efforts and time from both students and instructors. Moreover, the existing methods that are proposed to assist tracking the attendance of the students require designated equipment, which either requires expensive solutions to make this equipment highly available or require a longer time to process all the students in the classroom. The use of such methods also suffers from low efficiency in certain situations, where the number of students attending a class is wrongfully estimated, which may impose unneeded expenses or illegal distribution of the registration equipment. Thus, a more efficient method that relies on smartphones is proposed in this study to register the attendance of students in classes.

In order to provide a usable and efficient method, it is essential to distinguish students who are physically inside the classroom from those who are not, so that, it is not possible to register for attendance unless the student is actually in the classroom. For this purpose, indoor positioning technique, based on Bluetooth Low Energy (BLE) devices is used. Different distributions of the BLE devices are evaluated in this study; so that, students from outside the classroom are never allowed to register their attendance to the class, while students inside the classroom can easily register. A minimum of four BLE devices is required per each classroom to achieve that performance, where the accuracy of 100% is achieved using the random forest classifier, to classify students inside and outside the classroom.

Among many other possible implementations, the use of ASP.net using Model View Controller (MVC) architecture with C# programming language is the most flexible implementations, where the web services provided using such architecture is not dependent on the operating system of the smartphone device. In this case, the power levels of the signals transmitted by the BLE devices are measures by the smartphone, using the Bluetooth model on that device, and sent to the server. In case that the sent information is identical to the information stored in the database, the student is allowed to register to that class by providing the login credentials of that student. Moreover, an image of the student inside the classroom is required to be uploaded directly from the camera of the smartphone, to increase the security of attendance registration, where false registrations can easily be detected based on the uploaded images. The implemented method also can be easily attached to the existing services running on any service of a teaching facility, where information like students' names, credentials and courses can easily be retrieved, while the summary of the attendance registrations can also be quickly sent back to that server. Such integration allows the addition of the proposed method to the working systems without requiring any extra effort from the students, as well as instructors and administrators.

In future work, computer vision techniques are going to be tested to predict the authenticity of the registrations based on the images provided upon registrations, i.e., these techniques are going to be used to predict whether that uploaded image is actually taken inside the classroom or is uploaded using a software that uses stored images as camera images.

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EDUCATION

Degree	Institution	Year of Graduation
M.Sc.	Çankaya University	2018
B.Sc.	Al-Maa'ref University College	2007
High School	Anah	2002

WORK EXPERIENCE

Year	Place	Enrollment
2008	University of Anbar	Computer Programmer

FOREIGN LANGUAGES

Advanced English, Beginner Turkish

Appendix (A)

Classes Implemented in the Web Application

```
namespace CnkStd.Models
{
 public class CnkUser
 {
 public string Name { get; set; }
 public string ID { get; set; }
 public bool II { get; set; }
 }
 public class CnkUsers
 {
 public List<CnkUser> Users { get; set; }
 }
 public class Register
 {
 public int Id { get; set; }
 public string StudentName { get; set; }
 public virtual Session Session { get; set; }
 public DateTime? Time { get; set; }
 public bool Finished { get; set; }
 public string Extension { get; set; }
 public virtual List<Beacon> iBeacons {get; set;}
 }
 public class Beacon
 {
 public int Id { get; set; }
 public int Major { get; set; }
 public int Minor { get; set; }
 public int Power { get; set; }
 }
 public class Classroom
 {
 public int Id { get; set; }
 public string Name { get; set; }
 public int ClassType { get; set; }
 public int iBeacon1 { get; set; }
 public int iBeacon2 { get; set; }
 public int iBeacon3 { get; set; }
 public int iBeacon4 { get; set; }
 }
 public class ClassType
 {
 public int Id { get; set; }
 public string Name { get; set; }
 public double Width { get; set; }
```

```
public double Length { get; set; }
 }


 public class Session
 {
 public int Id { get; set; }
 public DateTime? Opened { get; set; }
 public DateTime? Closed { get; set; }
 public Classroom Classroom { get; set; }
 public virtual Course Course { get; set; }
 public bool Status { get; set; }
 }
 public class SessSum
 {
 public Session Session { get; set; }
 public int Cnt { get; set; }
 }
 public class Course
 {
 public int Id { get; set; }
 public string InstID { get; set; }
 public string Name { get; set; }
 public bool Open { get; set; }
 public int Classroom { get; set; }
 }
 public class Sessions
 {
 public List<Course> Open { get; set; }
 public List<Course> Closed { get; set; }
 public List<Classroom> ClassRooms { get; set; }
 public List<SessSum> Earlier { get; set; }
 public Sessions()
 {
 Open = new List<Course>();
 Closed = new List<Course>();
 ClassRooms = new List<Classroom>();
 Earlier = new List<SessSum>();
 }
 }
}
```

Appendix (B)

iBeacon Devices Information Collection Source Code for Mobile Devices

```
let knownBeacons = beacons.filter{ $0.proximity != CLProximity.unknown }
if (knownBeacons.count > 3) {
    for _beacon in knownBeacons{
        let bn = String(describing: _beacon.major)
        //let bp = String(format: "%.3f", _beacon.accuracy)
        let bp = String(describing: _beacon.rssi)
        let br = String(describing: _beacon.minor)
        let bt = bn+", "+br+", "+bp+";"
        r = r+bt
    }
    uu=r
        }
```

Appendix (C)

Classes Implemented in the Web Application

```
namespace CnkStd.Controllers
{
 public class SManagerController : Controller
 {
 public ActionResult Upload(HttpPostedFileBase file)
 {

 if (file != null && file.ContentLength > 0)
 {
 var context = new ApplicationDbContext();
 var F = context.Registerations.Where(f => f.Finished == false).ToList();
 int rr = int.Parse(Request.Cookies["RId"].Value.ToString());
 Register FF = context.Registerations.SingleOrDefault(r=>r.Id==rr);
 foreach (var r in F)
 if (r.StudentName == User.Identity.Name)
 {
 r.Finished = true;
 FF = r;
 }

 FF.Extension = Path.GetExtension(file.FileName);
 FF.Time = DateTime.Now;
 context.SaveChanges();

var fileName = Path.GetFileName(FF.Id.ToString() + Path.GetExtension(file.
FileName));
 var path = Path.Combine(Server.MapPath("~/uploads"), fileName);
 file.SaveAs(path);
 }
 return Redirect("/");
 }
 [Authorize]
 public ActionResult Index(string Id)
 {
 List<Beacon> Beacons = new List<Beacon>();
 foreach (string iBeacon in Id.Split(';'))
 {
 string[] IB = iBeacon.Split(',');
 Beacon ib = new Beacon()
 {
 Major = int.Parse(IB[0]),
```

```
Minor = int.Parse(IB[1]),
Power = int.Parse(IB[2])
};
Beacons.Add(ib);

}
List<Beacon> TopB = Beacons.OrderBy(b => b.Power).Take(4).ToList();
List<Beacon> CB = TopB.OrderBy(b => b.Minor).ToList();
List<int> MV = CB.Select(m => m.Minor).ToList();
List<Classroom> AC = new List<Classroom>();
var context = new ApplicationDbContext();
var AAC = context.Classrooms;
Classroom IC = new Classroom();
foreach (Classroom DD in AAC)
{
List<int> CMV = new List<int>();
CMV.Add(DD.iBeacon1);
CMV.Add(DD.iBeacon2);
CMV.Add(DD.iBeacon3);
CMV.Add(DD.iBeacon4);
if (MV.All(CMV.Contains))
IC = DD;
}
var ss = context.Sessions.Where(s => s.Status).ToList();
foreach (Session s in ss)
if (s.Classroom == IC)
{


Register ff = new Register() { Session = s, StudentName = User.Identity.Na
me, Finished = false };
ff.iBeacons = CB;
context.Registerations.Add(ff);
context.SaveChanges();
Response.Cookies["RId"].Value = ff.Id.ToString();
return View(s);
}
return Redirect("/");

}
}
}
```