Design and Implementation Proximity Based IoT for Smart Attendance System

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ABSTRACT

The reporting of course attendance is an essential component of academic administration. The inconsistent attendance of students is a crucial problem since their academic achievement may be adversely affected by their absence. Thus, student attendance must be recorded, but manual note-taking is ineffective because it takes much time. In addition, manual attendance records have complex documentation processes and are riskier due to the ease of falsifying attendance records. This study designs and deploys a smart attendance system by leveraging proximity-based IoT. The smart attendance system comprises an Android application that acts as a user interface, a beacon Bluetooth Low Energy as a proximity sensor, and a cloud server as a backend system; all are integrated with IoT network technology. The application supports three different features designated for administrators, lecturers, and students. Furthermore, this study conducts a field test by sampling students enrolled in a course. The test involves a range of mobile devices to access the application connected to two courses. In one course, the functionality testing result is 91.67%, while in another, it is 100% successful. This deployment successfully accelerates data input for the campus administrator and records the course log efficiently.

1. Introduction

Attendance reporting for lectures is a crucial element of academic administration. This documentation of attendance applies to lecturers and students. Some campuses require lecturers to report their attendance and keep a course logbook. Regarding students, attendance is a requirement for academic performance assessment. The irregular attendance of students is a primary concern for educational institutions. Students' absence may negatively impact their academic achievement (Shah & Abuzneid, 2019). Certain educational institutions continue to implement policies defining minimum student attendance requirements to be eligible for exams. Students who do not satisfy the minimum attendance requirement are not eligible to take the exam.

In the meantime, the majority of lecturer and student attendance is still recorded manually. Each student who participates in the course and the lecturer who delivers the course contribute their corresponding attendance records. When the class size is very large, this manual note-taking condition is ineffective because it requires a considerable amount of time (Ramani et al., 2023). In addition to adding complexity to the documentation process, manual recording is comparatively risky due to the ease with which students can falsify attendance records (Zoric et al., 2019).

In order to address the aforementioned issues, a digital system for documenting attendance is required. Many researchers have attempted to digitize attendance records through the development of Internet of Things (IoT) applications (Teran et al., 2017). Furthermore, IoT has been adopted to solve many problems regarding the reporting system (Hayati et al., 2021), tracking attendance (Abdulkareem, 2018), and monitoring system

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(Nugraha et al., 2018). The IoT has also been widely adopted in the industrial sector (Rahmawati et al., 2022), medical usage (Hayati et al., 2017), and academic (Hake et al., 2022). Nonetheless, optimization remains necessary as a result of the technology's chosen characteristics.

Some researchers have conducted further studies regarding smart attendance applications utilizing proximity-based methods. A study. A study conducted by Apoorv and Mathur introduced a solution for efficiently managing attendance using Bluetooth technology with minimal energy usage and the Android platform. The system comprises an identification card that is equipped with a beacon stamp. This card is then integrated with an Android application, which enables lecturers to record student attendance and manage student information (Apoorv & Mathur, 2016). This technique is vulnerable when a student's identity card is entrusted to a peer, as students do not physically verify their attendance. In 2022, Hake et al. built an attendance management application that employs proximity detection to recognize students and document their attendance. The beacon technique uses scanning to efficiently detect individuals and determine their identity by utilizing the unique ID in their mobile devices, thereby documenting their existence (Hake et al., 2022). Regrettably, the platform does not possess a feature that enables professors to furnish details regarding specific announcements. Another study by Kumar et al. introduced an attendance system that utilizes Beacon Bluetooth Low Energy (BLE) technology. This system lets students record their attendance using Android devices (Kumar et al., 2016). Nevertheless, the attendance system exclusively pertains to students. Thus, this study enhances existing solutions by incorporating functionality to record lecturer attendance, additional features to deliver information services from lecturers to all students, and connecting with Internet of Things (IoT) technology.

This study develops and implements a smart attendance system utilizing proximity-based IoT. By adopting this methodology, digital attendance is executed to enhance simplicity, efficiency, and security. The developed application simplifies data entry for the campus administrator. This system is capable of automatically recording course activity log data and attendance information for all students based on the number and time of available courses. Next, the system's effectiveness is concerning to how easily lecturers and students use it. Lecturers are not required to register students individually. Compared to digital attendance utilizing fingerprinting, the efficiency of proximity-based is that students do not need to form a queue to record their attendance. Lastly, the solution for this attendance system is also more secure because each application installed on the user's device has a single identity, which minimizes attendance manipulation.

The remaining sections of the paper are structured as follows: Section II explains the literature review and underlying theory of beacon. Section III describes the proposed method of proximity based IoT for smart attendance system, and Section IV presents the result and discussion of the implementation system. The last section, Section V, concludes the study.

2. Literature Review

2.1. *Literature Review*

(Kumar et al., 2016) develope a module to facilitate the tracking and monitoring of student attendance based on Bluetooth low energy (BLE). Their study compares the analysis of beacons about radio frequency identification (RFID), near-field communication (NFC), and fingerprint technologies. RFID is deemed unsuitable for tracking and monitoring because the technology requires the reader to be present to access the information stored in the RFID (Shah & Abuzneid, 2019). Then, implementing smart attendance using the RFID needs a substantial number of readers, hence rendering it inefficient. In addition to this, the efficiency of RFID technology depends on the quality of the RFID tag or card, the reader, and the proximity maintained between RFID card and the reader (Miao et al., 2020). Meanwhile, the use of NFC to track and monitor student attendance is restricted by a limited range since the NFC range reaches only 10 centimeters. NFC also has very low-speed data transfer;

it is up to 424 kilobits per second. Thus, the utilization of NFC for transferring substantial quantities of data is deemed inappropriate. In addition, tracking and monitoring of student attendance could be done utilizing fingerprints, yet it is high cost and susceptibility to reading inaccuracies.

In 2015, Noguchi et al. developed an attendance system utilizing beacons. The design requires an integrated circuit (IC) implanted in a student's identification card. During the simulation at Ibaraki University in Japan, each student's identification card is equipped with an IC implant to facilitate attendance tracking. However, this system has a limitation since students are required to physically tap or attach their cards to the scanner in order to gain access. Naturally, this process is time-consuming when each student needs to tap individually. Hence, the study developed a synchronous attendance system that enables concurrent participation, allowing all students to record their attendance concurrently (Noguchi et al., 2015).

Apoorv & Mathur introduced a novel system for managing attendance that utilizes Bluetooth with low energy consumption and the Android platform. Every student identification card is affixed with a beacon stamp. The infrared movement detector calculates the number of students attending a learning environment. Their studies created an Android app designed explicitly for lecturers. The Android applications receive the data via a Bluetooth device connected to each detector. The app allows the lecturer to record student attendance, manage student information, access their class timeline, and receive warnings for students with insufficient attendance (Apoorv & Mathur, 2016). This system is vulnerable when a student's identity card and stamp are given to a buddy, as students do not personally take attendance.

Kumar et al. presented an attendance system based on Beacon BLE. The system allows students to report their attendance using Android devices. The student must download and install an application designed to generate automated attendance. After installing the application on their Android device, the student needs to register. Once the student completes the registration, a notification requesting approval to activate Bluetooth will appear. Once Bluetooth is activated, the mobile device will communicate with the beacon signal, ultimately generating the attendance record (Kumar et al., 2016). However, the attendance system only applies to students, while lecturers can examine the attendance report.

In 2017, Okamotio et al. investigated the transition from image processing to Bluetooth Low Energy in advertising techniques. They discovered that the use of image technology to identify consumers in a store has several drawbacks, including the difficulty in obtaining customer attributes that are used to determine the type of advertising that will be displayed. The reason for the high error rate in image processing is that it is a detection process rather than a certainty identification procedure. Aside from that, image processing could operate with greater precision, particularly when the client's face is concealed, as with a scarf or disguise. As a result, the author suggests a method of advertising that employs BLE beacons. This study concludes that it is possible to acquire a larger quantity of attributes. A total of 52 individuals participated in the author's experiments: 19 men and 33 women. An investigation utilizing image processing to determine gender yielded the following results: seventeen men and twenty-seven women were identified. Upon employing the beacon, a total of 18 males and 31 females were located. The analysis of this data revealed that beacons exhibit superior gender identification capabilities in comparison to image processing (Okamoto et al., 2017). However, this study needs further investigation to ascertain the efficacy of beacon technology in the realm of advertising. In this investigation, beacon advertising did not replicate the extent to which the advertisement reaches users.

In 2022, Hake et al. deployed an attendance management app that utilizes proximity detection to identify users and record their presence. The beacon technique effectively uses scanning to detect individuals and ascertain their identity using their distinct ID stored in their mobile devices, recording their presence. The application offers configurable settings based on the user's preferences, enabling the user to participate in, create, and observe events. Unfortunately, the platform lacks a function that allows lecturers to provide information about specific announcements. Additionally, it does not disclose any details about its server, such as whether it is local or cloud-based (Hake et al., 2022).

2.2. *Beacon: IoT Proximity Sensor*

Beacon is a communication protocol that utilizes Bluetooth Low Energy (BLE) transmission media to distribute information. Beacons are capable of providing activity sensing, localization technology, and proximity detection. The application of localization to beacons addresses the deficiencies of RFID, Wi-Fi access points, and GPS. (Jeon et al., 2018)

The detection accuracy of proximity beacons surpasses that of alternative technologies. Beacons possess the ability to discern proximity within a range of 2 to 100 meters. It is wider than NFC, which has an interaction distance of a mere 10 to 20 cm. At a predetermined distance, the output generated by proximity detection of the Beacon may initiate a command in response to the user's interaction with the detected object. Additionally, Beacon can identify any device that has a Bluetooth connection active. (Jeon et al., 2018)

(Menon et al., 2017) state that the Beacon module utilizes energy more economically and efficiently. Automatically, BLE on Beacon will establish a regional signal area. Upon the entrance of a BLE-enabled device into the Beacon location, the Beacon will transmit a signal to the targeted device. The convenience of placement of beacons on any surface is attributed to their small size and simplicity.

Beacons operate by emitting signals continuously whenever a device reaches its designated range. A series of codes transmitted by the Beacon will determine the action of the device. Each device that is actively using Bluetooth is regarded as an additional beacon (Kim et al., 2018).

The beacon type utilized in this study is Cubeacon. Cubeacon Card utilizes the nRF52832 device from Nordic Semiconductor (Eyro Digital Teknologi, 2016a). It is equipped with programmable iBeacon firmware parameters, including but not limited to the UUID, major value, and minor value. Cubeacon has its own mobile backend as a service (MBaaS), Mesosfer. The Cubeacon MBaaS offers an integrated cloud server that enables applications to control each Beacon and construct scenarios, monitoring points, and geofencing (Eyro Digital Teknologi, 2016b).

3. Reseacrh Method

This study designs and implements an application of a smart attendance system applied in the university. The application has three different features privileged for administrators, lecturers, and students. Administrators manage the application to support many courses. The application possessed by the lecturer can notify each student regarding any announcements, including the rescheduling of lectures. Lecturers are also able to observe students who attend their classes. In the meantime, the student application can be utilized to receive the notification and access their daily course schedules.

3.1. *Application Requirement*

This study identifies that there are four requirements needed to build the smart attendance application. The requirement is specified as follows:

1. Beacon: This study employed Cubeacon cards, which function as beacons as well as proximity sensors. Unbiased user IDs (UUIDs) are assigned to each Cubeacon card and can be configured to synchronize with the mobile application and server. By mounting the Cubeacon card to the classroom wall, mobile applications that have been installed can connect to the proximity sensor through a Bluetooth connection.
2. Transmission media: The IoT smart attendance application is integrated using two transmission media: an Internet connection and Bluetooth Low Energy. Beacons and mobile devices utilize Bluetooth as media for communication. The mobile device subsequently acquires the beacon identity information

transmitted by Bluetooth. Meanwhile, the internet connection facilitates the data transmission between the cloud server and the mobile device application, and vice versa. In order to access the database and other parameters stored on the cloud server, the mobile device must be connected to the internet.

3. Mobile device: The mobile device serves as both an end user for application installation and a gateway for data redirection to the cloud server. As a user-end device, we determined that the type of operating system used on the mobile device is Android. Additionally, the mobile device in use must have a minimum BLE version of 4.0. By default, devices running Android OS Jellybean version 4.2 already have access to BLE. Therefore, we intended for the smart attendance application to be installed on an Android device running Jellybean 4.2 or later.
4. Cloud server: The cloud platform utilized in this study is cloud of Mobile Backend as a Service (MBaaS). MBaaS integrates the capabilities of a mobile application, sensor, and IoT connections. MBaaS facilitates authentication, communication, storage, and protocol integration for cloud servers. We configure the integration of the cloud database with our custom applications. Lecturer, course, classroom, schedule, and user identity information are all contained in the database. MBaaS is outfitted with the MBaaS SDK, which enables the development of synchronous applications that utilize its services. The libraries included in the MBaaS SDK facilitate simplified database management through a mobile application using MBaaS.

According to the mentioned requirements above, we visualize the topology diagram of the proposed application system. Figure 1 depicts the topology of our proposed system.

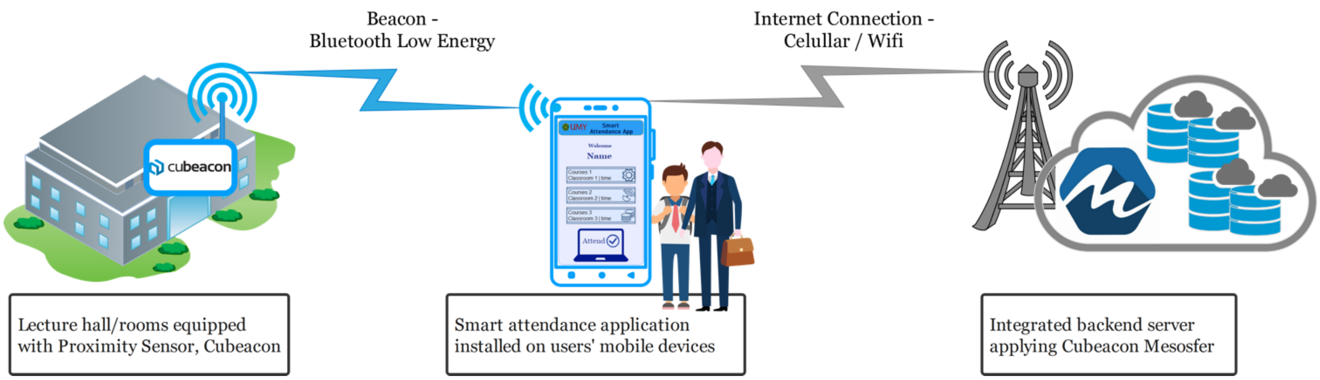


Figure 1. Proposed topology diagram

3.2. *Use Case Diagram*

This study uses a unified modeling language (UML) standard to describe the program design. We map the relationship between an application and a user called an actor using use case diagrams. According to our preliminary study, the use case diagram of the proposed smart attendance application is portrayed in Figure 2. Further, the details of the use case diagram are presented in Table 1.

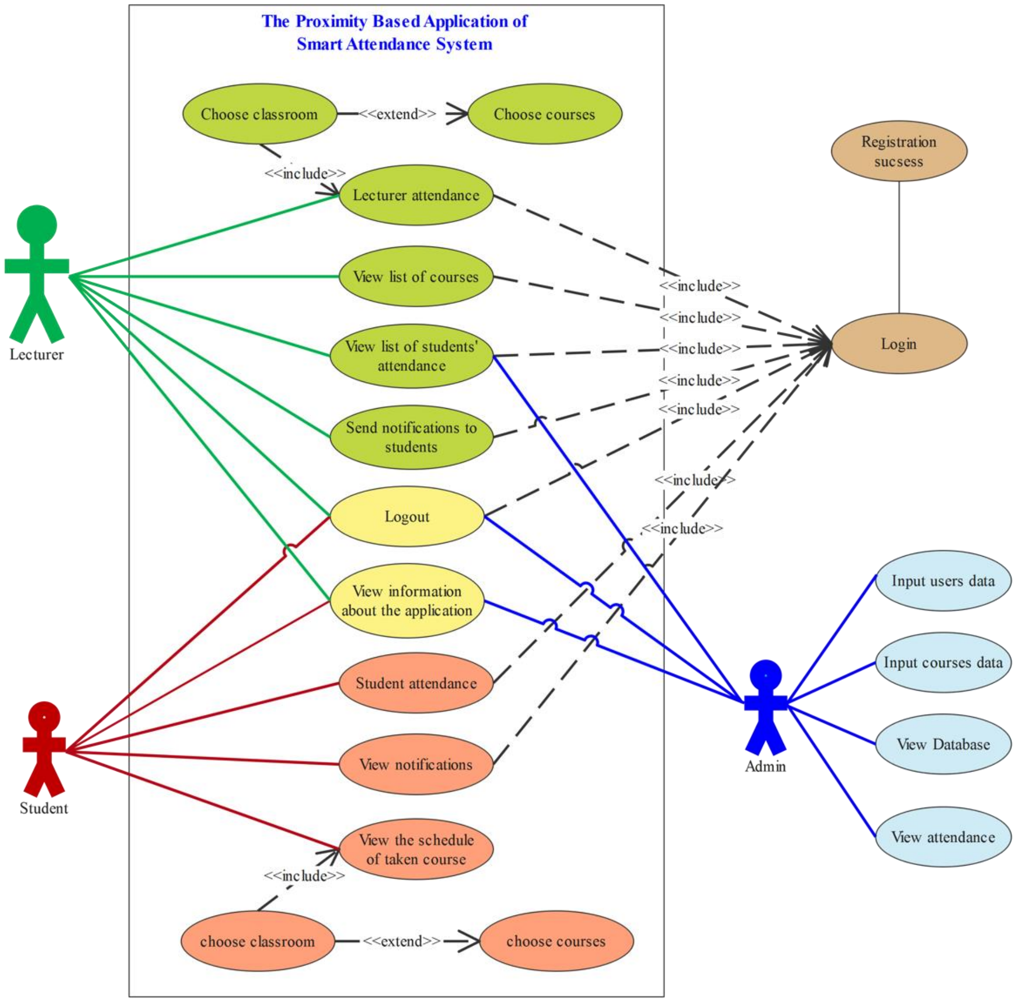


Figure 2. Use Case Diagram of Proposed Proximity Based Smart Attendance Application

Table 1. Details of the Use Case Diagram

Action Name	User	System
Introduction	An introduction to the application will be provided to users, encompassing the application's title, logo, and supporting entities.	In order to present the introduction, the system runs a class program by employing the commands.
Option	The user selects the role (lecturer or student).	The system will document the user's decisions. Each of these alternatives has its system.
Login	The user enters their email address and password.	The system transmits email and password information to the MBaaS server, which verifies the correspondence between the provided email and password and the database.
Main Page	Users are able to access the application's primary view. Color distinctions are made between the appearances of lecturers and students. In terms of functionalities, lecturers are equipped with a mobile notification system.	Once the information inputted during the login process is validated against the database, the application will proceed to the main display.

Action Name	User	System
View the Beacon Detected Rooms	Users are able to examine a list of adjacent rooms.	Each room will be equipped with beacons that emit a signal containing information pertaining to the beacon ID. In order to process the ID, the application verifies it in the database. The room name associated with that ID will subsequently be displayed within the application.
View the List of Courses in the Selected Room	Courses that are currently being taught and those that have yet to commence are displayed to users.	Utilizing a database retrieved in accordance with the Beacon Identity, the system shall exhibit the course schedule for that particular room.
Take the Attendance	Following course selection, students will complete an attendance procedure.	The system will evaluate the chosen courses by applying two indicators: time and the appropriateness of the course. Students are permitted to take attendance for the first fifteen minutes of the class. It is prohibited otherwise. Students who are eligible for taking attendance are those who are enrolled in the relevant courses.
View the Course Schedule	The weekly lecture schedule is accessible to users.	The system will retrieve data regarding the lecture schedule from the lecture schedule database.
View about the Application	Users are able to access profiles that detail the application, the developer team, and any supporting parties.	The system will present the application, developer, and supporting entities.

3.3. *Database Design*

The database used in the smart attendance application is MBaaS. The back-end MBaaS provides an application programming interface and storage of the database. The database contained in MBaaS includes student and lecturer identities, courses, lecturer halls/rooms, and an attendance database. Figure 3 shows the database entity relationships used to build the application.

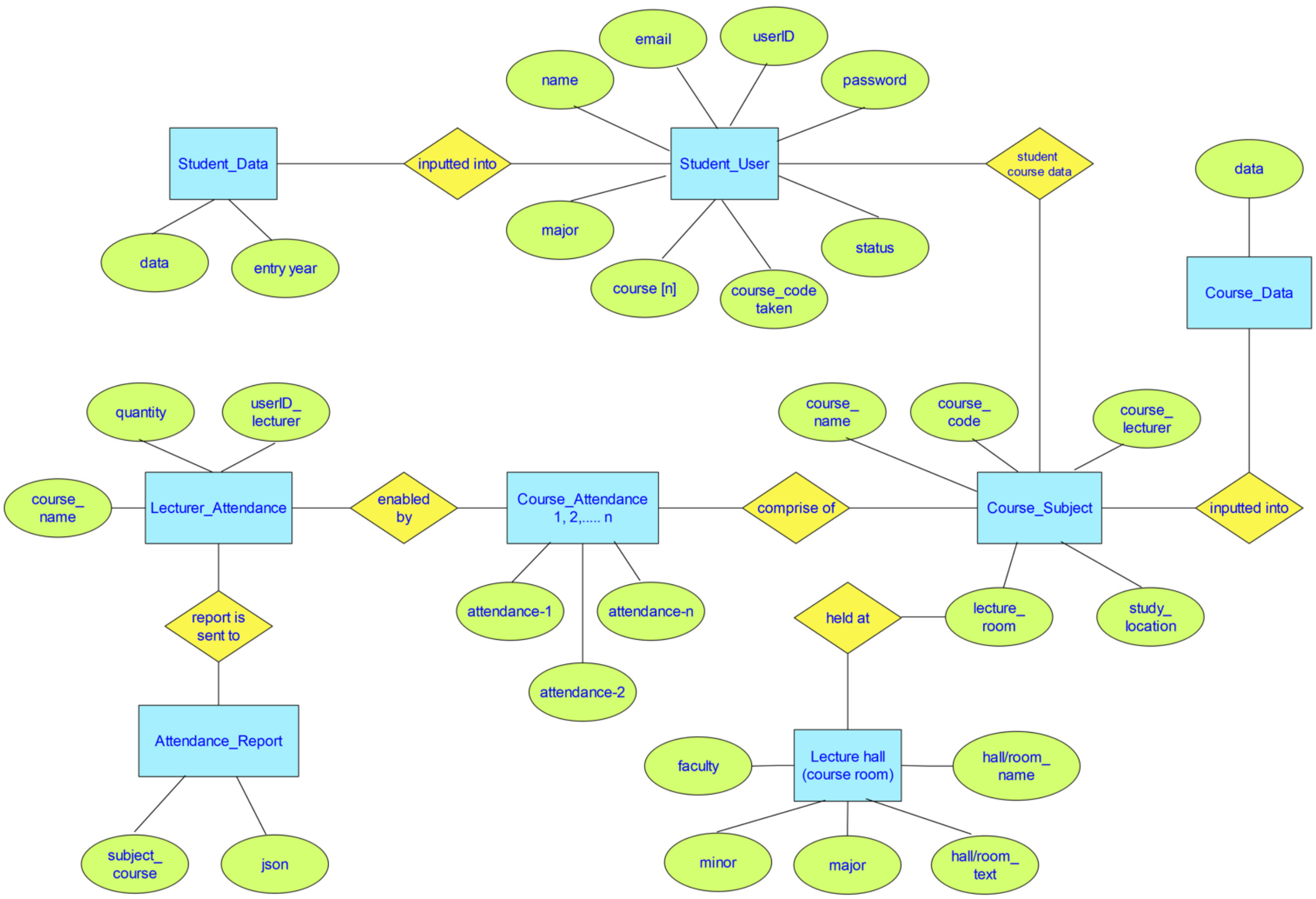


Figure 3. Database entity relationship

In line with the entity relationship diagram presented before, we construct specific tables that are used to clarify the database of the smart attendance application.

Table 2. Student Data

No	Attribute Name	Variable	Data Type
1	Student data (in JSON)	Data	string
2	Entry year	Entryyear	string

Table 3. Student User

No	Attribute Name	Variable	Data Type
1	Student/Lecturer ID	userId	string
2	First Name	Firstname	string
3	Last Name	Lastname	string
4	Email	Email	string
5	Password	Password	string
6	Major	Major	string
7	Status	Status	string
8	Course Code Taken	course[n]	string

Table 4. Course Data

No	Attribute Name	Variable	Data Type
1	Course Subject Data	Data	string

Table 5. Course Subjects

No	Attribute Name	Variable	Data Type
1	Course Name	courseName	string
2	Get Course Name	courseNameGet	string
3	Course Code	courseCode	string
4	Course Lecturer	courseLecturer	string
5	ID Course Lecturer	courseLecturerId	string
6	Day	Day	string
7	Time	Hour	string
8	Room	Room	string
9	Lecture Room	Classroom	string

Table 6. Lecture Halls

No	Attribute Name	Variable	Data Type
1	Room / Hall Name	roomName	string
2	Room / Hall Name Text	roomNameText	string
3	Faculty	Faculty	string
4	Location	buildingLocation	string
5	Major	Major	string
9	Minor	Minor	string

Table 7. Student Attendance

No	Attribute Name	Variable	Data Type
1	Student Name	userName	string
2	Student ID	userID	string
3	Course	Course	string
4	Attendance-n	Attendance1-n	string
5	RSSI	Rssi	string
6	Transmission Power	Txpower	string
7	Range	Range	string

Table 8. Lecturer Attendance

No	Attribute Name	Variable	Data Type
1	Lecturer ID	userLecturer	string
2	Course Code	courseCode	string
3	Course Name	courseName	string
4	Number of Meeting	Quantity	string

No	Attribute Name	Variable	Data Type
5	Couse Entry Code	entryCode	string
6	Date of Course Meeting	dateOfMeeting(n)	string

Table 9. Attendance Report

No	Attribute Name	Variable	Data Type
1	Course Name	Course	string
2	Attendance Report Data (in JSON)	Json	string

3.4. *Interface Design*

This study uses graphical tools to create the layout of the designed application. The present study employs graphical software to develop the application's layout. A total of six main layouts compose the smart attendance application. The application's homepage, comprising user identification, the daily course schedule, and an attendance icon, is depicted in Figure 4 (a). The navigation drawer illustrated in Figure 4 (b) comprises an identity and various options, such as a menu for viewing the lecture schedule, information, and the ability to log out. As shown in Figure 4 (c), the layout list exhibits a list of identified rooms along with the corresponding course within the chosen room. The confirmation display which appears when the user records attendance is depicted in Figure 4 (d). Figure 4 (e) shows the layout when attendance is recorded successfully and data entry is complete. Lastly, figure 4 (f) depicts a display of notifications received by students that the lecturer had previously sent. The layout overview of the appearance of the smart attendance application is provided below.

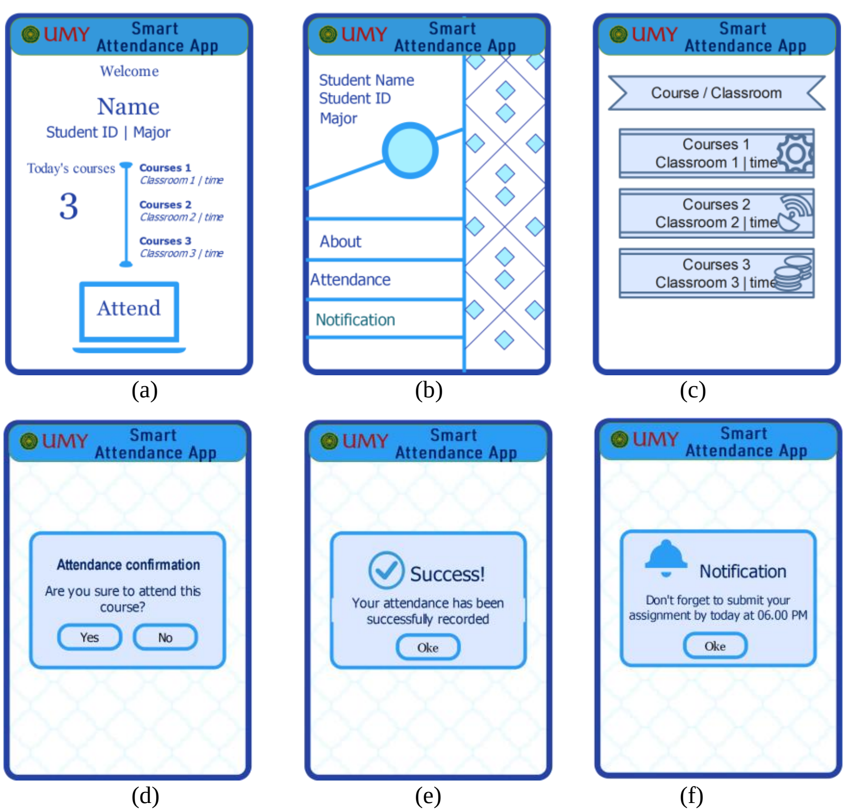


Figure 4. Interface design of the smart attendance application

4. Result and Discussion

This section explains the implementation of the smart attendance application, followed by an analysis of the experimental results. Section 4.1 discusses the implementation scenario that incorporates Android operating system-based mobile applications and database service. Section 4.2 discusses the result of the experiment in a specific classroom environment.

4.1. *Implementation of Proximity Based for Smart Attendance*

The smart attendance application was developed incorporating the following features:

1.) By utilizing an Android device integrated with the IoT transmission media, the application facilitates attendance management, surpassing the efficiency of traditional paper-based systems.
2.) Depending on the courses they teach, lecturers have access to the teaching timetable.
3.) Students can view the class schedule based on the courses they have taken on the online course selection sheet.
4.) All students enrolled in a course may receive notifications from the lecturers.

4.1.1. *Smart Attendance Application*

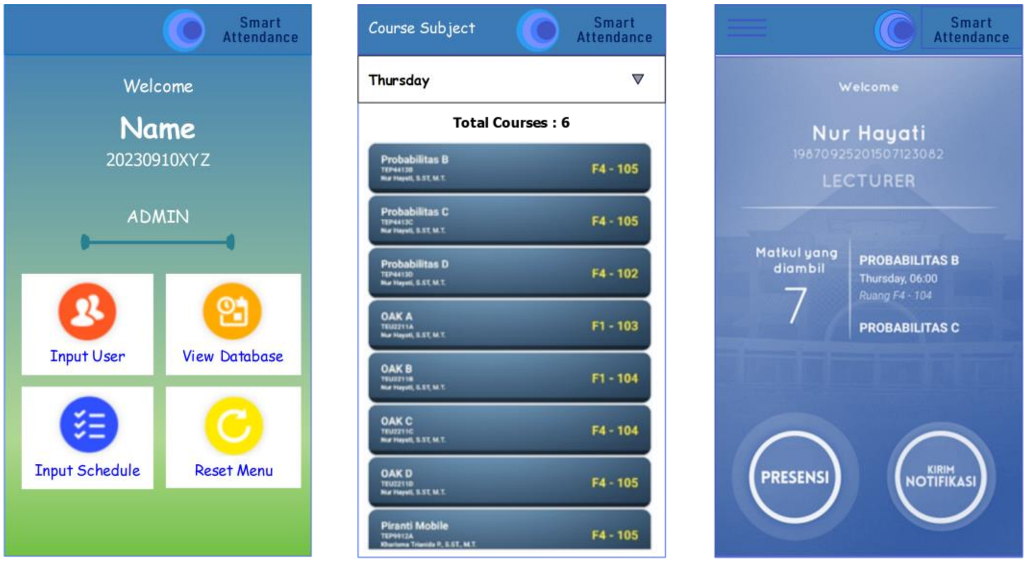
A smart attendance application developed in this study is an Android operating system-based mobile application. The application is intended to run on Android operating systems ranging from 4.3 (Jellybean) to the most recent version of Android. The application is classified into three distinct user modes: administrator, lecturer, and student. Particularly, a page that exhibits class schedules and profiles is accessible in all modalities. Prior to accessing each mode, the Android device will execute multiple systems. Upon execution, the application verifies the user's session to determine if they have signed in previously. If the check results indicate that the user has previously logged in, the system verifies the user's classification as an administrator, student, or lecturer. Figure 5 presents certain parts of the developed smart attendance application.

The following are the software specifications that were utilized in the development of the smart attendance application.

1.) Operating System: Windows 10 64-bit Software
2.) Programming Languages: Java and XML
3.) Development Software: Android Studio 2.3.3
4.) Java SDK: Android Development Tools V. and Android SDK Platform-tools Rev.
5.) Database: MBaaS Cloud

Further, the hardware specifications used are as follows:

1.) Asus N46VZ
2.) Core i7 Gen 3 (codename: Ivy Bridge) 3630QM 2.40 GHz
3.) 8GB RAM



(a) (b) (c)

Figure 5. Smart Attendance Application (a) Administrator main page (b) Display of the course list (c) Lecturer main page

4.1.2. *Database Implementation*

Upon launching the application, the subsequent procedure involves the installation and administration of the database. The database utilized in the proximity-based smart attendance application within this study is MBaaS. The integration of the MBaaS database with Android is facilitated by the MBaaS Software Development Kit (SDK), hence simplifying the data processing between the Android platform and the database for developers. Aside from the MBaaS SDK, there is also the Cubeacon SDK, which integrates applications and beacons with program techniques.

An essential component for establishing a connection between Android devices and the database is the MBaaSApp.java class, which is responsible for initiating the API key from MBaaS. Figure 6 exhibits the MBaaSApp.java snippet code.

```
package com.umy.ProjectnyaAdit.All;

import android.app.Application;
import com.eyro.cubeacon.*;
import com.eyro.mesosfer.Mesosfer;

public class MesosferApp extends Application {
    @Override
    public void onCreate() {
        super.onCreate();

        // set Cubeacon SDK log level to verbose mode
        com.eyro.cubeacon.Logger.setLogLevel(LogLevel.VERBOSE);

        // enable background power saver to save battery life up to 60%
        Cubeacon.setBackgroundPowerSaver(true);

        Cubeacon.initialize(this);

        Mesosfer.setPushNotification(true);

        // initialize Mesosfer SDK
        Mesosfer.initialize(this, "MrKJXn89XH", "v6LS5MpMsqbIQ1Qbj5vUyl8cnKDVk9PG");


        // initialize Cubeacon SDK



    }
}
```

Figure 6. The snippet code of the MesosferApp.java

The MBaaS API key is made up of an Application ID and an Application Key. This API key is accessible via the Application menu in MBaaS. A unique API key will be assigned to each user. The following is the API key that the presence application utilizes.

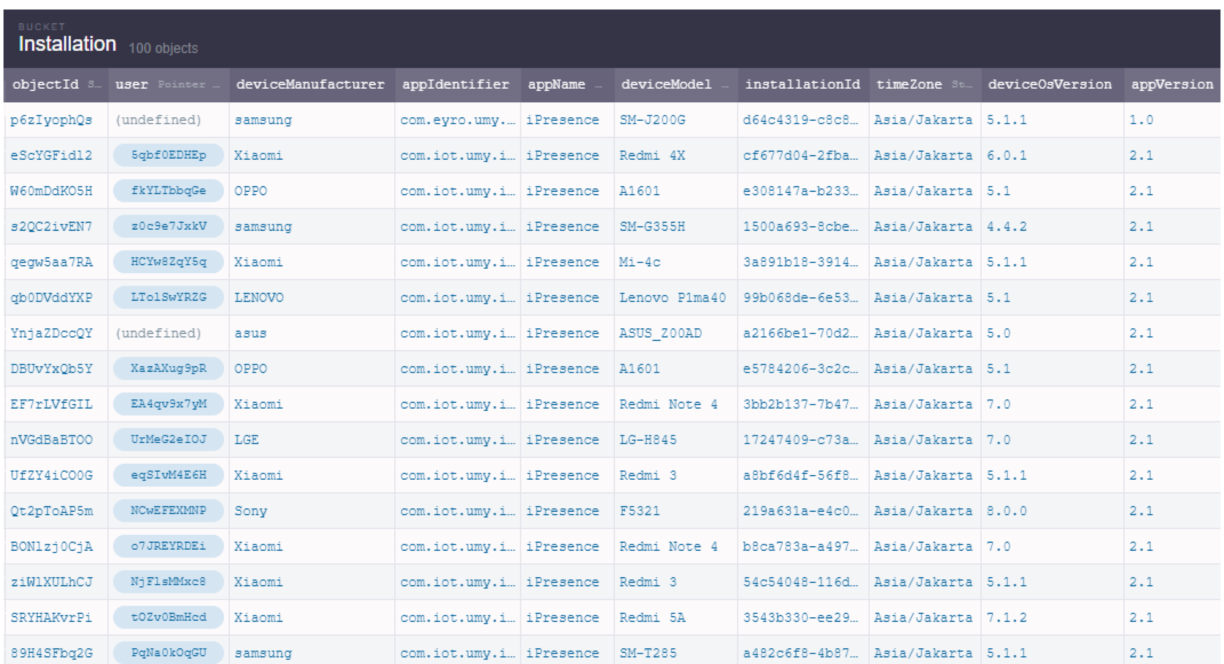
1.) Application ID: MrKJXn89XH
2.) Application Key: v6LS5MpMsqbIQ1Qbj5vUyl8cnKDVk9PG

The database comprises a record of all devices that have successfully installed the smart attendance application. Table 13 provides the list of database variable installations.

Table 10. List of database variable installations.

No	Attribute Name	Variable	Data Type
1	Object ID	objectId	string
2	Object ID User	user	pointer
3	Device Brand	deviceManufacturer	string
4	Bundle Project Name	appIdentifier	string
5	Application Name	appName	string
6	Model Device	deviceModel	string
7	Installation identity	installationId	string
8	Time Zone	timeZone	string
9	Android Series	deviceOsVersion	string
10	Application Series	appVersion	string

The primary purpose of the installation database is to determine the specific device employed by the user. The user variable within the Installation database specifies the objectId that is stored in the User database. Thus, it is possible to figure out the identity of individual users' devices. A sample of information taken from the database installation is shown in Figure 7.


BUCKET
Installation 100 objects

objectId S…	user Pointer …	deviceManufacturer	appIdentifier	appName …	deviceModel …	installationId	timeZone St…	deviceOsVersion	appVersion
p6zIyophQs	(undefined)	samsung	com.eyro.umy.…	iPresence	SM-J200G	d64c4319-c8c8…	Asia/Jakarta	5.1.1	1.0
eScYGFidl2	5qbf0EDHEp	Xiaomi	com.iot.umy.i…	iPresence	Redmi 4X	cf677d04-2fba…	Asia/Jakarta	6.0.1	2.1
W60mDdKO5H	fkYLTbbqGe	OPPO	com.iot.umy.i…	iPresence	A1601	e308147a-b233…	Asia/Jakarta	5.1	2.1
s2QC2ivEN7	z0c9e7JxkV	samsung	com.iot.umy.i…	iPresence	SM-G355H	1500a693-8cbe…	Asia/Jakarta	4.4.2	2.1
qegw5aa7RA	HCYw8ZqY5q	Xiaomi	com.iot.umy.i…	iPresence	Mi-4c	3a891b18-3914…	Asia/Jakarta	5.1.1	2.1
qb0DVddYXP	LTolSwYRZG	LENOVO	com.iot.umy.i…	iPresence	Lenovo P1ma40	99b068de-6e53…	Asia/Jakarta	5.1	2.1
YnjaZDccQY	(undefined)	asus	com.iot.umy.i…	iPresence	ASUS_Z00AD	a2166be1-70d2…	Asia/Jakarta	5.0	2.1
DBUvYxQb5Y	XazAXug9pR	OPPO	com.iot.umy.i…	iPresence	A1601	e5784206-3c2c…	Asia/Jakarta	5.1	2.1
EF7rLVfGIL	EA4qv9x7yM	Xiaomi	com.iot.umy.i…	iPresence	Redmi Note 4	3bb2b137-7b47…	Asia/Jakarta	7.0	2.1
nVGdBaBTOO	UrMeG2eIOJ	LGE	com.iot.umy.i…	iPresence	LG-H845	17247409-c73a…	Asia/Jakarta	7.0	2.1
UfZY4iCO0G	eqSIvM4E6H	Xiaomi	com.iot.umy.i…	iPresence	Redmi 3	a8bf6d4f-56f8…	Asia/Jakarta	5.1.1	2.1
Qt2pToAP5m	NCwEFEXMNP	Sony	com.iot.umy.i…	iPresence	F5321	219a631a-e4c0…	Asia/Jakarta	8.0.0	2.1
BONlzj0CjA	o7JREYRDEi	Xiaomi	com.iot.umy.i…	iPresence	Redmi Note 4	b8ca783a-a497…	Asia/Jakarta	7.0	2.1
ziWlXULhCJ	NjFlsMMxc8	Xiaomi	com.iot.umy.i…	iPresence	Redmi 3	54c54048-116d…	Asia/Jakarta	5.1.1	2.1
SRYHAKvrPi	tOZv0BmHcd	Xiaomi	com.iot.umy.i…	iPresence	Redmi 5A	3543b330-ee29…	Asia/Jakarta	7.1.2	2.1
89H4SFbq2G	PqNa0kOqGU	samsung	com.iot.umy.i…	iPresence	SM-T285	a482c6f8-4b87…	Asia/Jakarta	5.1.1	2.1

Figure 7. A sample of database installation applied for smart attendance.

The first and seventh Object IDs in the 'User' database are devoid of a user identity, as the individual who installed the application effectively on the mobile device either did not log in or was unable to log in. The device was, therefore, unidentified. Upon successful registration and login, the user column will be updated to contain the objectId obtained from the 'User' database.

Additionally, a bucket installation is necessary for the database implementation. Except for user and notification data, a bucket database comprises every table in its structure. The bucket database is a MBaaS feature that enables developers to create tables based on their requirements. The smart attendance system comprises thirteen elements of data: course information, lecture halls, and attendance data for each course. The initial letters of every element of data are capitalized, and there is no space between the first and second words.

4.2. *Experimental Result*

The experimental result was carried out in order to assess the operational effectiveness of the integrated system. A smart attendance application is installed on some mobile devices, while Cubeacon cards are mounted on the classroom wall. Subsequently, each mobile device activates its Bluetooth communication system in order to detect the Cubeacon card proximity sensor. Internet connectivity is also available on the mobile device, allowing it to synchronize the attendance system with the back-end cloud server.

Various mobile devices are employed to assess the efficacy of integrated applications. The assessment criteria encompass the efficacy of application installation, the accuracy of proximity sensor detection, and the functionality of apps to perform digital attendance within the designated environment. The specifications of the mobile devices utilized in the testing are detailed in Table 4.11.

Table 11. The specification of mobile device utilized for testing the smart attendance application

Device Brand	Device Model	Android OS Version	Type of Device	Processor specification	RAM (GB)
LGE	LG-H845	7.0.0	Mobile	Octa-core 1.8 GHz	3
Oppo	A1601	`5.1.0	Mobile	Hexa-core 1.5 GHz	3
Asus	ASUS_Z00AD	5.0.0	Mobile	Octa-core 1.8 GHz	4
Himax	M23	7.0.0	Mobile	Quad-core 1.25 GHz	3
Lenovo	P1ma40	5.1.0	Mobile	Quad-core 1.0 GHz	2
LGE	LG-H845	7.0.0	Mobile	Octa-core 1.8 GHz	3
Oppo	A1601	5.1.0	Mobile	Hexa-core 1.5 GHz	3
Samsung	SM-G355H	4.4.2	Mobile	Quad-core 1.2 GHz	0.768
Samsung	SM-T285	5.1.1	Tablet	1.5 GHz	1.5
Sony	F5321	8.0.0	Mobile	Hexa-core 1.4 GHz	3
Xiaomi	Redmi 3	5.1.1	Mobile	Octa-core 1.2 GHz	2
Xiaomi	2014817	5.1.1	Mobile	1.2 GHz	1
Xiaomi	Mi-4c	5.1.1	Mobile	Hexa-core 1.4 GHz	2
Xiaomi	Redmi 4X	6.0.1	Mobile	Octa-core 1.4 GHz	4
Xiaomi	Redmi Note 4	7.0.0	Mobile	Octa-core 2.0 GHz	3
Xiaomi	Redmi 5A	7.1.2	Mobile	Quad-core 1.4 GHz	3

The field experiment is conducted by selecting a sample of students and lecturers from the Department of Electrical Engineering at Universitas Muhammadiyah Yogyakarta. All databases, including those containing student and lecturer identification data, are configured and stored at a cloud back-end system, MBaaS. The

Android OS series, Bluetooth, and mobile device specifications are detailed in Table 10. In the context of internet connectivity for end devices, it is provided by the respondent or utilizes a wireless campus network.

Two courses, Operating Systems, and Telecommunications Networks, are utilized to assess the efficacy of the attendance system. The smart attendance application has been deployed on a total of 16 mobile devices. Out of the total count, 12 devices were employed for assessing attendance in the Operating Systems course. In comparison, 6 devices were utilized for the same purpose in the Telecommunications Networks course (2 devices are owned by individuals who are enrolled in both courses). The results of application functional testing are detailed in Table 12 and Table 13.

Table 12. The results of the functionality testing conducted for operating systems courses.

No	Student Name	Student ID	Class	Meeting-1
1	Arifah Yuliani	20150120125	A	1
2	Muhammad Hafiz Aldy	20150120069	A	1
3	Muhammad Fachri	20150120056	A	1
4	Fazal Hawari	20150120095	A	1
5	Doane Puri Mustika	20150120163	A	1
6	Bangkit Dwiputra P.	20150120120	A	1
7	Kharisma Fajar Sidik	20150120152	A	1
8	Adnan Prayudha	20150120051	A	1
9	Ayu Al Israh	20150120076	A	1
10	Tri Handayani Putri	20150120043	A	1
11	Ratna Murti	20150120114	A	1
12	Purwoko Nurhadi	20150120052	A	-

Table 13. The results of the functionality testing conducted for telecommunication network courses.

No	Student Name	Student ID	Class	Meeting-1
1	Doane Puri Mustika	20150120163	A	1
2	Nurohman Fadilah	20150120081	A	1
3	Dimas Agung Nugroho	20080120002	A	1
4	Muhammad Wilimilio Rizkidana	20150120158	A	1
5	Kharisma Fajar Sidik	20150120152	A	1
6	Fatkhurrohman	20150120096	A	1

Table 12 shows that the functionality testing conducted for telecommunication network courses reaches 91.67%. One device out of the twelve that are examined is installed effectively but is incapable of detecting the beacon; consequently, the lecture hall does not appear on the list of options. As a result, the application is unable to do attendance tracking. All devices can install, operate, and record attendance satisfactorily, with the exception of this one. The value of "1" in the meeting1 column indicates the completion of this task. The outcome indicates that the entry of the student's attendance data into the database is successful. Meanwhile, the result of the functionality testing conducted for telecommunication network courses has been 100% successful. Table 13 presents the data experimental result.

5. Conclusion

The present study has achieved the successful design, development, and implementation of a proximity-based Internet of Things (IoT) smart attendance application. The application is installed and executed successfully on all end devices. Out of the total number of end devices, sixteen are found to have completed attendance tasks and integrated data into the database. However, one device experienced a failure in recording attendance due to its inability to detect the beacon. The failure is potentially attributed to a malfunction in the Bluetooth device. Then, it resulting in the absence of the lecture hall list.

According to our implementation testing, the proposed system is easy to realize on a large scale since the initial system has been built. Large-scale implementation can be done by cloning the program, adjusting the student database, updating the class schedule, and installing the beacon reader in many lecture halls. In addition, future research might be conducted to improve the security of this system by integrating features that limit the user's identification to a single device.

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References

Abdulkareem, A. (2018). *The Design, Development and Evaluation of A Smart Attendance Tracking System using Bluetooth Low Energy Beacons, A Thesis Submitted to The Graduate School of Natural and Applied Sciences of Çankaya University*.

Apoorv, R., & Mathur, P. (2016). Smart attendance management using Bluetooth Low Energy and Android. *2016 IEEE Region 10 Conference (TENCON)*, 1048–1052.

Eyro Digital Teknologi. (2016a). *Cubeacon Card*. https://cubeacon.com/docs/Cubeacon-Card-Datasheet-V_0.3.pdf

Eyro Digital Teknologi. (2016b). *User Guide Cubeacon Tools Mobile Android App*.

Hake, A., Samanta, A., Kasambe, P., & Sutar, R. (2022). Automatic Attendance Marker Using Beacon technology. *2022 IEEE Region 10 Symposium, TENSYMP 2022*. https://doi.org/10.1109/TENSYMP54529.2022.9864555

Hayati, N., Ramli, K., Suryanegara, M., & Salman, M. (2017). An Internet of Things (IoT) Reference Model for an Infectious Disease Active Digital Surveillance System. In *IJACSA) International Journal of Advanced Computer Science and Applications* (Vol. 12, Issue 9). www.ijacsa.thesai.org

Jeon, K. E., She, J., Soonsawad, P., & Ng, P. C. (2018). BLE Beacons for Internet of Things Applications: Survey, Challenges, and Opportunities. In *IEEE Internet of Things Journal* (Vol. 5, Issue 2, pp. 811–828). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/JIOT.2017.2788449

Kim, M., Lee, J., & Paek, J. (2018). Neutralizing BLE Beacon-based electronic attendance system using signal imitation attack. *IEEE Access*, *6*, 77921–77930. https://doi.org/10.1109/ACCESS.2018.2884488

Kumar, B. G. A., Bhagyalakshmi, K. C., Lavanya, K., & Gowranga, K. H. (2016). A Bluetooth Low Energy Based Beacon System for Smart Short Range Surveillance. *2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, 1181–1184. https://doi:10.1109/RTEICT.2016.7808018.

Menon, S., George, A., Mathew, N., Vivek, V., & John, J. (2017). Smart workplace — Using iBeacon. *2017 International Conference on Networks & Advances in Computational Technologies (NetACT)*, 396–400. https://doi:10.1109/NETACT.2017.8076803

Miao, Q., Xiao, F., Huang, H., Sun, L., & Wang, R. (2019). *Smart Attendance System Based on Frequency Distribution Algorithm with Passive RFID Tags*. http://creativecommons.org/licenses/by/4.0/

Nugraha, A. T., Wibowo, R., Suryanegara, M., & Hayati, N. (2018). An IoT-LoRa System for Tracking a Patient with a Mental Disorder: Correlation between Battery Capacity and Speed of Movement. *2018 7th International Conference on Computer and Communication Engineering (ICCCE)*, 198–201. https://doi:10.1109/ICCCE.2018.8539316.

Noguchi, S., Niibori, M., Zhou, E., & Kamada, M. (2015). Student attendance management system with bluetooth low energy beacon and android devices. *Proceedings - 2015 18th International Conference on Network-Based Information Systems, NBiS 2015*, 710–713. https://doi.org/10.1109/NBiS.2015.109

Okamoto, T., Sasaki, Y., & Suzuki, S. (2017). Targeted advertising using BLE beacon. *2017 IEEE 6th Global Conference on Consumer Electronics (GCCE)*, 1–5. https://doi:10.1109/GCCE.2017.8229404.

Rahmawati, P., Hikmaturokhman, A., Ni'amah, K., & Nashiruddin, M. I. (2022). LoRaWAN Network Planning at Frequency 920-923 MHz for Electric Smart Meter: Study Case in Indonesia Industrial Estate. *Journal of Communications*, *17*(3), 222–229. https://doi.org/10.12720/jcm.17.3.222-229

Ramani, G., Pradeepkumar, G., Palanisamy, P. N., Ashika Preethi, S., Sekhar, V., & Kumar, N. S. (2023). Smart Attendance Monitoring System Using IoT. *2023 9th International Conference on Advanced Computing and Communication Systems, ICACCS 2023*, 1099–1104. https://doi.org/10.1109/ICACCS57279.2023.10112850

Shah, S. N., & Abuzneid, A. (2019). IoT Based Smart Attendance System (SAS) Using RFID. *2019 IEEE Long Island Systems, Applications and Technology Conference (LISAT)*, 1–6. doi:10.1109/LISAT.2019.8817339.

Teran, M., Aranda, J., Carrillo, H., Mendez, D., & Parra, C. (2017). IoT-based system for indoor location using bluetooth low energy. *2017 IEEE Colombian Conference on Communications and Computing, COLCOM 2017 - Proceedings*. https://doi.org/10.1109/ColComCon.2017.8088211

Zori, B., Dudjak, M., Bajer, D., Martinovi, G., & Juraj Strossmayer, J. (2019). *Design and development of a smart attendance management system with Bluetooth low energy beacons*.