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Nuno
Armas Barbosa

IamHere: Attendance Management Service

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia de Computadores e Telemática, realizada sob a orientação científica do Doutor José Luis Guimarães Oliveira, Professor Catedrático do Departamento de Electrónica, Telecomunicações e Informática da Universidade de Aveiro e Doutor José Manuel Neto Vieira, Professor Auxiliar do Departamento de Electrónica, Telecomunicações e Informática da Universidade de Aveiro

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Palavras Chave Orador, Estudante, Arquitetura, Casos de Uso, Serviço, Aplicação Móvel, Servidor, Base de Dados

Resumo

Nos dias que correm, o registo de presenças em ambiente de sala de aula é considerado um processo temporalmente dispendioso. Com o avanço atual das tecnologias e a sua disponibilidade, faz sentido aplicar novas ferramentas de modo a reduzir os tempos de registo de presenças, bem como minimizar as falhas existentes nos processos atuais. Da aplicação destes novos métodos, garante-se não só o aumento da fiabilidade do processo de recolha de presenças, bem como o incremento do tempo útil de aula.

Neste sentido, a presente dissertação faz uso das tecnologias RFID, NFC, QR Code e Bluetooth, com o objetivo de disponibilizar, via aplicação móvel, mecanismos de utilização simples e que são acessíveis a diversos utilizadores. Estes mecanismos, funcionando em sinergia entre si, permitem um processo de aquisição de presenças mais facilitado.

Keywords Lecturer, Student, Architecture, Use Cases, Service, Mobile Application, Server, Database

Abstract

Nowadays, the attendance recording in a classroom environment is considered a slow process. With the advances in technology and its availability, it made sense to apply these new tools in a way that allows a reduction of the time spent collecting attendances, and also to solve some of its current flaws. From the use of these new methods, it's possible to increase the accuracy of the attendance retrieve process and consequently increase the useful class time.

This way, the present dissertation takes advantage of the RFID, NFC, QR Code and Bluetooth technologies, aiming to provide, through a mobile application, simple and accessible mechanisms to a diverse set of users. These mechanisms, working in synergy, allow an easier attendance retrieve process.

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Acronyms

ANSI American National Standards Institute. 45

API Application Programming Interface. 30

ATM Automated Teller Machine. 16

GPS Global Positioning System. 10, 13, 54

IDE Integrated Development Environment. 39

IoC Inversion of Control. 42

MAC Media Access Control. 12

NFC Near Field Communication. i, 1, 5, 7, 8, 19, 22, 23, 27, 31, 32, 47, 49, 52, 53

OS Operating System. 39

PCA Principal Component Analysis. 14

QR Code Quick Response Code. i–iii, 1, 5, 9–11, 15, 16, 20, 23–25, 28, 31–36, 46, 47, 49, 52–54

REST Representational State Transfer. 30

RFID Radio Frequency Identification. i–iii, 1, 5–8, 15, 19, 22–25, 27, 28, 31, 32, 46, 47, 49, 52–54

RSSI Received Signal Strength Indicator. 12

SQL Structured Query Language. 44, 45

URL Uniform Resource Locator. 32, 35, 43

Chapter 1

Introduction

1.1 Motivation

Nowadays most universities deal with thousands of students daily. Each of these students can have more than one class in the same day. This brings the need, in most lectures, to assure and validate that each individual student is present. Most of the processes used to retrieve the presences of the students depend on work done by the lecturer. These processes of asserting which students are present can take a lot of class time. For example, if a class takes place in an auditorium this means that the number of students can be substantial, leading to a greater time consumption of the class time, if the lecturer calls each student by name. Other method used by some lecturers consists of printing a paper sheet with all the names of the students enlisted for the class, and then let the sheet cross the classroom and each student signs his name to record his presence. This last process has two main issues, it allows impersonation between the students and requires that, after the class, the lecturer records all those presences into the university system. Although the lecturer can start the class faster, if he passes the paper sheet through the students, the problem of impersonation remains what in some part invalidates the process of assuring

the present students.

Having in mind the issues mentioned previously came the idea of modernizing the process with technologies used nowadays. Many companies deal with the identification and recording of workers presences to achieve a better management of personal and payments of salaries. For that reason they used different methods and technologies that enforce the correct recording of presences always having in account the cost reward of the process and technologies used.

1.2 Objectives

This dissertation will present technologies that are used in identification processes. These will be introduced in chapter 2, through implementations in different fields, that have similar requirements as the ones of this dissertation. Some of this fields will have different objectives, but will also have to assert some aspects that are very similar to the ones needed in the dissertation. For example, the service IamHere will have to assert that it is identifying the correct student through the different technologies, and then associate said student with the correct class.

Moreover, the main problem to be tackled is oriented to the retrieve and assurance of the attendance associated with students in a classroom context. While tackling the problem, there are some objectives to have in mind, the main being that of the time spent. By saving time, in the process of presence retrieve, the lecturer can gain a considered amount of class time daily, in the case of different classes. Moreover, the student will also have more class time if, in all his classes, the retrieve of the presence is a faster process.

Intuitiveness is another important point. This will bring ease of use for both students and lecturers, on a daily basis. This ease of use will have impact on the acceleration of the process of presence retrieve, because if all the users can easily synchronize in which

method of retrieve to use, this will save class time for them.

This dissertation will account for different technologies. These will have to be easy to use, cost-effective for the scenarios at hand and will have to counter the possibility of impersonation between the students.

Finally, having the previous points in mind, the objective of this dissertation is to bring the cost-effective and easy to use technologies to a classroom environment. Lastly, it is important to consider that these technologies should also bring to the lecturer simplicity, security and correctness of the attendance, that he will have to acquire daily.

1.3 Document Structure

This dissertation is composed by four other chapters succeeding.

- **Chapter 2** is oriented to contextualize the technologies that are used in the field of attendance management.
- **Chapter 3** integrates the use cases developed in a classroom context and the system requirements to create such use cases.
- **Chapter 4** contains the development technologies used and the architecture that brings all these technologies together in order to tackle the use cases needs.
- **Chapter 5** discusses the conclusions achieved by the work developed and future work that would improve the application.

Chapter 2

Attendance Management Tecnologies

Nowadays the registration of student's attendance is made by resorting to a sheet of paper, which is signed by each attendant student. This process is not the most efficient due to time consumption and the imprecise student registration. Although it can accomplish a close to reality attendance registration, there is always the problem of impersonation, that will lead to the need for a thorough confirmation, by the Lecturer, to determine the real attendance. In order to tackle this problem, there were developed solutions that take advantage of the technologies available nowadays, namely: RFID, NFC, QR Code, Bluetooth, as well as, face, iris and fingerprint recognition. These technologies, are known to be easy to use and able to provide an extra layer of trust to the process of attendance management.

2.1 Radio Frequency Identification (RFID)

Nowadays the use of sensing technologies like RFID have become commonly seen. This technology is dependent of a tag and a reader: the tag is activated by the reader and then responds with the identification data; The reader, on the other hand, retrieves that

identification data and can then use it in its logic. These tags can take a diverse set of shapes. The most commonly seen are cards, keychains or stickers. The versatility of RFID tags bring ease of use due to simple need to approximate the tag to the reader. That ease of use is improved because the process of reading the tag is fast. Although, the tags need to read at close range, this limitation brings a feature which is related to security: eavesdropping is more difficult due to the closeness needed to read the RFID tag.

In the attendance management systems the RFID technology have been used by different entities and deployed in different ways, providing an overview of the possible implementations of RFID. Some of these implementations will be cited in the next paragraphs.

In article [1], the authors explored the RFID technology in a classroom environment. Here the authors developed an Arduino RFID reader which is connect to a server through an Ethernet connection. This reader is responsible to read the student cards and send the identification number to the server. These card readings have two purposes. The first purpose is managing the students assiduity in the lectures. The second is to provide the students, through a web based application, academic information such as timetable, lecture time, classroom numbers and student related data. In this article the authors also make a comparison between the traditional system and the proposed system, Table 2.1.

Table 2.1: Comparison Between Systems

Parameters	**Traditional System**	**Proposed System**
Human Interference	Yes	No
Time Consuming	More than 5 minutes	Less than 2 minutes
Efforts Spend	Yes	No
Speed	Slow (human)	High (computer)
System Security	More vulnerable	Authenticated persons only
Resourses (Documents)	More paper work	Only one electronic record
Data Accuracy	Low	High Accuracy
Registration Time	More than 8 minutes for each student	1-2 minutes
User Friendly	No	Yes

Moreover in article [2] the authors implemented a system in which the students acquired

an identification RFID card. These cards had been previously associated with the respective students in a database, in order to match with posterior readings. Then, at time of their arrival, the students could scan their cards on the RFID reader. If the reader flashed a green light it meant it was a valid identification card and the student arrived at a valid time. If, however, the reader flashed a red light it meant it couldn't find a match for that card on the database. It would also flash red, if the students swiped his/her card before the end of the lecture day. Finally, it was also developed a web interface that was used for management of students and employees attendance. This interface was responsible to provide reports to the administrator the facilitated the process of attendance management.

A different approach was used with RFID. In the article [3] the authors used a tag and reader setup, but in this case they used a tag that is stationary and is constantly being read by a RFID reader, that is parallel to the tag, at a distance of one meter. The authors then detected the interference caused by a person crossing the reader's field of reading. This interference is then saved as a fingerprint of the person, so that it can be used as a match reference in posterior readings. The authors in this implementation acquired a matching accuracy of 92%. This accuracy is very interesting because they developed a RFID based system that is device-free which allows the identification of personal without extra efforts by the user.

2.2 Near Field Communication (NFC)

Near Field Communication (NFC) is a technology broadly used in different areas of our day to day life. This technology can be used as payment method (in stores and other goods selling facilities), as a pairing method (in order to allow the pairing between devices and transmit data with each other), as a validation method (in buses or train stations that use ticket cards) and it can also emulate RFID cards or tags.

The features and benefits brought by NFC are boosted by the fact that many smartphones possess this technology, allowing for the easy access to all previously mentioned features.

Although NFC brings advantages in facilitating some tasks, it is restricted by the range at which it can work, which is of just a few centimeters. This low range, although it limits the technology in long distance communications, brings an advantage in security because it is harder to eaves drop on the communication that it is being made. With this low range communication and the possibility of emulate a RFID card it's possible to have a technological device, with a set of cards, that are equivalent to physical cards, but only readable when the user wants.

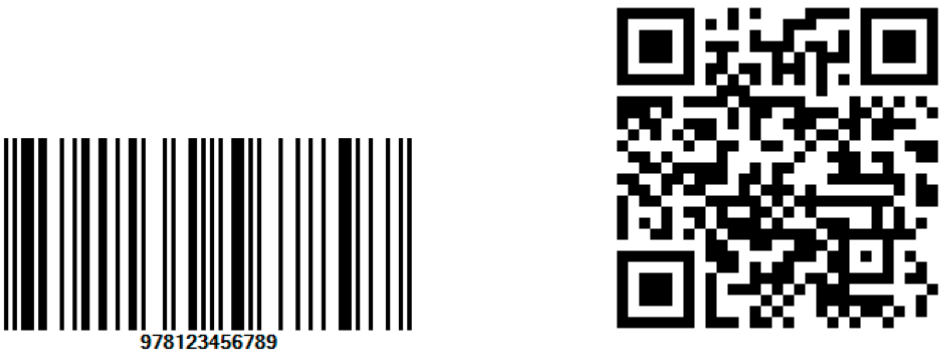
In article [4] the authors implemented a system based on NFC and fingerprint scan. This system relied on a NFC reader. Through this reader the lecturer could configure the classroom reader with a lecturer name, a course, the type of event (lecture, mid semester exam or final exam) and start or stop the attendance retrieve process. When the students arrived at the classroom, they would have to scan their NFC tags on the reader and then scan their fingerprint. In this scenario the NFC tags acted as an identification of the student and the fingerprint scan authenticated the student against the identity provided by the NFC tag. To easily manage the system, a web interface was developed to provide the lecturers a better overview of the retrieved attendance. In this web interface it was possible to view the course list, the attendance record associated with each course, the attendance associated with an event and list of students associated with a course.

The system depicted in article [5] was developed with RFID and NFC. The system used a NFC reader located in the classroom desks. This allowed the retrieve of the presences when the students are at their sit in the classroom. The students would have to tap their RFID student cards into the reader at the desk, to allow a correct record of the presence in the class. To ease the use of the system was also created a web Application to help

the lecturer manage their courses. In this interface the lecturer can view his lectures and students present in each one.

2.3 Quick Response Code (QR Code)

Nowadays every supermarket or any item selling shop, relies on bar codes. These codes bring the advantage of tagging the items with a common pattern that uniquely identify them. Although the bar code provides the advantage of uniquely tagging items, for some industries the required amount of information associated with a pattern is higher. These requirements were met by the creation of the QR Code, which allowed for the possibility of associating more information to a common pattern similar to the bar code.



(a) (b)

Figure 2.1: Bar Code and QR Code

The QR Code was developed using a pattern that does not store information in only one dimension, as the bar code, but instead takes advantage of a two-dimensional pattern. Hence,it provides the possibility of storing more information, going over 4000 characters[6], and still occupy a small amount of space. This feature brought widespread advantages in countless industries worldwide, that rely on a good management of their inventory and companies that need to advertise products. Although the data storage capabilities of the QR Code are very good, there are other features that gave the QR Code the visibility

that it has today. The fast reading capability through a smart phone made it very easy to use, by everyone ,and the low price of generating QR Codes made them a go-to for many companies. Finally, it is needed to say that, although the price of generating the QR Code is very appealing, the price of developing an app capable of do it might not be as attractive, even though there are many open source libraries to help integrate it.

In the article [7] was implemented a system based in QR Code and GPS. In this implementation, the lectures were seen as events, and these events were then managed by an administrator. During the attendance retrieve, the student was required to login into his student account and scan a QR Code with an Android Application. This QR Code would contain the event's information and would display it to the student. Then, the student could send a request to a server, with his GPS location, that would record his login in the event, if the location was valid. By the end of the event, the student would go to the mobile application, and press the logout button, during the determined time frame for the validation of the logout. Only after the a valid logout it was recorded a valid presence for the student.

During the implementation of the attendance system developed in the article [8], the authors implemented a system dashboard in which they could add the users that would interact with the platform. These users included lecturers, students, program heads and study program administrators. After these users were added they could create the schedules for the classes and associate the students and lecturers. The other side of the implementation required a device in the classroom that has a camera and internet connectivity. This way when the lecturer arrives at the classroom, he/she scans a QR Code in the device and starts the class. This enables the device to start reading the QR Codes that the students will display on their smartphone through the dashboard developed. Each student, by having his unique QR Code, allows the system to assert his/hers location as well as his/her presence in the class. From the previously talked dashboard, the administrators

could generate reports of the courses and the associated attendance.

Moreover, in the article [9] the attendance system was developed using a blockchain and QR Code. The blockchain data structure allows the storage of data linearly. Here, every data manipulation, insert, update or delete, is seen as a new block added to the chain, increasing its length. This blockchain will be responsible to store the users, new subjects, QR Codes associated to the subjects and the attendance of the students. This system is then managed through a dashboard, which ease the process of reading and managing the blockchain. Once the lecturer is at the class, he can generate a new block on the blockchain with the QR Code that will be read by the student's mobile devices. When the students read the QR Code the system will then add a new block to the blockchain with the presence of the student associated with that subject.

2.4 Bluetooth

Bluetooth is a wireless technology that can replace cables connecting devices, while keeping a reliable communication between the intervenient parties. This technology has the capability of keeping a wireless communication between devices, having a 10 to 100 meters reach. The reach of the Bluetooth communication depends on the frequency at which the communication is done. In short, Bluetooth can communicate through low or high wireless frequency, but the choice between high and low can impact the rate at which data is transferred between devices and the distance they can have between them. As the frequency gets higher, the data transfer increases too, but it means that the distance at which the devices can communicate decreases. This brings the necessity of evaluate the system requirements in order to choose the best frequency to use.

This kind of wireless communication brings the advantage that the devices can keep a communication without having a field of view between them. This feature can provide

communication between parties in crowded spaces.

As mentioned previously, there is the possibility of manipulating the frequency at which the Bluetooth devices communicate between them. This means that if we have three devices communicating at the same frequency, it's possible to know which are farther from which, by evaluating the signal strength received from the devices. This way, the lowest Received Signal Strength Indicator (RSSI) indicates that it is the farthest device and the highest RSSI is the closest device.

Additionally, there were also created Bluetooth Beacons. These devices can have different communication frequencies, as mentioned before, but their objective is to send a constant signal with a unique identifier. These beacons can be installed in walls or be as little as keychains. Now, if it is created a scenario in which two Bluetooth beacons are installed in parallel walls inside a classroom, it's possible to triangulate a receiver inside the classroom, because if the Bluetooth receiver takes a measurement of the RSSI received by the beacons it can assure if the receiver is in the middle of the two beacons or in this example, inside the classroom.

In article [10] the attendance system was implemented through stationary Bluetooth sensors located in the classroom. These sensors were responsible for detecting the Bluetooth devices present in the classroom and send their information to a web application. This web application was responsible for the validation of the readings between the different sensors, to assert the presence of the student inside the classroom. The students to be detected by the Bluetooth sensor needed to send their mobile device's Media Access Control (MAC) address to the web application. The lecturer would star by specifying which class he/she was going to teach and would associate a list of students enlisted in the class. Through this list of students a list of MAC addresses was sent to the Bluetooth sensors in the classroom. This way the sensors know which students to identify.

Furthermore, the authors of the article [11] used an approach based on the Bluetooth

technology present in mobile phones and GPS. To use Bluetooth and GPS it was developed a mobile application. This application allowed consultation of the available classes for both students and lecturers. Through the classes available, the lecturer could start a class session. This class session would associate the GPS coordinates of the lecturer with the class and, with these coordinates, the system would create a geo fence. This geo fence would allow the system to create an area bounded to the lecturer's GPS location. The students, through their mobile application, would only be able to access the class session if they were within the range of the geo fence. If the location condition was met, then the students would be able to detect the lecturers mobile phone and register their attendance.

The authors of the article [12] implemented a system that used Bluetooth beacons. These beacons could also be emulated by a smartphone that has Bluetooth capabilities. If it is used the lecturer's smartphone to act as a beacon, it is avoided the costs of installing beacons in every classroom. The system developed by the authors, allowed the students at the class to register their presence, through a mobile application. This application would send a notification to the student at the end of the class so that he would record his presence again. This repeated process of registering the presence, at the beginning and at the end of the class, allowed a validation that the student was present during all class. A second validation, that was allowed in the mobile application, depended of the lecturer. If the lecturer saw fit he could add a question that would be presented to the students during the last check in of the class, and would record the answer. To manage the system more easily, it was also developed a web application. This interface allowed the users to add classes and associate the Bluetooth beacons to them. The web application also allowed the lecturer to see the present students in the class and which had given the first and second presence check.

Finally, in article [13] it was used an approach based on Bluetooth beacons. These beacons would be spread by classroom and have associated to them the information about

the classes that would take place there. To interact with these beacons, it was required that the users used a mobile application. This application would require access to the Bluetooth of the device, so that it could detect the beacons around it. When the application detected a beacon it would send a notification to the user. This notification contained the name of the room and the courses registered to it. After that, the students could start the attendance process by logging in successfully. After the login, the student would be presented with a schedule page. Here, the student would have to choose a schedule that matched the classroom's day and hour of the lecture. After that, the student was redirected to the attendance page where he would press the attendance button, to record his/her presence.

2.5 Face Recognition

Face recognition as a biometric identification technology is widespread used. It is used daily seamlessly between individuals to identify each other. Although it is used by persons with ease, the same don't apply to computers. These must rely on high-definition cameras, that require strategic positioning to acquire the best imaging to identify an individual. This imaging is then evaluated by machine learning algorithms, that analyze different characteristics in the images to find an identity match. If a match is found, it's possible to allow access or associate the presence of an individual with a given place and time.

The face recognition process is not an easy task, so to tackle this problem are used different machine learning algorithms. The first machine learning algorithm we are going to see is the Principal Component Analysis (PCA). This algorithm relies on a process of finding distinct characteristics present in the images, grouping them by those characteristics. The second machine learning algorithm is called neural network. The process behind a neural network uses a triggering process like the neurons in a brain. These neurons will generate an impulse when the images fed to neural network have specific characteristics.

The main difference between the first algorithm and the second, is that the first one categorizes the image information and the second reacts upon that information. This difference brings the concept of the neural network closer to the inner workings of the human brain.

In article [14] the authors developed a system that relied on RFID and face recognition. By using both technologies in conjunction it was possible to avoid impersonation more easily. The process of retrieving attendance started by the system asking the student for their RFID identification. If the system gets an identification for such RFID tag, it would then proceed for the face recognition module. The face recognition phase would then acquire a set of images from the student's face, to use on the recognition. The system would then increase the student count associated with class and record a new student presence, if the RFID identification matches the face recognition. If the RFID tag does not match the student, the system would record the RFID tag and the images, from the student, in the database with a flag, so that it could be investigated later. Using a double validation of the student identification allows for a more trustworthy attendance process.

Furthermore, the article [15] explored the face recognition process, associated with attendance recording. During this implementation, the authors developed a system that relied on a camera that was positioned, strategically, at the entrance of the classroom, in order to identify each student as they entered the classroom. To get good imaging, when in front of the camera, each student needed to get within 90 centimeters of the camera. This distance requirement was needed to reduce the unwanted background captures. This way enhancing the accuracy of the recognition. The system proved capable of identifying students wearing glasses and even identifying a student whose beard had grown since the day he was added to the system.

Moreover, in the article [16] the authors created a system based on QR Code and face recognition. In this system was deployed a monitor at the entrance of the classroom. This monitor would display a QR Code when the lecturer started the class, through the mobile

application. Next, when the students arrived at the classroom, they scanned the QR Code with their mobile application. This application would then acquire the course class information, the lecturer and the schedule of the class through the QR Code. The mobile application would also capture an image of the student's face to validate the presence and save it into the database.

2.6 Iris Recognition

Iris recognition systems are yet another branch of the biometric recognition software. Even though they are probably the least common of the technologies here mentioned, they fit within a wide range of applications able to unequivocally identify a person.

Some of the above mentioned applications, are used in order to grant access to either physical or logical places, such as accessing delimited areas in airports or accessing databases located in restricted systems.

Due to their higher security features (when compared to the other non biometrical technologies here mentioned) these are starting to be applied in companies such as banks, to allow access and execution of tasks in an Automated Teller Machine (ATM) instead of using a credit card. This technology reduces the insecurity associated with eavesdropping, since no longer it's required to insert the access pin to access the account.

Iris recognition is a safer technology, when compared to others, due to it's uniqueness, complexity and, in most cases, immutability of the iris. These characteristics are provided by the fact that each person, even before birth, have a unique texture associated with each iris of each eye. This uniqueness can even be found in identical twins and in the case of a person who suffers from blindness it can still be scanned with efficiency. The fact that the iris is an internal organ makes it less likely to suffer external damage that can impact the reading and leading to a new registration in the system.

In the developed system depicted in article [17], the authors used iris recognition as a method of identifying students. In this system the students would be associated with a set of pre processed images of their irises. These images would be used in the process of finding a match for a given reading. The students, by stepping in front of the camera, allowed the acquisition of an image of their face. This image was then processed, in a similar process as the enrolment phase, but in this case it was used to verify if there was a match in the database. If a match was found, the attendance for that student was recorded, otherwise the system would go back to the image acquisition process.

The article [18] used iris scanning as method of identification of the students that attended a class. In this system it was required an enrollment phase, in which the students scanned their irises. These scans were then associate with the students in the system. This process was needed to later identify the student through a match between the reading collected and the one saved in the system. After the enrollment phase was finished, it was possible to identify the students in the classroom. When the students arrived at a class they were required to scan their irises in the scanner, to associate their presence with class they were in.

The system depicted in article [19] presented a system that could use either fingerprint or iris recognition. The system required that the students went through an enrollment phase in which their fingerprint and iris were scanned and saved in a database, to use in posterior verifications. When the student arrived at the classroom it was required a scanning of a fingerprint or iris to allow the system to associated the student with the class. Finally, the user interface allowed the retrieve of a report of attendance that could have different time periods.

2.7 Fingerprint Recognition

Fingerprint scanning, as another biometric type of reading technology, is heavily used nowadays in activities that require person identification our validation. With this in mind, each person possesses a set of fingerprints that are unique to them. Each person is born with a certain pattern that is the same during his life time. Although, if the fingerprint suffers any kind of damage can mean that a correct identification through that fingerprint is rendered impossible.

The reliability, in the field of biometric identification, that fingerprint scan brings its heavily used in airports, as evidence in criminology, as an unlock option for many smartphones and as a step of verification to allow a payment.

This technology brings advantages when it comes to managing entries and exits of personal. Namely because, by having a fingerprint scanner at the entering and exit of a room, it allows a fast and reliable registration of the presence of a person without the need of any extra equipment.

An attendance management system based in fingerprint rely on a database in wich are stored the fingerprints of each person that is supposed to be identified by the system. This database is used when the someone scans their fingerprint, at a scanner, while entering or exiting a division. This way the fingerprint can be compared with the one in the database and register the attendance of the person or grant access to the division.

In article [20] the system was designed using fingerprint scanning. This system required that the lecturer logged into it, to register the student's fingerprint. Here the students would have to fill an information page and scan their fingerprints. This would allow the system to associate the students with their fingerprint, to later match the scanner readings with the fingerprint saved in the database. Later, at the time of the class, when the lecturer inputs a valid login into the system, the students would then be allowed to start scanning

their fingerprints, so that the system could verify if there was a match for them in the database. If the system found a match it would associate the student with a presence in the database.

The authors of article [21] developed a system based in a fingerprint, supported by a micro controller. To be able to identify the students that are scanning the fingerprint, it is needed an enrollment phase. In this phase, the student associated his fingerprint with his profile. Later, it was inputted into the microcontroller the course number and class date and time. After these inputs were made, the students could then start scanning their fingerprints. An attendance record would be saved when a fingerprint match is found. The record of attendance would have the course number, the date and time at which the student was recorded, the identification number of the student and if the student arrived late at class.

2.8 Summary

After conducting this study it's possible to say that any of the previous talked technologies have good capabilities relative to attendance registration. Utilizing any of these technologies individually it was rendered possible to create software-based systems targeting the management of attendance of students or personal in university or industry context. Although it's needed to emphasize the fact that all these technologies have interaction range restrictions. From the technologies with bigger range restrictions we can talk about NFC and RFID, although these range restrictions may be seen as a through back, they bring advantages in the security field and don't bringing a dull interaction. The NFC technology can also be paired with RFID, do to the fact that it has the capability of reading RFID tags. In the range restricted technologies there is also the face, iris and fingerprint recognition, but these technologies compared to the RFID although they have

range restrictions they also bring security due to their range of interaction. Furthermore, QR Code and Bluetooth bring a bigger gain in terms of how many students can record their presence at a time, this is due to the interactions of the previous mentioned technologies require a person to person interaction, increasing the time of presence retrieve proportionally to the number of students.

Chapter 3

System Requirements

This chapter will follow a structure in which will be depicted the main actors of the system, the use cases and the technologies associated with each use case.

The main actors are those to whom the system is targeted at. These entities will be presented in different use cases, aiming to improve the classroom attendance retrieve. These use cases will have to reduce the time spent recording every student's presence, as well as, provide user friendly interactions, guaranteeing an easier integration on daily processes.

3.1 Main Actors

The system requirements have, as main actors, the admins, the lecturers and the students. The admin will be responsible to manage the system and to provide the other users the data they require to execute their operations. The lecturer will be responsible to decide which attendance method he/she prefers and provide the students with his/her side of the interactions. Finally, the students will have to use the same attendance method as the lecturer, to complete the process correctly.

In the interactions created, the lecturer will have a set of methods that will give him/her more control over who is attending a given class. That way, decreasing the time that takes to retrieve the class attendance, when comparing to the traditional signed paper method.

3.2 Use Case Scenarios and Interactions

The overall system has some main guidelines to follow. These guidelines are given by the target interaction that the users will have with the system. These are the main targets of the system and, their identification, allows for the possibility of designing a more fitted system. In addition, these targets may also provide response to some doubts that might arise during the development of the system, given that the main objective is to provide said interactions to the end users.

3.2.1 RFID

Due to its versatility, RFID tags are available in a diverse number of shapes, two of which being identification cards or a keychains. This versatility allows for several advantages, namely in terms of easily identifying a person and registering the time and place where the RFID tag was scanned. Furthermore, this technology grants fast and accurate reading properties. In some cases, depending on the RFID reader, they can even read the tags without being required to take them out of the wallet.

Nowadays, a large range of smartphones have NFC technology. This technology permits communication between devices at a short distance of, at most, 10 cm, being more efficient at 5 cm [22]. The NFC brings, in terms of security, advantages related to the distance required for the communication, given that it protects against eavesdropping. Another advantage is that it provides a user with a RFID reader just by having a smartphone.

After analyzing the previously spoken technologies, and regarding that if the lecturer

gives permission to the IamHere application to access the NFC capabilities of his/hers smartphone, and that all students have a student card, it is possible to create a use case that goes as that presented by the letter c), in Figure 3.1 as yellow blocks.

As for the students, the process follows the yellow blocks present in Figure 3.2 as shown by letter a).

By the end of the process the lecturer can verify, through the application, which students have registered their cards.

3.2.2 QR Code

QR Code technology brings many advantages to the industries that depend on item identification, inventory mapping, as well as to those that need to advertise a product in a quick and easy way. The QR Code can also redirect the user to a page with more information on a product or service. This technology takes advantage of a two-dimensional design that provides the possibility to store more information in a simple pattern. Nowadays, almost every smartphone, that have a photographic camera, has the ability to scan a QR Code. This feature, paired with the fast decoding of the QR Code, brings the possibility of very interesting implementations.

In the IamHere system, regarding that both lecturers and students possess a smartphone, it is possible to follow the use cases presented by the green blocks and the letters a) and b) on Figure 3.1 for the lecturer, and green blocks and letters e) and f) on Figure 3.2 for the students.

In Figure 3.1 there are two flows that can use QR Code. These allow the lecturer the choice of displaying the QR Code in his/her smartphone and then lay it on the desk or display it with the help of a projector. The students interaction will be dependent of where the lecturer displays the QR Code. When the code is displayed on the lecturer's smartphone, the students interaction will be similar to the RFID use cases. This means

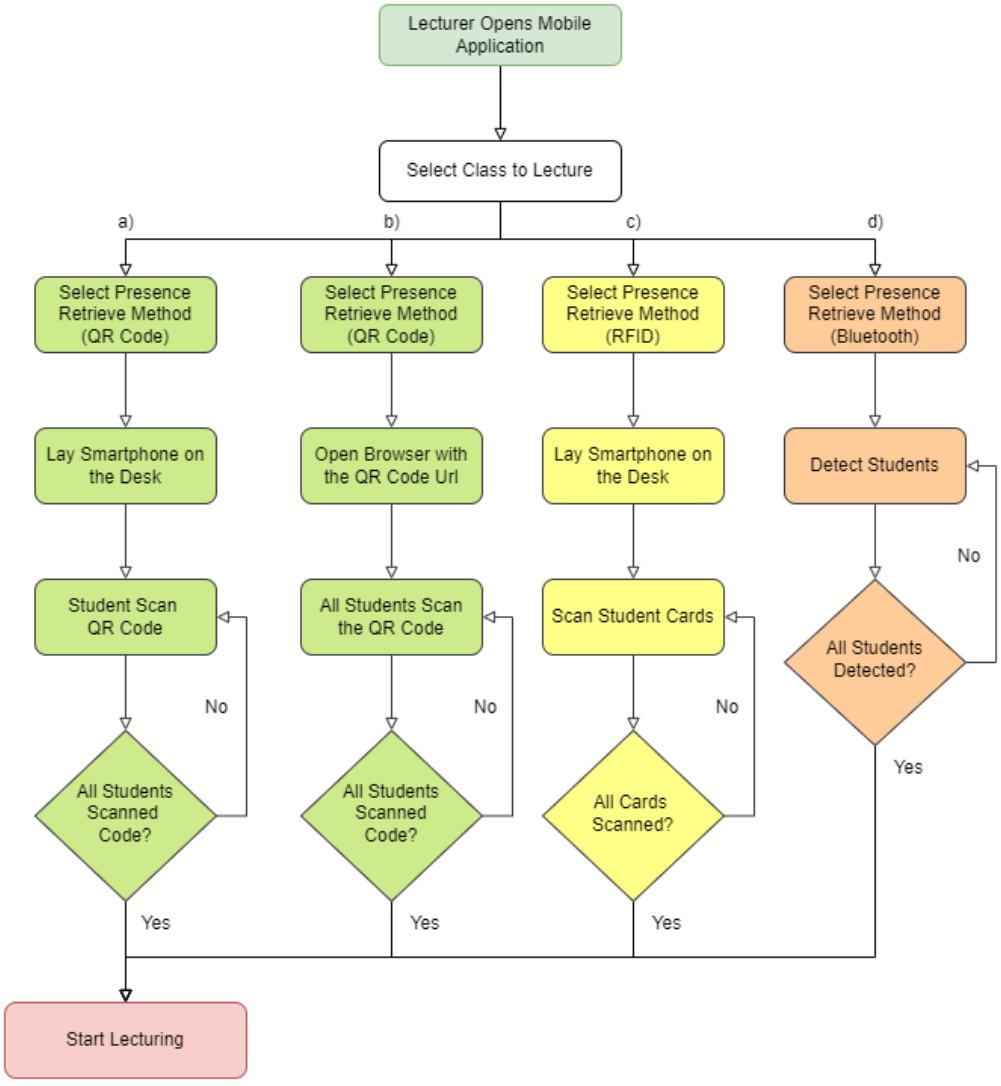


Figure 3.1: Lecturer Use Cases. a) and b) QR Code Use Cases; c) RFID Use Case; d) Bluetooth Use Case;

that when the students arrive at class, they will need to go to the lecturer's desk, to scan the code, and after that, go to their sit. On the other use case, that is different from the RFID, the students arrive at a class and go to their sit. The lecturer will then project the QR Code for all students, at the same time.

By the end, the students will receive an input from the application informing that their presence was recorded. The lecturer will have the possibility of consulting a list of the

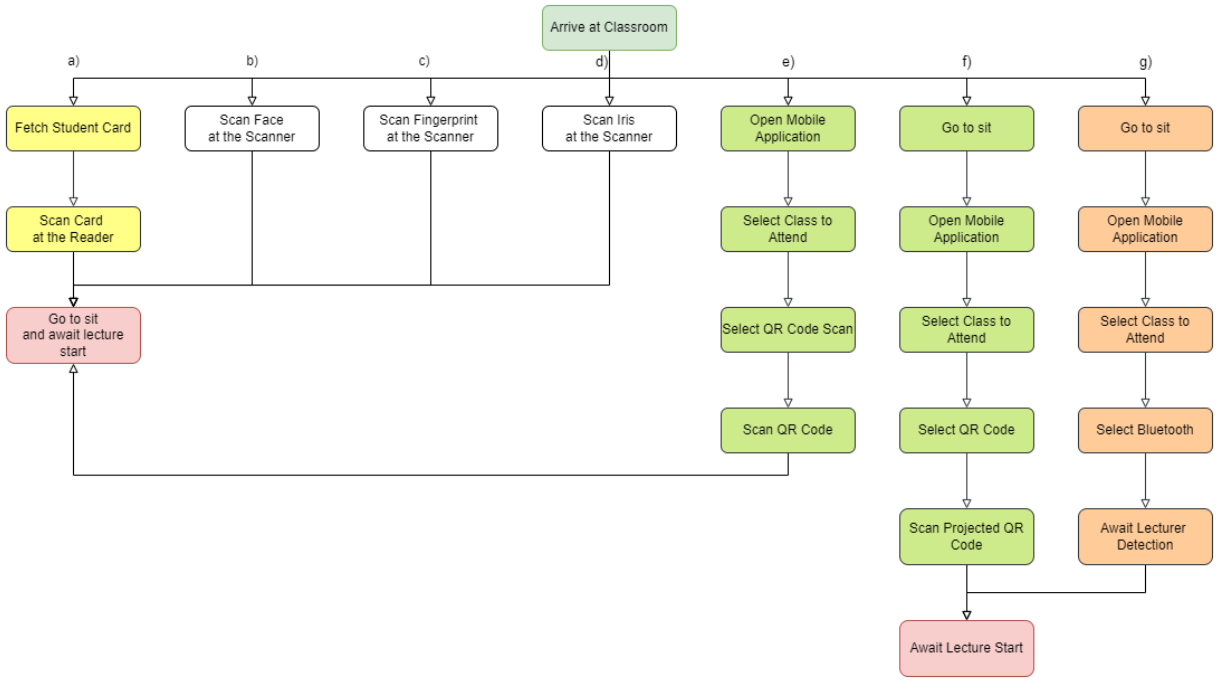


Figure 3.2: Student Use Cases. a) RFID Use Case; b) Face Recognition Use Case; c) Fingerprinta Recognition Scan Use Case; d) Iris Recognition Use Case; e) and f) represent QR Code Use Cases; g) Bluetooth Use Case

students in his class and their presence status.

3.2.3 Bluetooth

Bluetooth provides much versatility in the field of wireless communications. The fact that, nowadays, most smartphones use class 2 Bluetooth, which provides a communication range of ten meters[23], and the fast speed at which Bluetooth devices find each other, allows for a vast number of possible interactions for the systems that take advantage of Bluetooth.

The IamHere system was designed for use cases where both the students and lecturers interact with an Android app. In this case, it is needed that all users' smartphones have Bluetooth. It is also required that the users give permission for the mobile application to access the Bluetooth hardware and, finally, it is needed an internet connectivity.

Having the previous requirements been met, it is possible to create the use case represented by the orange blocks and letters d) and g) in Figures 3.1 and 3.2 respectively. In these use cases all students have a mobile application that will use Bluetooth to allow detection by the lecturer's smartphone and the record the presence. When the lecturer detects a student, the student is informed that his/her presence was recorded by the system and allow the lecturer to consult the present students in class through the mobile application.

3.2.4 Face Recognition

The face recognition technology is a biometric identification technology used, nowadays, in a diverse set of industries. It allows the identification of a person by standing in front of a camera, that sends the image feed to a system that analyzes and gives information about the identification. The face recognition process can be seen as the closest to the process used by most persons to identify other persons. This also means that the system needs to have a prior association of a person's data and it's face, so that in a posterior scanning it's possible to associate the reading with a person. Otherwise the system would have to inform that it is a stranger to the system. In Figure 3.2 the left white block with letter b) represents the flow through which the students go while using this type of recognition.

3.2.5 Iris Recognition

In the field of biometric readings there is iris recognition. This technology brings high accuracy and precision in personal identification due to the fact that the iris is an organ that is immutable during the natural life of a person. This technology is dependent of an iris reader to acquire the person's eye images. Also, to be possible the identification through the iris, it is required an initial step to provide the system with the capability of

identifying a person. This initial step is an enrolment phase in which the person's iris is scanned and the iris images are associated with the said person. After the enrolment of a person is done, it is possible to scan and identify the person. The use case that uses iris recognition process is represented by the flow that goes through the right white block present in Figure 3.2 with the letter d).

3.2.6 Fingerprint Recognition

The fingerprint scanning is a biometric identification technology broadly used in smartphones, as well as in access control to facilities and in criminology, since it brings accuracy and assurance in identifying a person. Since every fingerprint is unique to each person and even differing from finger to finger, it allows a bigger reliability when the system finds a match.

Subsequently, the system depends on a scanner to scan the fingerprints. These scanners can normally be found near entrances or in devices that allow authentication through fingerprint. In this section, it was created a use case scenario where the fingerprint scanner is located at the entrance of the classroom, allowing an easy access for the students. This scenario allows a later confirmation through the application to verify if the presence was correctly retrieved. This presence can either be validated by the lecturer or by the student.

The use case developed for the fingerprint scenario shares some similarities to the RFID and NFC. These similarities come from the fact that the fingerprint scanner is a piece of stationary hardware always requiring that the user goes physically to it. The process requires that the students, as they enter in the classroom, go one at a time to the scanner and scan their fingerprint. This use case is represented in Figure 3.2 by the middle white block and letter c). After a successful scan of the fingerprint the student or the lecturer can verify if the student has a presence associated with that specific class day.

3.3 Summary

In this chapter it was possible to provide examples of possible integration's of modern technologies into the attendance process. These integrations can either bring a faster way to acquire the all class attendance or accuracy in identifying a person.

The technologies which bring a faster attendance acquisition are QR Code and Bluetooth. This is due to the capability of more users being able to interact at the same time and by that acquire more presence records simultaneously. On the other hand, there is always a possibility of a student borrowing other student smartphone and impersonate the class mate.

Attending the biometric technologies analyzed in previous chapters, the RFID, fingerprint and iris are the ones that provide a better accuracy of identification. Face recognition can provide a good accuracy but it is more dependent on the algorithms used in identification and on the quality of the images acquired. These technologies are restricted because they need to be stationary, requiring the student to always get close to the scanner. The other drawback is the fact that they require a single user to interact at a time, leading to a time increase proportional to the number of students. The scanning process, required by biometric technologies, imply that the user has to be phisically present to be scanned. This way avoids impersonation in processes that require an external item that should be with the user (e.g. RFID).

Finally, all the previously mentioned technologies have very different costs associated with them, either monetary or in data storage. The biometric technologies are dependent on a phase of acquisition of the biometric data of each student and its storage on a database. There is also the associated cost of acquiring scanners to deploy in all the classrooms. This cost makes smartphones more interesting, because although there is a trade-off in accuracy, the majority of students already possess such a device.

Chapter 4

IamHere System

The following chapter will explain the implementation performed in the IamHere system. This system will be constructed over three main architectural components, that will have to work in synergy in order to replicate the use cases previously explained. Looking at section 4.1 it's possible to understand the components that constitute the IamHere system, both in the client and server sides.

The chapter will start by explaining the overall architecture of the system, as well as, the objectives and main interactions between the components. These components will have their sections, in which a more broad and thorough review is done.

Moreover, there is also a section aimed at analyzing the technologies used in each of the components of the architecture.

Lastly, the final sections describe the implementation that recreates the use cases depicted in chapter 3. From here, it was required the development of an application that gave a set of development screens to test the system. These are then followed by a set of mockup images that represent a more user friendly view of the service.

4.1 System Architecture

The proposed system can be observed in Figure 4.1, where is possible to visualize the connections between the system and the users, who will interact with it. Furthermore, it is possible to observe that the core system of IamHere, takes advantage of technologies, such as Spring Boot, which is a java based framework, and a MySQL database, which will be used to store information relative to the classes, the lecturers and the students. The IamHere service will expose a Representational State Transfer (REST) Application Programming Interface (API) that will have endpoints. These endpoints will be responsible for the communication between the smartphones and the IamHere service.

Finally, there will be a communication to a legacy system responsible to provide information, such as name, email and profile image, from the lecturers and students, in order to provide identification between them.

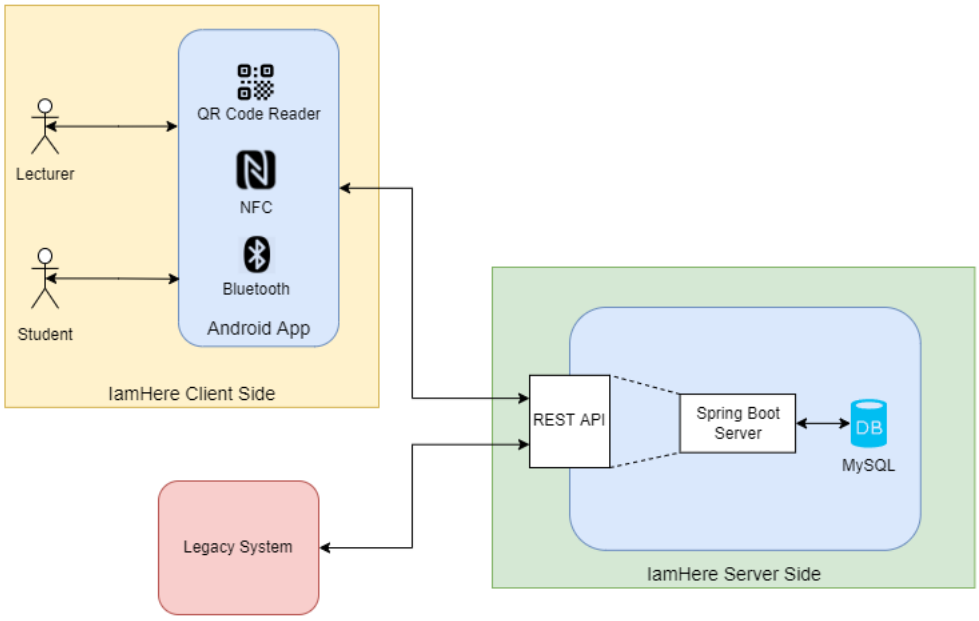


Figure 4.1: System Architecture

4.1.1 Client Side

The client side of the IamHere system, represented in the Figure 4.1, focused in incorporate the technologies RFID, NFC, QR Code and Bluetooth. These technologies can easily be brought together in a smartphone, easing the development of an application that can be provided to the end user. The use cases mentioned in this document can be accomplished by the synergy of these technologies.

This layer is also responsible for requesting and sending information to the server side layer. This exchange of information, if it is initiated by a student, will trigger a system request to retrieve said student profile information. This way, a student can access the information of a certain class and register his/her presence if needed. If the user is a lecturer, the system will then provide him with the information associated with his/her classes and allow the start of a presence acquisition process based on NFC, QR Code or Bluetooth.

In the IamHere system the RFID and NFC technologies are used in synergy. This means that if a student that carries a student card with RFID, it is possible for it to be read by a smartphone with NFC capabilities. The smartphone application constructed for an android smartphone, uses the NFC as reading mechanism to access the RFID card information. This information is then sent to the server side. This interaction can provide a couple of features. The first one is the possibility to register the association between a student and a studen's card into the system. The other possibility is to associate a card reading to the presence of a student in a class. After the association of the student to the student's card, the mobile application used by the lecturer will allow a read of the identification number present in the card. This way the data acquired by a lecturer, regarding the card, can be sent associated with a class, to the server side to verify the existence of said student card and record his/her presence associated with the class, if the card exists. The interactions offered by this method grant security against eavesdropping,

since the reading is executed at close range from the reader. However, the fact that the reading is done one card at a time, can bring nuisance if there is a large class, because the required time to acquire all the presences is proportional to the number of students. Nevertheless, it still provides a faster method than the traditional one of retrieving all the student's signatures or calling each student by name.

Moreover, the QR Code like the RFID and NFC require a mobile application to process the presence acquisition. Contrarily to the RFID and NFC interaction, this method only requires the smartphone camera, so that the QR Code can be scanned. Furthermore, this method is started by the lecturer, whom with the smartphone application can request the creation of a QR Code associated with a given class. This request will generate an image that is our QR Code. After the image is created it can be displayed using a URL. This fact allows the display of said image on the smartphone display or in a web browser page. This makes it a faster retrieve method of the students presences, if the QR Code is displayed with a classroom projector. However, if the lecturer displays the code in his smartphone, the students would have to go near it in order to record their presence. This last process can be compared with the RFID and NFC, because they both require the student to go near the lecturer's smartphone: in one case to scan his/her student card and in the other to scan the QR Code. When the QR Code is displayed on the lecturers smartphone, it will require the students to pass near him/her to scan the code. This will lead to a presence acquisition time proportional to the number of students. However, if the lecturer displays the QR Code on the classroom projector, it will allow all the present students to register their presence at the same time. Subsequently, if there is only one QR Code associated to the class, impersonation issues can arise. This can happen because the students can take a picture of the QR Code and send it their absent piers. The impersonation can easily be denied if the QR Code is recreated in time slots of seconds. This way, during the process of sending the QR Code, it would be invalid by the time those who are absent received it.

Another technology used was Bluetooth, nowadays present in most smartphones. With this technology was possible to develop a method to retrieve student presences. This retrieve method is dependent of the lecturer, because his smartphone needs to behave as a detector of Bluetooth devices. For instance, when the lecturer activates the Bluetooth detection method and the students enable the discoverability of their devices, it allows the lecturer to walk across the classroom detecting the present student's smartphones. This process is possible because Bluetooth technology allows the change of the Bluetooth device's name and enables it to be discoverable by other devices. Since it's possible to change the name of the device, it's possible to set it with a student code that allows student identification by the lecturer smartphone. After the student device is discovered by the lecturer, his smartphone will send the detected device's name to the server side. This way, the student association with the class can be verified and then a record of the student's presence is added to the system. Bluetooth allows a bulk detection of students, reducing the presence acquirement time, it does not have the impersonation issue that the QR Code has. This fact is due to the range limitation of Bluetooth, because the student smartphone must be close to the lecturer smartphone, not allowing absent students to register their presence from home when another student shares the QR Code with them.

Furthermore, to assist the users managing the system, an administrative dashboard is needed. This dashboard would allow visualization of classes and presences of a student. In the case of the lecturers, they would need more functionalities on the dashboard. Like the students, the lecturers would have access to their classes. Additionally, they would have the possibility of assessing all the students in each class and the presences associated with each one. Furthermore, the lecturer has the possibility to register a presence for a student, through a presence switch associated with the student, without the need of the previous talked technologies. Also, this dashboard allows the generation of a QR Code associated with a class, this way the lecturer can project his computer screen on

the classroom projector allowing the scan of the QR Code by all the present students simultaneously.

4.1.2 Server Side

In the IamHere system, the server side layer was created on a dedicated server. This server is located between the client side and the database, hence the importance of this architectural piece. In order to provide the data required by the users, a set of access endpoints were created in the server. These endpoints are based in paths that are constructed in two ways: dynamically, when a user id or other parameter is required, or statically, when is a direct retrieve of information from the database. These endpoints will not be accessed by all user profiles. This happens because the information that a lecturer may need is different from the one a student needs, hence the need to have different endpoints and with different logic's associated.

The server will use two communication channels, one directed to the client side layer and the other to the database. The retrieve and recording of data by users is only possible through the server, this way the access controls can be enforced and managed. When a student asks for a given class information, the request is sent to the backend server, this request will then be translated into a set of queries to the database. For example, when a student request is course classes the server verification's start by assuring that the student exists, and for that a request to the database for a student with the given student id is realized. If said query returns null it means the student doesn't exist. If the student exists, we can then request all the course classes associated with him. This query can return an empty list of classes. This happens when the student doesn't have any classes associated with him in that moment.

This backend server is also responsible for managing the creation of QR Code images. Each of these QR Code will be associated with a class day and stored in the server. After

the creation of the QR Code the lecturers will have the capacity to retrieve the image and display it through a URL.

4.1.3 Data Persistense

The IamHere system was built with a database as the data persistence mechanism. This allows the creation of a structured data model that offers a resilient and coherent base for the management of the system. This data model provides a structured method to create relations between the data, allowing a more efficient mechanism of consulting such data.

The database was created using tables. These can enforce the creation of unique entries on the table and relations between tables. These relations offer a structured way to question the database and the possibility to insert data into a table, following the data model restrictions. The fact that a given table A possess a relation with a table B will lead to an implicit verification of relation between the two of them. Looking at Figure 4.2 it is possible to verify that the table "CourseClass" has two keys: "course_class_id" and "professor_id". The first key provides uniqueness to each entry of the table and the second key enforces the relation between the table "CourseClass" and the table "Professor". This means that if we try to write an entry into the table "CourseClass" we have to provide a "professor_id" and this id must exist in the table "Professor", otherwise the operation will fail.

Moreover, the database modulation represented in the Figure 4.2 has six main tables: table "Person", "Student", "Professor", "CourseUnit", "CourseClass" and "ClassDay". These tables contain primary keys that provide uniqueness to their entries, although the primary key of the table "Student" and "Professor" is inherited from the table "Person". The fact that we can ensure that each entry in these tables are unique, allow us to relate them by having association tables like the "CourseClass_ClassDays". This association table relates the table "CourseClass" with the table "ClassDay". This means that we can

acquire all the class days identifiers associated with a given course class, by filtering the table "CourseClass_ClassDays" with the course class id.

Moving on, Figure 4.2 depicts the implemented data model in the IamHere system. From this data model we can identify, as core, the tables "Person", "Student", "Professor", "CourseUnit", "CourseClass" and "ClassDay". From the other tables we can look at "StudentCard" and "QRCode" as enrichment tables because they can complement the table "Student" and "ClassDay", respectively. This complement can be necessary if there is a need to associate a student card with a student or a QR Code with a given class day. Looking at the tables "CourseClass_Students" and "ClassDay_Present_Students", we can see they have a similar set of columns and they both use "student_id" as a way to associate a student with the entries. These tables, although they are independent, work in conjunction because on a first step, the students are associated with a given course class, through an association between the table "Student" and the table "CourseClass" stored at "CourseClass_Students". After this association is created, it's when the server allows a new association from a student to a given class day from that course class. This last association is stored in the table "ClassDay_Present_Students" and allows the verification if a given student was present in that class day.

Furthermore, was created another data model, present in Figure 4.3, and it can be seen as a simplification from the one in Figure 4.2. This data model does not have the notion of students and lecturers, but instead they are seen as persons. It also does not have the notion of course units or course classes, it only has notion of "Events". These two simplifications, backed by the tables "Event_Participants" and "Event_Supervisors", allow any person to take the role of supervisor or participant in an event, as well as, more than one supervisor. The fact that this model doesn't have the notion of student or lecturer user type, grants a more generic implementation with more possibilities of implementation across different industries.

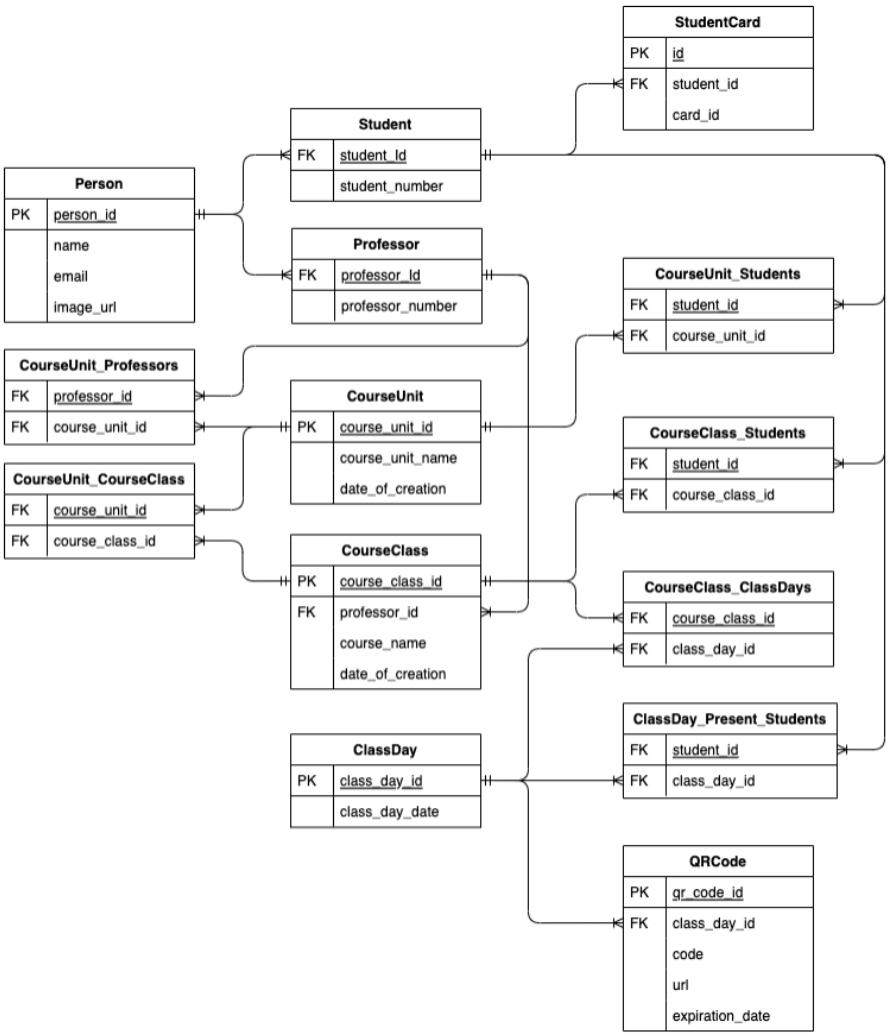


Figure 4.2: Implemented Database Model

Finally, both data models here explained can support the interactions previously described, but that in Figure 4.3 provides more versatility if the scenario isn't a classroom but a lecture, where the notions of students and lecturers are replaced by those of participants and supervisors.

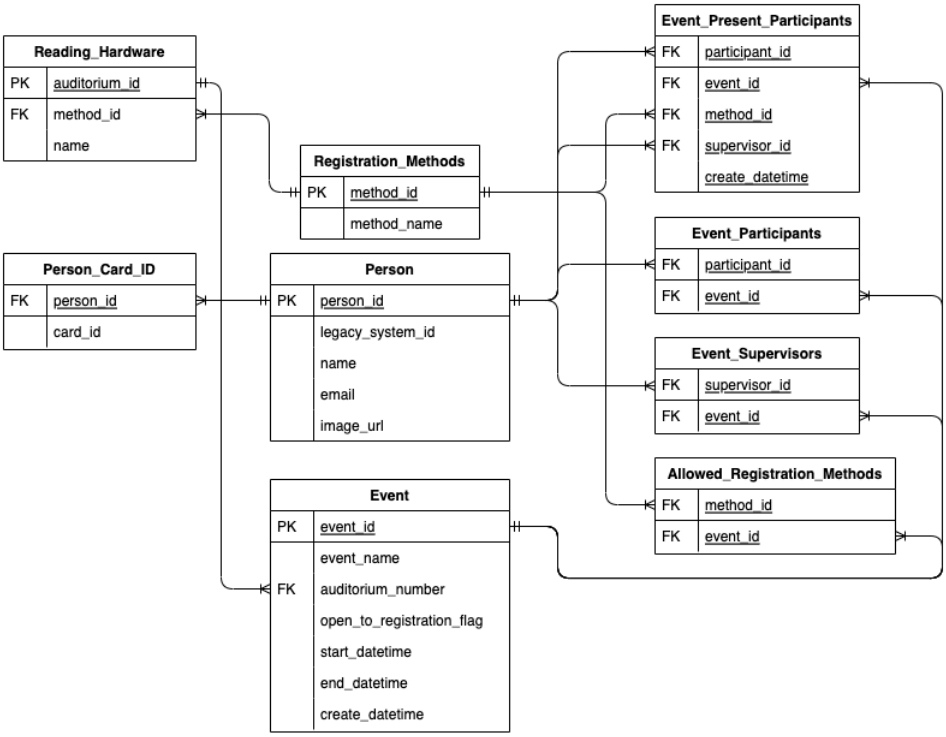


Figure 4.3: Reviewed Database Model

4.2 Development Technologies

During the planning of the IamHere system, it was predicted the need for client-server software patterns.

These patterns pass by needing the implementation of a client side mobile application, that will be the main interaction point for the users of the system. The other interaction point is with the server side, which will be responsible for the management and storage of the information needed for the correct functioning of the system. Having this in mind, it was used:

- Android - in order to create a mobile application;
- Spring Boot - which is a java based framework, that render possible the creation of server, from which the mobile app will consume the information that it needs;

- MySQL - which is a database used to store the information from whom the server will serve the information for the mobile application users.

4.2.1 Android Studio

Android Studio is a commonly used tool when developing Android applications. Android Studio is an Integrated Development Environment (IDE) that is based in IntelliJ IDEA[24]. It provides a code editor and the development tools present in IntelliJ, adding extra features that are directed to the development of Android applications[25].

Android Studio provides a diverse set of features that ease the development of Android applications. As it is a tool created targeting the need of developing Android applications, it brings an Android emulator and a diverse set of frameworks pre-installed for that purpose. It also gives the possibility of developing an Android application for any Android Operating System (OS) version[25]. On Figure 4.4 it is possible to observe the android emulator running an application that is in developing process. The fact that Android Studio provides a smartphone emulator does not invalidate the fact that it is possible to test Android applications, directly on a smartphone. In some cases, when the computer being used has low hardware specifications, it can slow down the emulator and the host computer. This can happen because the smartphone emulator is a virtual phone running inside the host computer, and it will require some of the processing power of the host. To bypass this problem, one can use an external Android smartphone, that will make testing an application a faster and smother process.

An Android application can be developed having as target the lowest OS wanted. This provides the possibility to develop an application that will be supported by an old smartphone, as well as by a newer one.

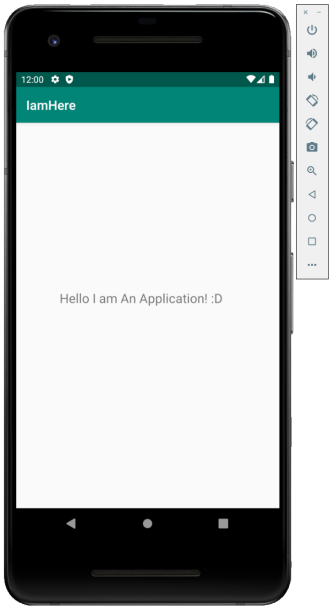


Figure 4.4: Android Studio Smartphone Emulator

4.2.2 Spring Boot

The Spring Boot is a framework that facilitates the creation of stand-alone, production-grade Spring based applications. This technology allows for the possibility to, quickly and easily, create a server.

The server that is created with Spring can use, as code base, the Java programming language, which is an object oriented programming language. This framework boosts the speed, simplicity and productivity in which is possible to deliver a java based application [26].

The use of Spring framework to create a server brings other advantages. During the development of this project some of these advantages stood out, namely:

- Fairly easy way to create a server;
- Possibility to create a database schema through the creation of Java classes;

- Possibility to easily configure a database connection through the Spring Boot properties file;

- The use of Beans that allow a fast configuration of the components of the server, through the use of keywords. These facilitate the configuration and interaction between the server components that, together bring the system we want to create.

Spring Initializr

In order to create a Spring Boot project, the Spring community has available a website where it is possible to configure a start up project suitable to the developer's needs, that can be observed in Figure 4.5. This website allows to choose in which base the project should be created: Maven or Gradle. Additionally, it allows the choice of the programming language in which it is desired to program the application. These languages can be Java, Kotlin or Groovy. After choosing the project base and the programming language, is time to introduce the project metadata, and for that there are some text input fields. These inputs are used to introduce the group of the project, the artifact name (which is the name of the generate source files of the application), the name of the application, a description of the application and a package name (that normally is a junction between the group and the application name). Next, there are two toggle button sections: one allows to choose which kind of packaging is desired, either JAR or WAR, and the other allows to choose which Java version use. Finally, there is a dependency selection section. This section facilitates the work for the programmer, because he can select all the libraries the application will need just by writing the names on the search bar and choosing from the available ones. Lastly, it is only needed to press the ''Generate" button, which will download the project with all the previous introduced configurations.

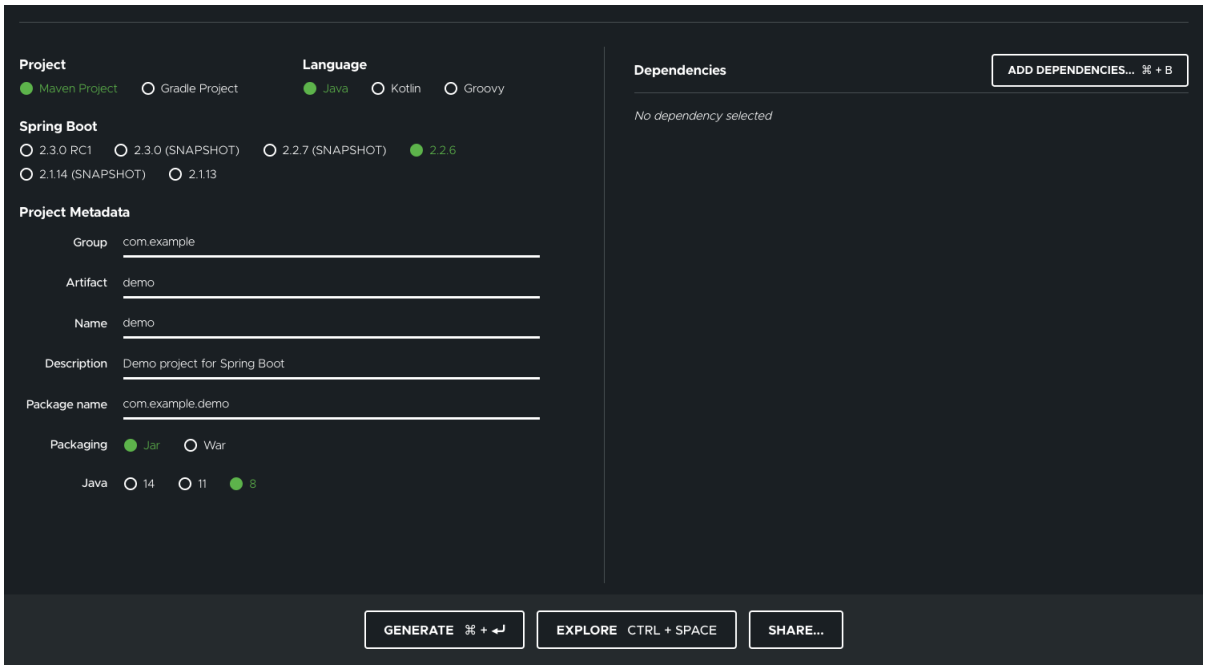


Figure 4.5: Spring Initializer

Beans

The Spring framework takes advantage of a mechanism called Inversion of Control (IoC). This mechanism has the objective of removing the need of writing repetitive code by the developer. This way the developer only has to create the classes that compose the target project and add lines started with ‘’@”, that will tell the IoC the existing dependencies inside the project and generate the needed code when compiling the project.

Database Communication

As mention before, when it is needed a communication with a database it is fast and easy to configure a connection to it. Looking to Code 1, it is possible to see the configuration needed to connect to the database. On the first line, is where it is defined a property that allows to configure the schema that the database needs to follow [27]. For this property it is possible to configure five modes as following:

- "none" – This mode does not interact with the database;
- "create" – Here on the start of the server the database is created accordingly with the entities models present on project;
- "create-drop" – This mode is similar to create, but it drops the table as the operations are finished;
- "validate" – This property is used to validate if the database has the tables and columns the project needs, otherwise an exception is thrown;
- "update" – Here the database is compared against the models created on the project and is only updated to match the project entities, without dropping unused tables or columns.

On the second line, is where the URL, that identifies the location of the database, is added. This configuration also allows to specify the name of the database, as shown on Code 1. The last two lines are used to specify the username and password that the server should use, in order to connect to the database.

```
spring.jpa.hibernate.ddl-auto=update
spring.datasource.url=jdbc:mysql://localhost:3306/database_name
spring.datasource.username=username
spring.datasource.password=password
```

Code 1: Database Connection Configuration

Database Schema Generation

Nowadays, the creation of a database is facilitated through the use of entity models, as shown in Figure 2. These models are generated through the creation of a java class that specifies the fields that compose the entity. On Figure 2, is possible to observe three lines

that start with ‘’@”. These lines are the ones that allow Spring to comprehend that the class has run time configurations that Spring must treat. The first line, where we observe ‘’@Entity” tells spring that this as class that should be mapped to the database, having the inner properties as columns. After thi, it is possible to observe two lines, one having ‘’@Id” and the other ‘’@GeneratedValue”. The first identify the property ‘’id” as being the primary key of the table Person and the second specifies that this property should be generated automatically by the database.

```
@Entity
public class Person{
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private long id;

    private String name;
    private String email;
    private String image;
}
```

Code 2: Person Entity

4.2.3 MySQL

MySQL is a very popular open source database. This database delivers good performance, reliability and is easy-to-use. MySQL has become a leading database in web-based applications and the fact that it is an open source database brings the advantage of low cost to acquire and utilize it.

A diverse set of global companies are using it nowadays, proving it can be a very dependable asset. Some of these companies are Facebook, Twitter, YouTube and Yahoo.

MySQL is based in the widely used Structured Query Language (SQL). Other databases that use this language are Oracle, Microsoft SQL Server, PostgreSQL and SQLite. The

language SQL was made a standard by the American National Standards Institute (ANSI).

4.3 The IamHere Prototype

The development required an application which helped validate the previous explained flows. This application served as foundation to the creation of the mockup figures in 4.9, 4.10 and 4.11.

For instance, it was required the capability of testing the system both on a student and lecturer's side. The screens present in 4.6 allow the impersonation of a student or lecturer. After the type of user is chosen, it is then allowed the choice of which user to impersonate.

a) Allows the choice between a student or a lecturer;

b) Displays a list of possible students to impersonate;

c) Displays a list of possible lecturers to impersonate.

(a) (b) (c)

Figure 4.6: Application Workflow - Developer Profile

The student side of the development application allowed, through the screens in Figure 4.7, the possibility to follow the use cases depicted in chapter 3. To accomplish the use

cases it was created a screen responsible to navigate the user to the desired tools, to register the presences.

Focusing in Figure 4.7:

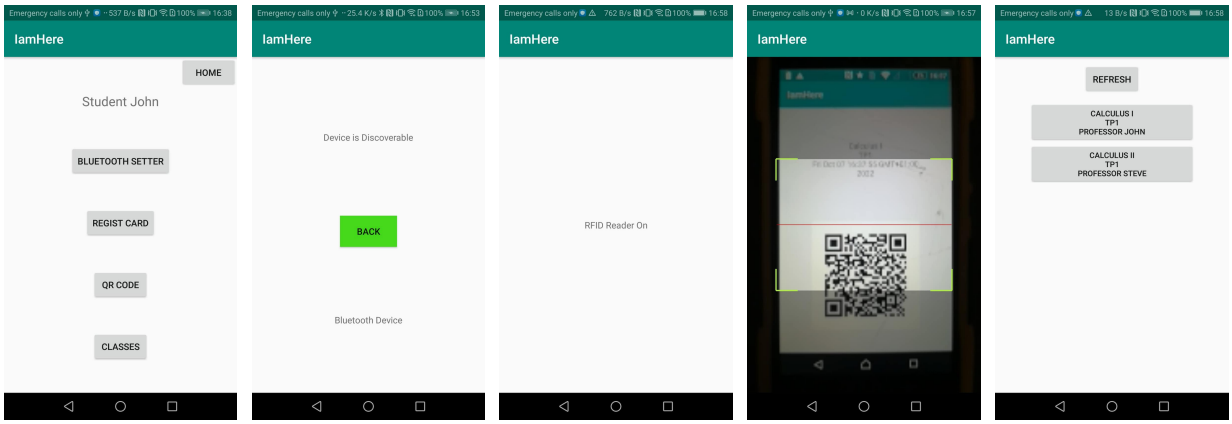
a) Displays the functionalities allowed to the student during development;

b) The smartphone acts as a student smartphone and enables discoverability to allow detection by the lecturer's smartphone;

c) Allows the association of a RFID tag with a student (this feature it is only supposed to be available to the student during development);

d) Allows the scan of a QR Code to record the student presence;

e) Displays the available classes for the chosen student.



(a) (b) (c) (d) (e)

Figure 4.7: Application Workflow - Student Profile

Just as important, the screens present in Figures 4.8 allow the impersonation of a lecturer, that when joined with the student screens grant the possibility to follow the use cases depicted in the chapter 3. Observing Figures 4.8:

a) Allows the choice of which class to manage;

b) Allows the choice of which day of the class to manage;

c) Displays the functionalities available to the lecturer, for a given class;

d) The smartphones enters in Bluetooth discovery mode to detect student smartphones;

e) When Bluetooth detects a student smartphone displays the student detected;

f) This screen allows the scanning of RFID tags;

g) When an RFID tag is detected the application displays the student's name associated with it;

h) The lecturer displays the QR Code associated with the class;

i) Displays a list of the students that have a presence associated with the class.

4.4 The IamHere Design

In the IamHere design were developed the bases necessary to provide the user with the use case scenarios depicted in chapter 3. From the use cases depicted the focus was on those that use RFID, NFC, QR Code and Bluetooth. These were the technologies that gave a more ease and costless integration in an android application.

The service has two similar interfaces in the android application, the existent differences are associated with the different roles the users can take: the student and the lecturer role. This difference influences the way these technologies are integrated in the application. Looking at the RFID and NFC technologies, the implementation is done on the lecturer application. The NFC on the android application works as a RFID reader. This way the students (without the need of an application) can scan their student cards on the lecturer smartphone and record their presence. However, QR Code and Bluetooth technologies need

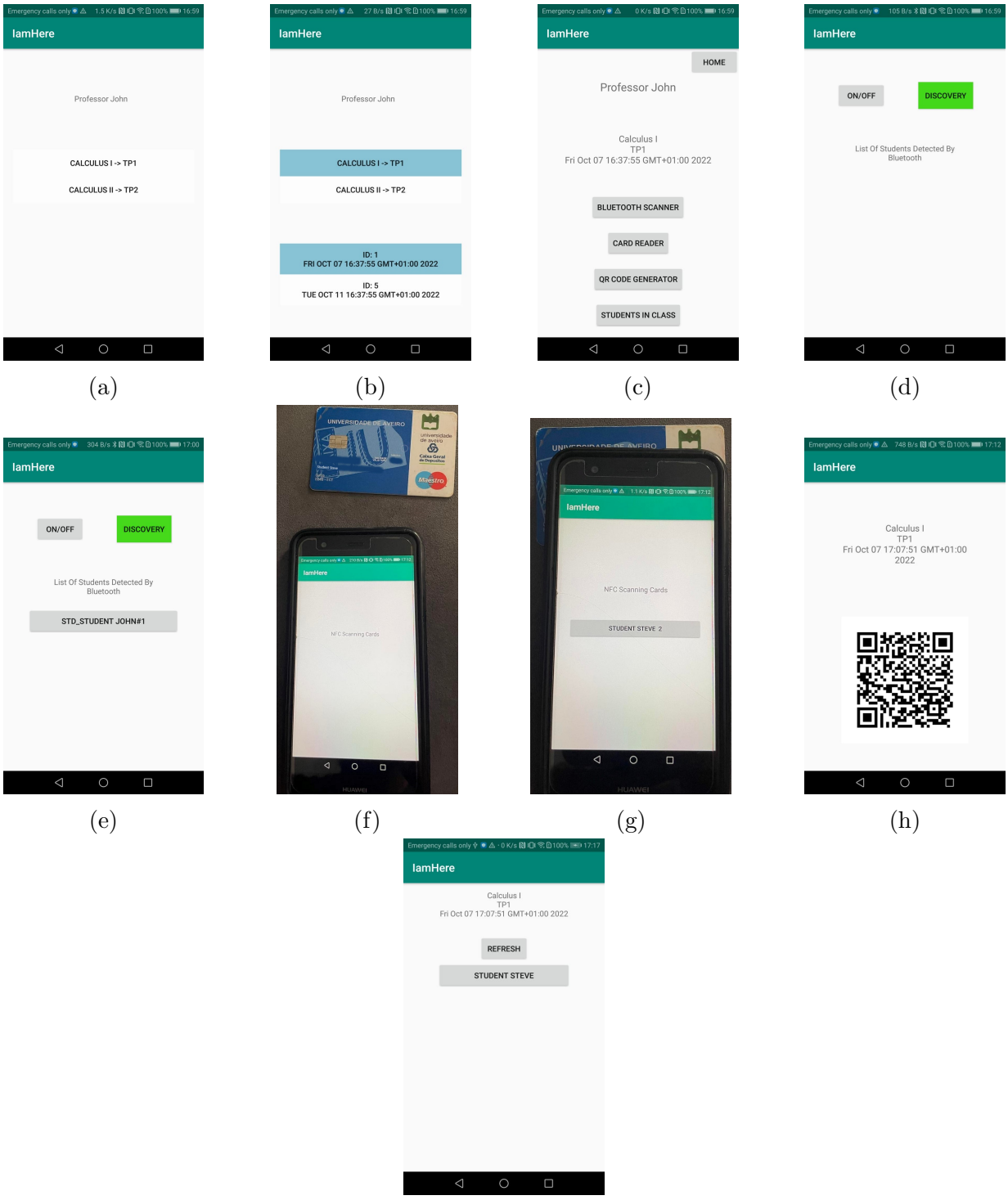
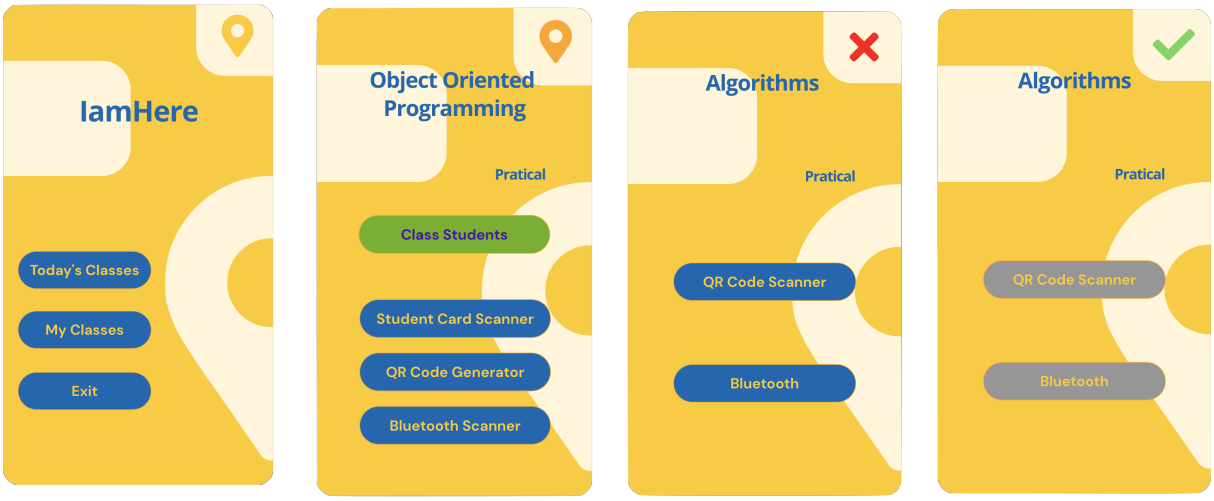


Figure 4.8: Application Workflow - Lecturer Profile

an android application for both students and lecturers. In the case of the QR Code, the lecturer application has the job of displaying the QR Code on the screen of the smartphone. In the case of the student application, it is required access to the smartphone camera to scan the QR Code displayed on the lecturer's smartphone screen. Lastly, the Bluetooth technology requires the student smartphone to be discoverable with a custom name for that class day. This way, the lecturer smartphone can look for Bluetooth devices to identify and record the students presences, associated with the class day.

The screens that are presented to the users are very similar between them. For example the home screen in Figure 4.9a is the same for both user roles. The main detectable differences are in the screen associated with a class day. Here are displayed different options for the different types of user roles. From the class day screens we can look at Figure 4.9b and Figure 4.9c and notice that they have similar options although they don't run the same process. For instance, both screens have the option for the QR Code, but on the lecturer screen he is going to request a QR Code to display and then show it on the screen as in Figure 4.10b. After the QR Code is displayed on the lecturer's smartphone, the student can scan it. For that the student selects the QR Code code scanner option present in the Figure 4.9c, which will prompt to the camera to allow the scan of the QR Code. The student screen has a second option which is related to the Bluetooth, here the student app will set the student smartphone as discoverable and allow the lecturer to use his smartphone to scan the Bluetooth devices that are discoverable in the classroom. On the lecturer smartphone while he is scanning for Bluetooth devices he will have the possibility to see which students are being detected, this screen is represented in Figure 4.10c. Moreover, there is an option that the lecturer has on the day class screen that the students don't have. This one is the card scanner option. On the card scanner the lecturer smartphone will use the NFC technology to scan the RFID student cards, the screen in which the lecturer does this action is in Figure 4.10a and, as in the Bluetooth screen, it is

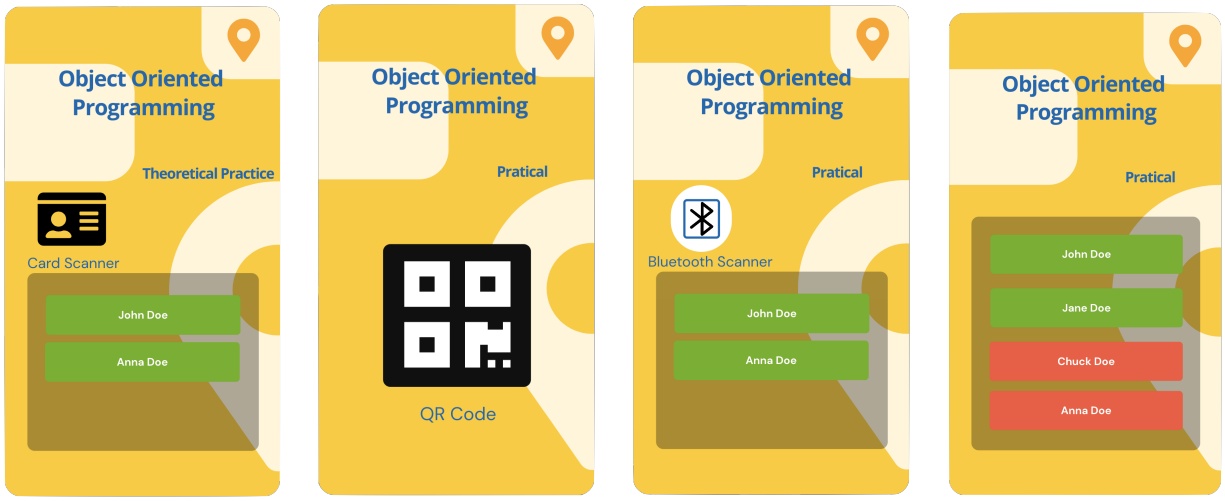
displayed the student to which the presence is being associated. Furthermore, the lecturer has the option to, at any given moment, verify all the class day students and which ones have a presence associated with them. Finally, the student screens present in Figures 4.9c and Figure 4.9d allow the student to verify if his presence have been registered for that class. First it's possible to see, in upper right corner, an "X" that represents the presence in the class that changes to a "check" when the student has a presence associated. Secondly after the presence is registered the action buttons are grayed out as seen in Figure 4.9d, to prevent further actions.



(a) (b) (c) (d)

Figure 4.9: Mockup Selection Screens

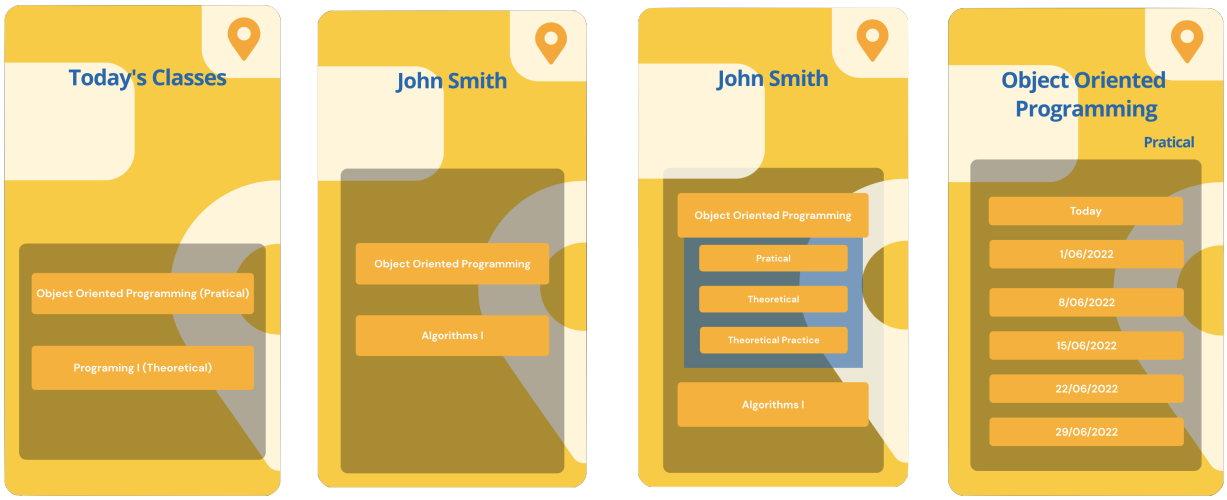
The IamHere mobile application also counts with screens that allow the student and lecturer to quickly access the classes they want to manage. In the home screen present in Figure 4.9a it's possible to access the classes that occur on that day, Figure 4.11a, to ease the presence retrieve process. On the home screen, if the user navigates to "My Classes", it will display the courses associated with the user, Figure 4.11b. If the user selects a course from the list, a dropdown menu will display the typologies available to the user as in Figure 4.11c. When the user selects a typology to visualize, a list of class days will appear, Figure



(a) (b) (c) (d)

Figure 4.10: Mockup Sensoring Screens

4.11d, allowing the navigation to a screen as in Figure 4.9b or Figure 4.9c, this screen will depend upon the profile of the user. If the user is a lecturer, he will have access to the tools to retrieve the presences. Otherwise, if the user is a student he will be able to see if he has a presence recorded to that class or record the presence at that time.



(a) (b) (c) (d)

Figure 4.11: Mockup Class Selection Screens

4.5 Summary

This chapter depicted the technologies and how they were implemented, in order to achieve the desired use case scenarios explained in Chapter 3. By having the use cases as guidelines, it was possible to use the technologies such as NFC, RFID, QR Code and Bluetooth, due to ease of implementation in a smartphone. This technologies, in fact gave a faster or more reliable way to acquire the presences of the students, allowing the lecturer to focus on lecturing the class. Technologies, such as face, iris and fingerprint recognition where not implemented due to the need of external hardware, that could not be emulated by a smartphone. Although the flows from these last three technologies would be very similar to the one implemented with the RFID and NFC. This similarity is brought by the fact that it would be a flow in which the students would be identified, one at a time.

Finally, the flows implemented in this chapter would accelerate the process of acquisition of presences. However, that would be dependent from a legacy system, which would have to provide the information of the users that would use the application, as well as the information associated with the classes.

Chapter 5

Conclusion and Future work

This thesis was developed with the purpose of providing a service capable of easing the attendance retrieval processes. In this document we started by providing examples of implementations and introductions of RFID, NFC, QR Code, Bluetooth, face recognition, iris recognition and fingerprint recognition. These examples brought a better foundation to a more consistent plan and design of the system. Next, were created use cases in which the previous technologies and the main actors were depicted interacting between them. These use cases gave a better understanding of the user requirements needed in the final service to provide a user friendly service. Following the use cases, we entered the implementation section. In this section was depicted the architecture and the technologies used in the construction of both client and server sides of the application. This architecture originated the creation of a development application, that was capable of executing the use cases associated with RFID, QR Code and Bluetooth. Finally, were designed the screens that transpose the development application features into a more user friendly application.

The developed system, with the implemented technologies, proved capable of identifying the students and accurately associate them with the correct class. Through the implemented technologies, it was possible to acknowledge that all the interactions decrease

the time required to retrieve the presences of a class. Regarding these technologies, is worth mentioning that QR Code and Bluetooth have a bigger decrease in time spent, when compared with RFID. This difference exists because the RFID interaction requires that the students interact with system one user at a time, while in the other technologies these interactions can affect all the class, at the same time.

The future work of this solution should focus on providing cross platform support. This way, it would be possible to reach a broader number of users. Further implementation can also use GPS, to create a geographic fence around the lecturer. This fence would allow the use of other stationary readers that, with GPS coordinates, could be associated with the class by being inside the geographic fence. It would also provide more security against impersonation, because it would force the users that want to be detected by the system to be within lecturer's reach.

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