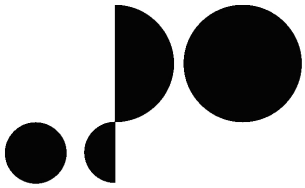

"WiAttend" Classroom Attendance Detection over Wi-Fi for Android

by

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ABBREVIATIONS

API	Application Programming Interface
APK	Android Package Kit
CD-ROM	Compact Disk - Read Only Memory
CPU	Central Processing Unit
CSS	Cascading Style Sheet
CSV	Comma Separated Values
DIY	Do It Yourself
GHz	Gigahertz (thousands of MHz)
HTML	Hypertext Markup Language
HTTPS/SSL	Hypertext Transfer Protocol Secure/Secure Sockets Layer
iCal/.ics	Internet Calendar
IEEE 802.11	Can be called as WLAN or Wi-Fi
ISM Band	Industrial Scientific Medical Devices Band
JSON	JavaScript Object Notation
KB	Kilobyte
MAC Address	Unique Identifier
MD5	Message Digest 5
MHz	Megahertz (million Hertz)
MIT	Massachusetts Institute of Technology
MS Visio	Microsoft Visio
PHP	Hypertext Preprocessor
RFID	Radio-Frequency IDentification
TX Rate	Wireless Transmit Rate
UHF	Ultra High Frequency
UoP	University of Portsmouth
Wi-Fi AP	Wi-Fi Access Point
WYSIWYG	What You See Is What You Get
XLS	Microsoft Excel spreadsheet file

ABSTRACT

This project integrates the smart technology of a mobile device, the surrounding indoor IEEE 802.11 signals for positioning and a remote server (API) to process and store data.

The integration of these various technologies, is achieved by the creation of an Android mobile application that allows the students of University of Portsmouth to prove their presence using just their mobile device. The device will exchange data with a remote server (API), which stores student attendance records.

For the completion of the Android application, usability testing was conducted, providing crucial data that were analysed and evaluated. In light of this evaluation, positive and negative aspects of the application have been identified and discussed.

Prior to the implementation of this project, research has been conducted on the already existing attendance system in order to eliminate as many drawbacks, using existing technology and taking into consideration the total cost of an actual setup of the new system.

Keeping always in mind that the majority of the students have at least one smart android device, the students using their smartphone, will be able to submit their presence using the new application.

1. INTRODUCTION

1.1 PROBLEM OVERVIEW

In the past, attendance checking was nothing more than a call of a name. The professor used to call each student's name, but once the number of students increased, it started to be a very time-consuming process. This process consisted of facial and voice recognition, and sometimes a recheck at the end of the session was necessary, which resulted to further wasted time.

Checking student attendance in schools and universities is a very important task that needs to be done during each session. It does not only "force" the students in a way to attend the class (Chung, 2004) but, it is also a safety measure that is conducted Internationally by the majority of universities.

The University of Portsmouth is currently using the "old-school" system of "pen & paper" and by scanning student ID's through an RFID reader. Both of these systems work but they are not quite accurate as they not only allow cheating, but they are also time consuming and since most of the in-class sessions last for only one hour, a new method should be introduced to limit the wasted time.

1.2 PROJECT AIMS

The aims of this project are to examine the development process of an Android application and produce a conceptual system, so it can be developed further as a commercial product for the use of the client.

The objectives of this work is the design and implementation of a classroom attendance detection application that eliminates as many drawbacks of the current university's system, using existing technology and taking into account the total cost of the actual setup of the new system.

The students using their smartphone, will be able to log into the mobile application using their existing MyPort username and password, and then register their device into the "New Smart System". Once their device is registered, they will be able to prove their attendance by simply using their Android smartphone.

1.3 PROJECT OBJECTIVES

1. Evaluate various IEEE 802.11 attendance systems that already exist
2. Conduct research and determine the systems requirements.
3. Select a suitable software development life cycle methodology to develop the system.
4. Select suitable software development tools for the mobile application.
5. Select suitable software development tools for the web based dashboard.
6. Integrate the mobile application, surrounding IEEE 802.11 beacons and API Server.
7. Calibrate an IEEE 802.11 beacon to avoid any signals to be transmitted outside of a specific range.

8. Implement a smart positioning algorithm, that verifies if the student is in a class.
9. Develop a web-based interface to have a visual representation of the database.
10. Document the whole process of the project.

2. INTRODUCTION

2.1 RESEARCH OVERVIEW

This section examines the research has been conducted on different attendance systems' substance, examining the earliest until the most modern technologies and methods, used to monitor the attendance of individuals in the educational and professional sectors. Crucial investigation has been conducted as well, on hardware and software currently on the market, in order to make a clear decision on the tools which will be used on the implementation process.

2.2 HARDWARE

Hardware for this kind of project is essential to track down, if the student is in the defined class. During the research process, various technologies have been considered to be used to solve the issue, but each one of them had its advantages and disadvantages that will be discussed below.

2.2.1 RFID TAGS

RFID are little chips embedded inside a card that somehow makes everything “smart” or “trackable”. Most RFID called “Tags” make no use of a battery because, they draw power from whatever happens to be reading them, for example the popular contact-less credit cards which are classified as passive. These Tags only consist of a tiny antenna and an embedded CPU to process radio waves and a small amount of data storage which can be as much as a few KB in total (Violino, 2017).

RFID systems are widely used on everyday credit card transactions or even to grand access into the University of Portsmouth Library. An RFID system consists of readers, tags, readers' controls and a software application to control and log into all the transitions.

The drawbacks of using an RFID system, are the additional cost of the installation and the possibility of a faulty reader or tag which results into a non functional system. Also, the possibility of a student to damage or lose the tag needs to be considered very seriously (Violino, 2017).

2.2.2 FACIAL RECOGNITION

The idea of a facial recognition can impress many of us, since it needs no readers, no signals and no bulky tags, but instead just a camera and an algorithm which can recognise your face and sort everything out for you. But is it really that simple? Once I started getting deeper into the subject, I realised that this is not the most suitable solution “yet” for the following reasons:

- Image Quality: The quality of the image can affect the running recognition algorithm, the better the image quality is, the better results it gets. So, high quality cameras are needed in every class, which is not an inexpensive way (Dutta, Veldhuis, R. N. J., & Spreeuwers, L. J., 2012).
- Processing and Storage: “Processing every frame of a video is an enormous undertaking”. Usually, such systems make use of clusters of computers to share the

processing and storage workflow. This results to additional costs on computer resources and storage (Edgell, & Trimpe, 2017).

- Privacy: Being recorded and having one's face stored on a database can be very frustrating and under the UK law it is illegal, if the person is not informed (Wall, 2017). Furthermore, The Guardian newspaper announced a “Huge rise in hack attacks as cyber-criminals target small businesses” (Smith, 2017). As we can see, even if the person is informed that they are being recorded, they will never know where those data can end up.
- Accuracy: In the last few years we have seen several announcements stating that their facial recognition system achieved near-perfect accuracy ("Google: Our new system for recognizing faces is the best one ever", 2017), but those tests performed on a very limited dataset of human faces with only 13,000 faces. Ira Kemelmacher-Shlizerman, a UW assistant professor of computer science also mentioned that, “We can’t just test it on a very small scale and say it works perfectly”. Another important research has been made by a team of the University of Washington, which challenged facial recognition teams to download a dataset with 690,752 unique individuals and test their algorithm ("LFW Face Database", 2017). Figure 1 represents a sample of the performance test, which illustrates that Google’s FaceNet took the lead with accuracy reaching 75% ("MegaFace - Identification Results", 2017).

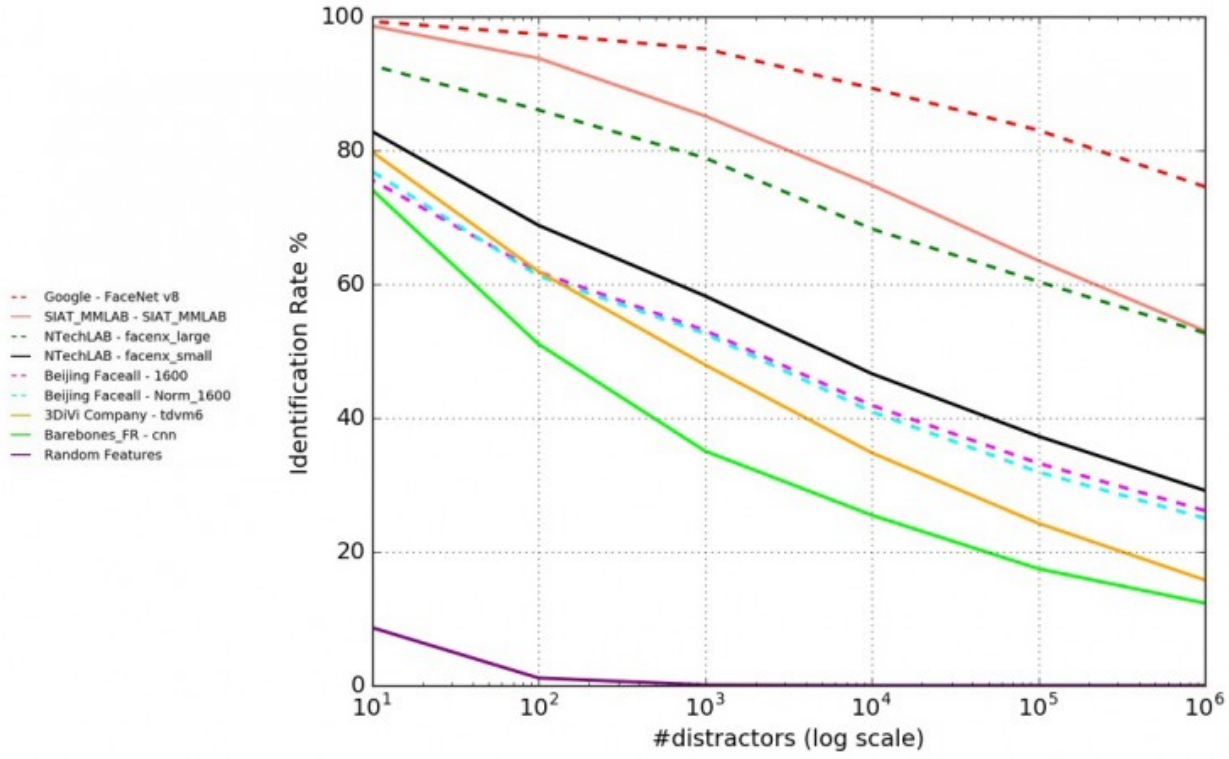


Figure 1 - Identification Performance Graph

2.2.3 BLUETOOTH

Bluetooth is a wireless technology standard for exchanging data over short distances, using short wavelengths UHF radio waves. Bluetooth transmits in the ISM band from 2402 - 2483.5 MHz also known as the 2.4 GHz licence free short-range radio frequency band ("Bluetooth Technology Website", 2017). It was invented by the Ericsson company back in 1994 as a wireless alternative to RS-232 data cables. It was not until 1997, when Jim Karthik made the communication between two portable devices possible using the Ericsson Technology, which is known to us today.

Bluetooth can transfer in low speed data such as audio, images and videos in a short range distance up to 60m - 100m. It is an interference resistant communication, but having a connection constantly active can really affect the power consumption of the transmitter and the receiver (O'Sullivan, 2015).

Bluetooth can be a useful and effective solution for a short range distance classes, but in cases where the entire area of a certain lecture room needs to be covered, bluetooth is not the best option.

2.2.4 IEEE 802.11

IEEE 802.11 or Wi-Fi, which stands for wireless fidelity are exactly the same thing. It is a popular technology used to connect multiple devices together without the need of cables (Baker, 2017). Wi-Fi is nowadays widely used on many portable devices, such as smartphones, laptops, tablets and the list keeps increasing day by day. It makes use of the 2.4 GHz licence free radio frequency and it allows "unlimited" simultaneous connections (Zaphyr, 2017). In addition, Wi-Fi network range can be easily extended using a Wi-Fi AP as a repeater.

The University of Portsmouth has already got its own Wi-Fi network installed and every class has at least one Wi-Fi AP to serve the students and staff. So by bearing that in mind, using the Wi-Fi technology in my project will not only reduce the cost of the implementation, but it will also be easy for the university to adopt the new system in future, since the possible changes will be minimal.

Furthermore, Wi-Fi nowadays is the key to marketing. People are obsessed with Wi-Fi, they feel the urge to be connected on a Wi-Fi network all day long, even if they do not clearly understand what Wi-Fi is (Wheeldon, 2017). Also, a Cisco's research show that 37% of people are willing to accept advertisements that might be irrelevant to them in order to grant access on a Wi-Fi network (Taylor, Young, & Noronha, 2012).

Finally, one of the disadvantages of the Wi-Fi technology is the indoor positioning accuracy. We know from fact that Wi-Fi signal can be measured by strength and not by distance. But researchers around the world like Atreyi Bose and Chuan Heng Foh, came up with a new model making indoor wifi positioning systems possible. It is worth to be mentioned that their model is not perfect but quite close to reality, where the difference of the calculated and the actual distance to be approximately around 2.3m to 2.9 m difference (Atreyi Bose, & Chuan Heng Foh, 2007).

2.3 SIMILAR SYSTEMS

A remote attendance detection system has been implemented in the past either as a commercial product or as a DIY project, each one of them was using different technologies, algorithms and features. On the following section a brief overview is given of several implementations with different technologies and compare them in every possible aspect.

2.3.1 BLUETOOTH ATTENDANCE

Mihir Dhkan created a similar application which is available now on the Android Market (Dhakan, 2017) that makes use of the Bluetooth technology. Mihir's idea is quite straight forward and can be divided into three steps:

- At the beginning, the software should be installed on the professor's device and in the very first step, the student needs to register their device by making their bluetooth devices discoverable. Then the software on the professor's device scans for those devices and creates a list.
- Later on, in every class the students should make their bluetooth devices discoverable again so the instructor can scan the area and check compared to the initial student list, who is absent.
- At the end of the session, the instructor can export the results as a CSV or XLS file.

2.3.2 AUTO ATTENDANCE

Mahvish Nasir came up with a very interesting idea, as his final year project. The Auto Attendance Face Recognition software with a combination of a High Quality camera, can detect every single face in the class and even distinguish the faces that should not be there (Nasir, 2017).

The Auto Attendance project needs an initial database with all the student faces, and the classes they belong to, in order to reach its full potentials. Then on every session the system scans all the faces that appear on the camera one by one, and compares them to the already registered ones. If the running algorithm returns a match, then the student's status is recorded as present.

2.3.3 SMART ATTENDANCE MANAGEMENT SYSTEM

Sukanta Biswas, an application development analyst came up with an idea identical to the Mihir's. But instead of using the Bluetooth technology, he makes use of the Android embedded Wi-Fi chip (Biswas, 2017). The concept is quite similar to the Bluetooth Attendance as it makes the professor's device act as a Wi-Fi AP, where the attendees of the session have to connect on it using the provided pass key. Then, the software will compare the students' Wi-Fi MAC addresses to a list of registered devices and return the results on the screen.

2.4 SIMILAR SYSTEMS EVALUATION

To conclude, based on the research I have discussed above, I decided to use the Wi-Fi technology for the following reasons:

- The cost for Facial recognition or RFID system is quite high for a mid-sized business like the University of Portsmouth. On the other hand, as it has already been said, the university has already setup a Wi-Fi network so there is not need for additional expenses.
- The Wi-Fi technology is not only a low cost solution but it also has high accuracy results compared to the facial recognition. It has almost the same accuracy results of a Bluetooth system but it is not limited to a short range frequency.
- In addition, the Wi-Fi technology does not breach any ethical issues like the facial recognition. No personal details will be transmitted or stored anywhere during the registration process.
- Finally, Wi-Fi stands out from all the other technologies for marketing reasons because, as Joe Chernov states “Good marketing makes the company look smart. Great marketing makes the customer feel smart.”

3. TECHNICAL APPROACH AND DESIGN

This section explains crucial project management methodologies that were used for the completion of the project. Having in mind the undertaken research and discussions that have been mentioned above, the project's specifications, technical decisions about the tools and the technologies that were used during the implementation, as well as the target devices and the final design of the application will be discussed and analysed in the following subsections.

3.1 PLANNING AND PROJECT TIMELINE

As Basil S. Walsh suggested "If you don't know where you are going, how can you expect to get there?" a decent planning for organising the project's tasks and personal deadlines was needed. For the advantage of a good time management, the project has been divided into several parts, including the scheduled supervisor meeting approximately once a week for providing updates or feedback about the current implementation process.

The parts that the project was divided into, can be found below in more detail:

1. Literature Review

   This part was one of the most important stages of the project. The research that has been undertaken on different technologies and several implementations carried out by other researches, not only saved valuable time but it also allowed the collection of the requirements of the system.

2. Design

   The design stage involved the selection of the tools and technologies necessary for the implementation, the declaration of the methodologies and the techniques among others, design the architecture of the system and finally design prototypes of each screen of the application. This stage sets the boundaries and sets up the workstation of the actual implication process.

3. Implementation

   The implementation phase puts all the pieces together considering all the research that has been previously conducted and involves the development of the final proposed product.

4. Testing and Evaluation

   This stage is carried out at the beginning of the implementation process as well as at the end of the implementation. The testing was conducted by the developer as well as by the supervisor. The testing process brought in sight minor bug fixes and future improvements.

5. Final Project Report

   The final stage of the project involved the composition of the report going through every single aspect that was carried out during the implementation process. In this report, essential results have been obtained and evaluated followed by a final conclusion.

The project's plan can be found in the Appendix D.

3.2 IMPLEMENTATION APPROACH

The implementation stage was divided into several parts as well. These stages involved the clarification of the requirements, the initial prototyping of the system, the implementation based on the requirements and initial prototypes, as well as the testing and evaluation of the final product. Finally, all the decisions made have been analysed and explanations have been provided discussing the tools selected and the tools that have been rejected.

3.2.1 SPECIFICATION

"WiAttend" aims to become a must have application for the students of the University of Portsmouth that will allow them to prove their presence in the class by using their Android device. Also, this application should not be limited into functionality, it should allow future improvements and the code structure should be easily maintained. Due to time constraints, the project's functionality has been divided into XX stages for now:

- The first stage involved the registration of the user's device with the university's system. By registering the user's device, possible false presence submissions will be eliminated and the security of the system will be empowered.
- The next stage involved the core function of the project which is the collection of data that will be analysed and determined if the student is in the right class on time and then record the presence accordingly. This function involves several methods of data collection and data analysation using mathematical formulas.
- Another crucial stage is the ability to inform the personal tutor in case the student can not make it to class on a specific day. The application should allow the student to send an e-mail to the personal tutor informing them about their absence through the application
- Added to the core functionality, a calendar has been considered as a useful requirement which allows the student to view the provided by the university session's schedule on the "WiAttend" app. Such functionality can be considered as useful, since the student will not need anything other than that.
- Last but not least, the interface plays an important role into the whole project. An approachable interface to students is necessary for this kind of application, since it targets both students with IT background and students with no IT knowledge at all. The satisfaction of the user while using the "WiAttend" app is a mandatory key for the project's success.

The features requirements that have been mentioned above have also been divided into technical and design ones. The technical requirements involve the functional and non-functional requirements of the project. The design requirements include the attributes that have been taken into consideration during the research, on how to develop a user friendly application. The requirements have been categorised and listed below:

Technical requirements:

- Registering Devices
  The application should require by the user to register at most one single device into the university's system. This security measure disallows multiple or false entries into the system which can lead to false records, or even cheating the system.
- Smart scanning/positioning algorithm
  In order to prove the students' presence into the class an algorithm should be running that collects and analyses data and determines the students' positioning at a specific time.
- Presence Submission
  Upon positioning determination, the system should update the system's database and mark the student as present if is indeed in the class.
- Calendar View
  The user should be able to load an .ICS file through a live link into the application. Once the file is loaded, the calendar entries are shown in a classic calendar style interface for better user experience. This feature is partially functional. The idea was to load the student's calendar directly from the MyPort account, but because of the lack of MyPort's API, it has been decided to load the .ICS file from a live link. The feature can be fully functional on future iterations.
- Additional sample future improvements.
  The application includes sample features that can be implemented in future iterations. These features are not fully functional and the data they contain are for demonstration reasons only. The features allow the student to view personal details currently on the university's server, the marks that have been achieved on various modules, as well as the key dates of the university.
- Remove device from the system
  The user can remove the android device's records from the system at any time. This feature can be useful in case the user would like to use a new device or just to completely disable the remote attendance system.

Design requirements:

- Ease of use UI
  The key for an easy to use UI is to design it in a way that no guidelines will be required to use it in its full potentials. The UI experience should be as simple as it can get, without the need of a user manual for further explanation.
- Prevention of unexpected errors
  In general "WiAttend" is collecting data, but collecting false data automatically makes the project useless.In order to ensure that no unexpected errors will occur, the UI should prevent the user from making any changes during crucial data processing. This safety measure does not eliminate the possible errors but it reduces the possibilities to a high percentage scale.

- Usage of UoP colour palette

  “WiAttend” is intended to be used by the University of Portsmouth. So the colour palette should be similar to the UoP’s. This not only makes the application more adoptable but it also makes it look “good”, which is one of the key elements in the mobile app development area.

- Well informed pop-ups

  As has already been foretold, no written guidelines should be required for the use of the application. One of the most important aspects to achieve that goal is to have well informative pop-ups that can guide the user during the usage of the application. This will not only reduce the errors' possibilities but it can also make the user’s experience more enjoyable.

- Avoidance of gestures and special effects

  In order to keep the user’s experience to a high standard, special effects and gestures have been avoided. These effects might look “good” but at the same time they are “memory hungry”. Saving the processing resources of the targeted device leaves space for additional features and improvements that are more useful than a looking-good colourful effect on the screen.

3.2.2 TOOLS AND TECHNOLOGIES

i. Software Platform

The chosen platform for the implementation of this project was a one-way option. Based on the NetMarketShare the most popular mobile platforms are Android that reaches up to 62.94% of popularity, and right behind it is the iOS with 33.39% (Netmarketshare, 2017). Although, due to the fact that there is no public API on the iOS platform that gives direct access to iPhones Wi-Fi chip to scan nearby Wi-Fi networks (Technical Q&A QA1942, 2017), Android platform was the final decision.

ii. Targeted Devices

Based on the AppBrain’s graph the most common Android API Levels are 14-25 (AppBrain, 2017). By excluding older API levels does not makes much of a difference since, it takes out just the 2% of the Android popularity. Furthermore, older API’s are not supported anymore by the Android community so the security risk can be high.

iii. Portrait Orientation

Due to time constraints, it was decided that the application would run only on portrait mode. This decision was made to reduce possible errors due to the fact that “Some device configurations can change during runtime (such as screen orientation, keyboard availability, and language). When such a change occurs, Android restarts the running Activity (onDestroy() is called, followed by onCreate())" (Android Developers, 2017). In addition, such functionality was not considered as mandatory, but there is always the possibility to be added in the future.

iv. Hybrid (Cordova) vs Native

Choosing between a native and a hybrid app was one of the most important decisions during the implementation. A native app can offer better performance and easier access

to built-in device's capabilities. On the other hand, hybrid apps offer lower cost of development and they need lower requirements (Marszałek, 2015). Furthermore, hybrid apps use cross-compatible technologies like HTML, CSS, Javascript etc. which are familiar technologies and no time is needed to be spent on learning new languages. Also, a hybrid app can be adopted on different platforms like iOS and Windows without any further changes into the code. Based on the facts that have been discussed above, Cordova has been selected to be used.

v. Ionic vs Xamarin Framework

Both Ionic and Xamarin can be useful to develop a hybrid interactive app but each one of them has its own pros and cons. Xamarin needs a licence that costs $1000 per year per developer (Xamarin, 2017), it takes time and needs a lot of patience to debug, nevertheless it offers many features and it is also easy to maintain. Besides that, Ionic is an open-source framework licensed under MIT and it is known for its ease of use and rapid development features. The benefit of using Ionic is that it offers average user experience and it is not suitable for complex apps (Malhotra, 2016). Ionic was the chosen framework due to the open-source availability and the rapid development features that it offers.

vi. HTML5 and AngularJS

The core languages for the project implementation have been determined to be HTML and AngularJS. Ionic framework makes use of HTML5 for the UI environment and then AngularJS takes over all the functional environment. “This process can be called MVVM (Model View View-Model) where Models talk to View Model objects through something called the $scope object, which listen for changes to the Models. These can then be delivered and rendered by theView, which is the HTML that expresses the code“ (Conrad, 2012).

vii. Software Equipment

For the implementation of the project, several tools needed to be used in order to fulfil every aspect of the preset requirements. Some of the tools were not really necessary but they made the implementation process much easier.

- Cordova version 6.5.0, which wraps the HTML/Javascript app into native container that allows access to the device functions (Apache, 2017).
- Ionic framework is offered in two versions. Ionic v2 which is the latest one, provides everything that Ionic v1 offers, with a much more flexible framework, but it lacks on plugins compatibility since it is a brand new version. Ionic v1 on the other hand, is an older version but, the majority of plugins are fully supported and the internet had plenty of documentations and problem solving solutions for any kind of issue that has been faced (Ionic, 2017).
- Ionic Creator has been used for the creation of the UI prototypes. The creator is provided for free by the Ionic Team but with limited features. A paid subscription was also available but it has been avoided since low cost is one of the project’s objectives.
- Sublime Text v2 has also been used for the coding part. Sublime is a lightweight text editor that supports a huge list of coding languages (Sublime Text, 2017). Since this project deals with several different languages, Sublime fulfilled the project’s needs and no additional text editors were needed.

- Pixelmator has been used for the creation and modification of several graphic contents that were required by the UI (Pixelmator, 2017).
- MS Visio has been used for the creation of all the demonstration diagrams (Microsoft, 2017).

viii.Cordova Plugins Equipment

As it has already been said, Cordova is a platform that gains access to the Android environment using several plugins. For the implementation of this project the following plug-ins have been used:

- Ionic Calendar directive gave to the application a shiny taste of a calendar and allowed the visualisation of the .ICS file on the screen (twinssbc, 2016).
- iCal Parser script written by Carl Saggs based on JavaScript helped the .ICS file processing and exported the data into a format that can be readable by the Ionic Calendar Directive (Saggs, 2012). In order to achieve that, minor modifications were needed.
- Wi-Fi Wizard plugin allows the WiFi management on Cordova based applications (Apache, 2015). This plugin has been used for scanning surrounding Wi-Fi networks.
- Cordova File Transfer allows the download of external file into the device (Cordova, 2016). The plugin has been used for downloading the .ICS file from live links.
- Mohamed Sarah released the MacAddress plugin that helps to export the device MAC Address in a text format that has been used for the device registration (Salah, 2014).
- Angular MD5 plugin has also been used to encrypting the exchanged data for better security reasons (gdi2290, 2016).
- RandomUser.Me API has been used to generate random user data. This is “a free, open-source API for generating random user data. Like Lorem Ipsum, but for people” (RandomUser.Me, 2017).

ix.Remote API Server Tools:

The application is a third-party system that exchanges data with the already existing university’s system. For security reasons UoP does not provide any access to the existing system, so a demo system needed to be implemented to test and evaluate the project's functionality. The server is considered to run a MySQL server service for storage purposes and an Apache Service to handle all the application's requests. “WiAttend” is designed to send data into the API Server for processing, the server processes the data and replies back to the device with a successful or unsuccessful status according to the processing output.

- For the database decision there was not much to consider, since university's servers make use of the MySQL and one of the objectives of the project was to be easily adoptive. It can be considered that this was another one-way option. If that was not the case, MySQL would still be the choice because it is widely used for this kind of implementations and it provides massive security measures. It is also an up to date database system (MySQL, 2017) and it has very good documentation available to guide the implementation through every single step.

- For the database design MySQL Workbench was used since it provides an easy to use platform with all the necessary tools for High-End database projects (MySQL, 2017).
- For the server side processing PHP was decided to be used. The reasons behind this decision is that it allows easy access to the MySQL service and there are plenty of resources on how to integrate an Ionic app with it (Masteringionic, 2016).

3.2.3 CHOSEN METHODOLOGY

A Methodology is the framework which is going to be used to structure, plan and control the development process of a system (Chowdhury & Huda, 2011). Making the right decision for the chosen methodology is a crucial task because it does not only provide planning guidelines to follow for the completion of the project, but it also includes techniques, models and tools that can speed up the development process; it can help to deliver the product on time and it reduces the risk of failure.

Incremental development methods are very beneficial for small to mid-sized individual projects that require their completion in a short period of time. These methods are similar to the waterfall model but in addition it allows backtracking (Van Cauwenberghe). Backtracking makes changes to the initial design possible if it is required, which is not possible with waterfall. The model works in sprints and each sprint involves a specific feature or a group of similar features. Each sprint can last from one to two weeks and at the end of each sprint testing and evaluation are required. This methodology makes the client have direct interaction with the product because, the client can be the one who tests the product and gives back to the developer recommendations to evaluate on the next sprints (Panoptic Development). This approach offers a very good impact on the project's process because it ensures that the product will fulfil the clients' requirements and expectations to a maximum level.

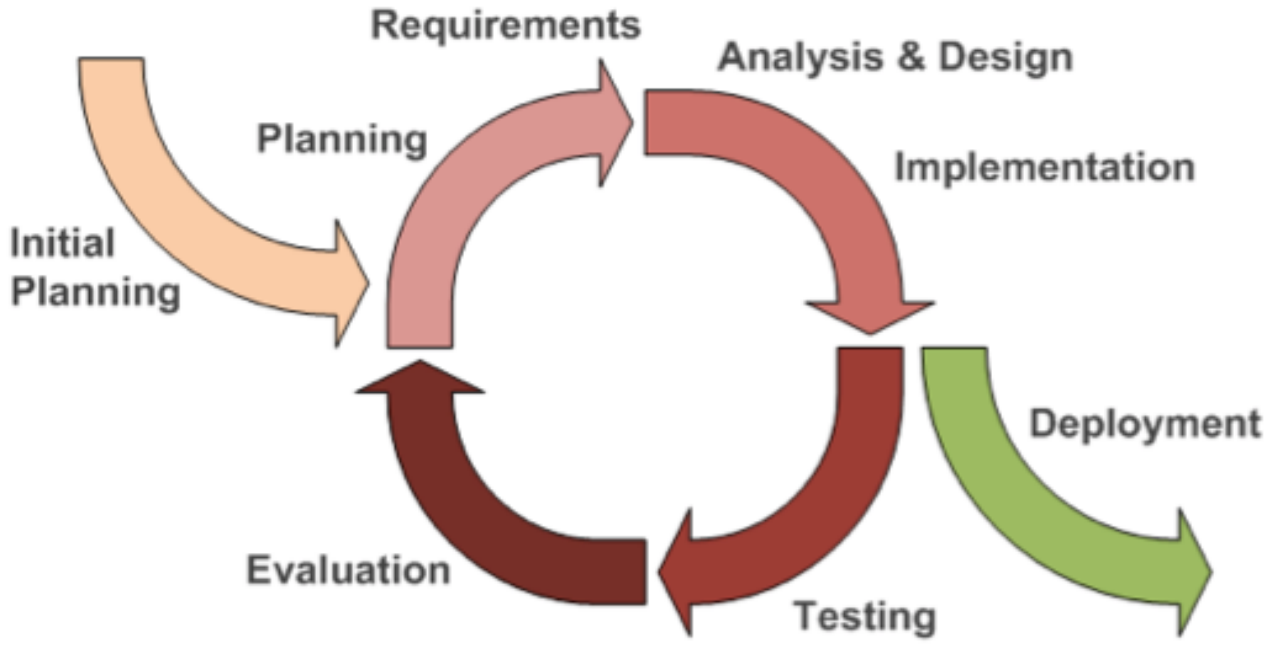


Figure 2 - Iterative and Incremental Development Model (Sheehan, 2013)

For the “WiAttend” development, the Feature Driven Development (FDD) methodology has been selected as it is an Iterative and Incremental Development process that allows feedback to be given from the supervisor/client on each iteration. Based on that feedback, modifications on the initial design can be possible and it ensures at the end of the development process that the supervisor/client is pleased with the final outcome.

3.2.4 SYSTEM DESIGN

i. System Architecture Design

Technically, the UI that is designed using the Ionic framework can be called a WebView that occupies the entire screen and runs in the native container. The operating system which in this case is Android uses the same Native container and with that combination, Cordova can grant access into the device’s services and input using different plugins. Figure 3 represents an image graph on how Cordova interacts with the device’s Operating System.

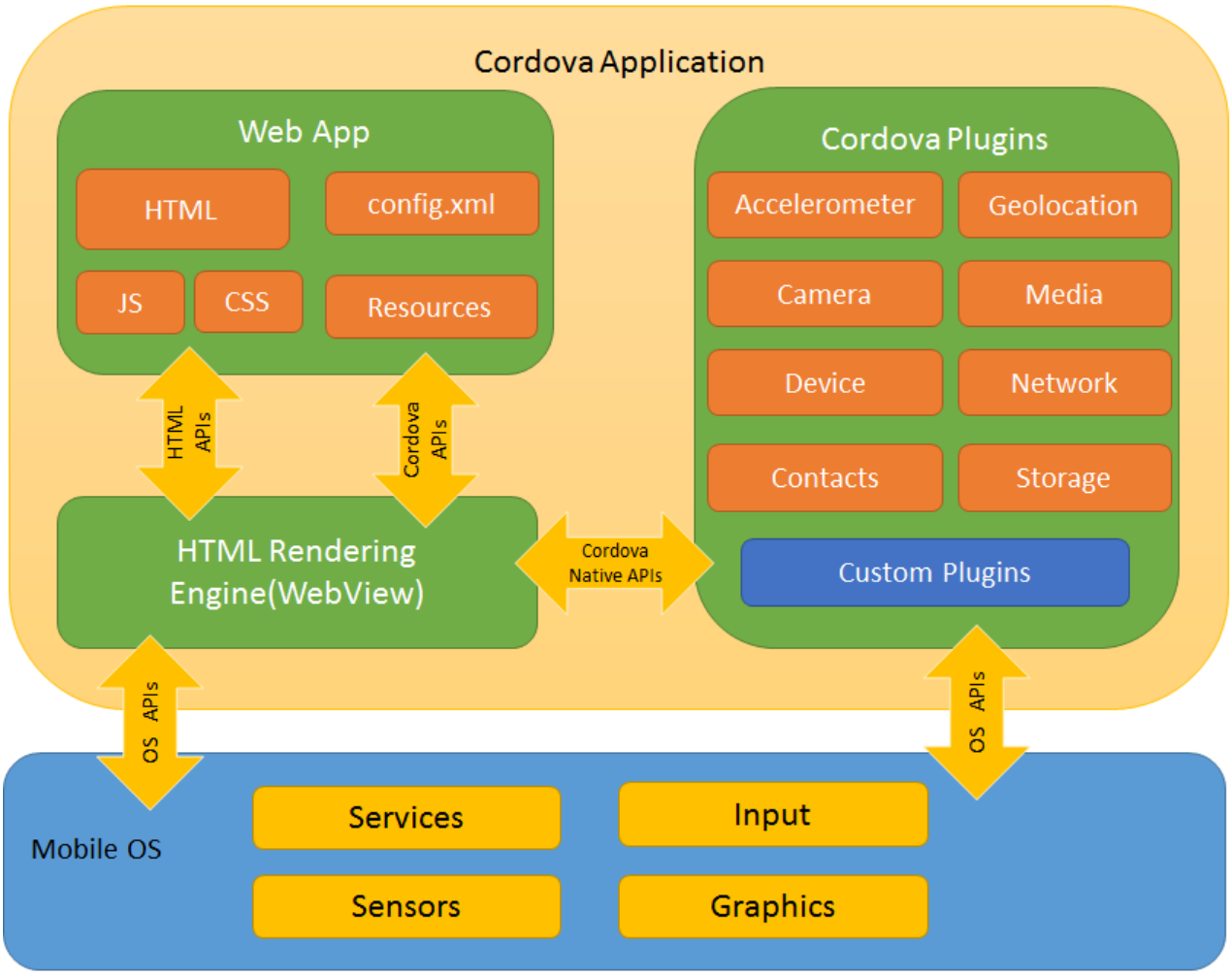


Figure 3: Cordova Application Architecture (Apache Cordova, 2017)

In this case, using the Wi-Fi Wizard plugin the application is granting access into the Wi-Fi chip and it creates a list with the surrounding Wi-Fi networks. Then along with the user’s identification details (encoded) they are sent to the Remote API Server for processing and the device is waiting for the server’s respond. Once the data are

processed, the server updates the MySQL database and a response is sent over to the device to inform the user about the results. A web-based dashboard has also been considered for implementation, which allows an overview of certain data on the database to be inspected during the project demonstration.

ii.Application UI Design

According to the design requirements, the UI should be user-friendly and easy to navigate through all the functionalities that have been discussed previously in this report, without the need of any written manual. The UI has been decided to be implemented into 7 different pages including the home dashboard. The pages are as follows:

1. The dashboard that includes the navigation menu for all the application's features.
2. The calendar page, where the calendar UI directive is implemented.
3. The attendance page, where the presence submission can be made.
4. A page that includes the student's marks.
5. A page that contains the student's personal details.
6. The "Key Dates" page, which redirects into the key dates web page of the UoP.
7. Finally, the "Preferences" page where the student can register the device on the API Server or to enable the calendar feature.

The figures below are going through every single page that has been designed for the "WiAttend" application, along with explanations on why they have been designed in that way and the requirements they served.

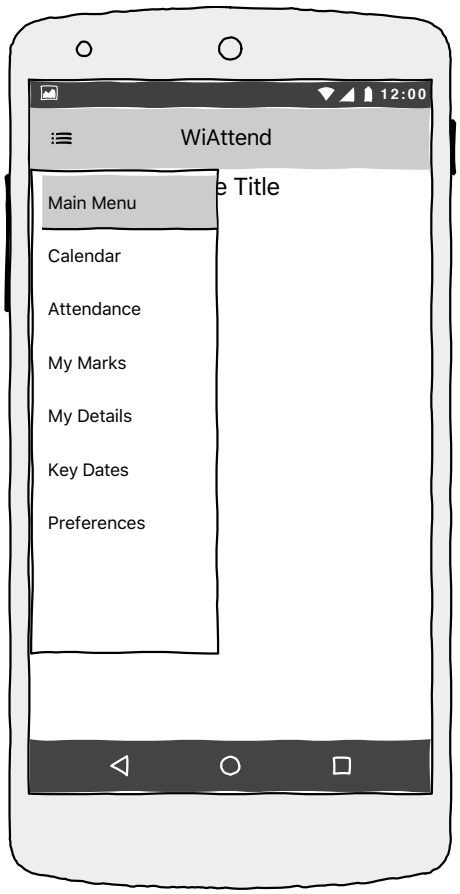


Figure 4 - Initial Home Page Prototype

The initial design of the home page required the user to tap the menu button on top left corner to bring up the navigation menu so the user can navigate through the application's features. This method though showed that the device was using more memory resources because of the default Ionic's animations and also it was not as user friendly as the initial specifications required. After a lot of consideration, a new design was implemented.

This new home page is the first screen that the user sees once the application is loaded on the device. It consists of a grid of 6 buttons that can be used immediately without the need of loading another menu page or any animations that can stress the memory resources of the device. This method does not only make the UI user friendly as required, but it also gives a taste of a well organised menu.

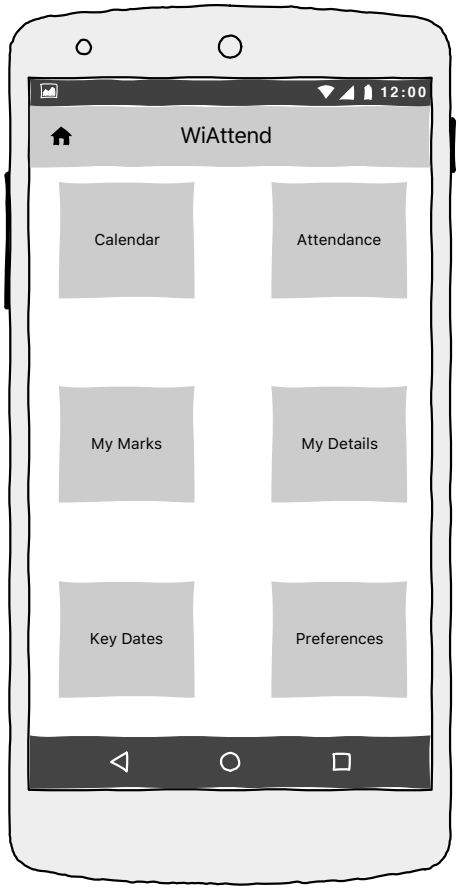


Figure 5 - New Home Page Prototype

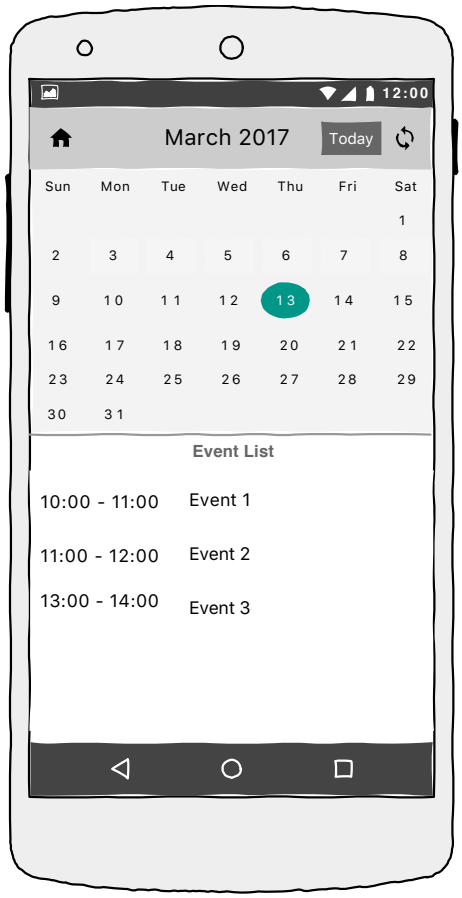


Figure 6 - Calendar Page Prototype

The calendar page allows the user to navigate through the present calendar events. The top status bar consists of a home button that returns the user back to the dashboard, the name, year, day of the month, a button that returns the user to today's date and a refresh button that reloads the .ICS file.

On the upper half of the screen the user has the ability to swipe left or right to change the page/month on the calendar View. Also, by tapping on any date on the calendar, the events of that day are loaded on the lower half of the screen which is the event list.

The attendance page is the core View of the application but it consists only of 3 buttons.

- The checking button that requires the user to tap and hold for a few seconds in order to activate it.
- The report absent button that loads up the device's default email client to send an email to the tutor.
- The rescan AP's button, which rescans the area for Wi-Fi networks.

At the end of the page a few lines of notes inform the user on how this View works.

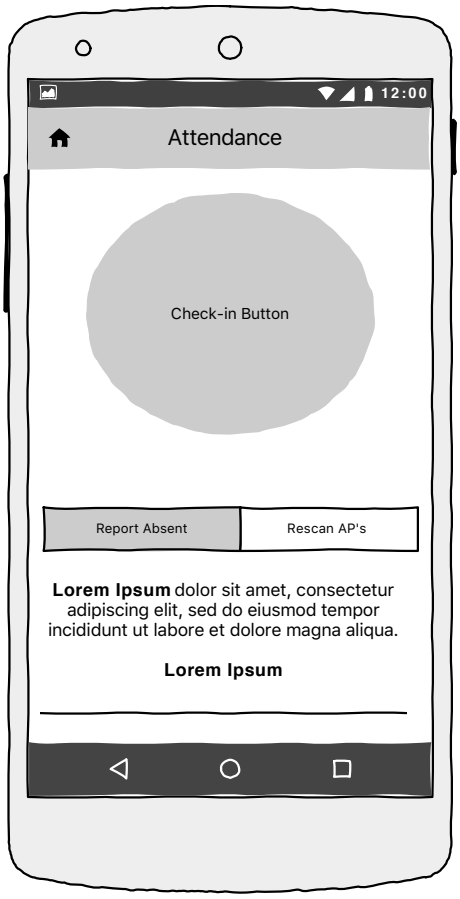


Figure 7 - Attendance Page Prototype

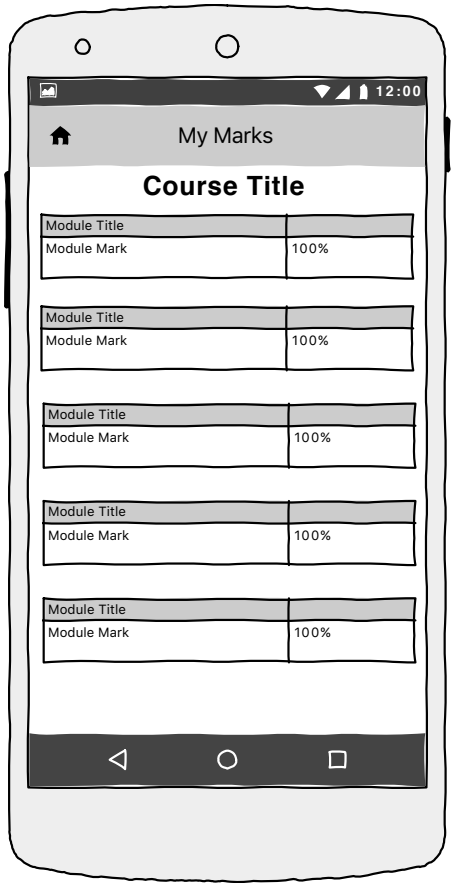


Figure 8 - My Marks Page Prototype

The "My Marks" page includes the student's course title on the upper centre of the screen and underneath several tables follow with the modules that are included in the course along with the student's achieved mark. The design of this page is quite simple since it is for demonstration purposes only.

The “My Details” page has a banner on the upper section of the screen that includes an avatar image, the full name and the studied course of the student. Underneath, a table of the rest personal details of the student follows. This page will also be implemented for demonstration purposes only, so the details illustrated are invalid and were taken from the RandomUser.Me API.

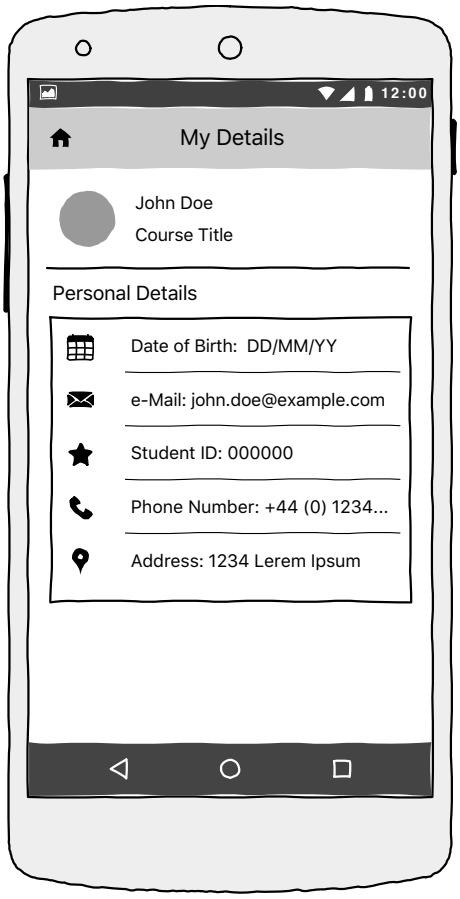


Figure 9 - My Details Page Prototype

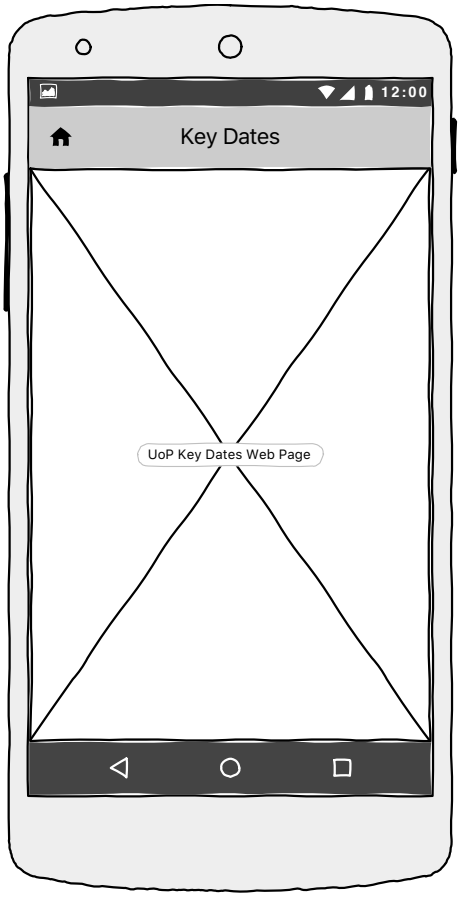


Figure 10 - Key Dates Page Prototype

The “Key Dates” page is a simple view, that loads in an inner frame, the Key Dates web page of the University of Portsmouth. There is no special functionality here. The user can navigate through the web page as in a normal browser.

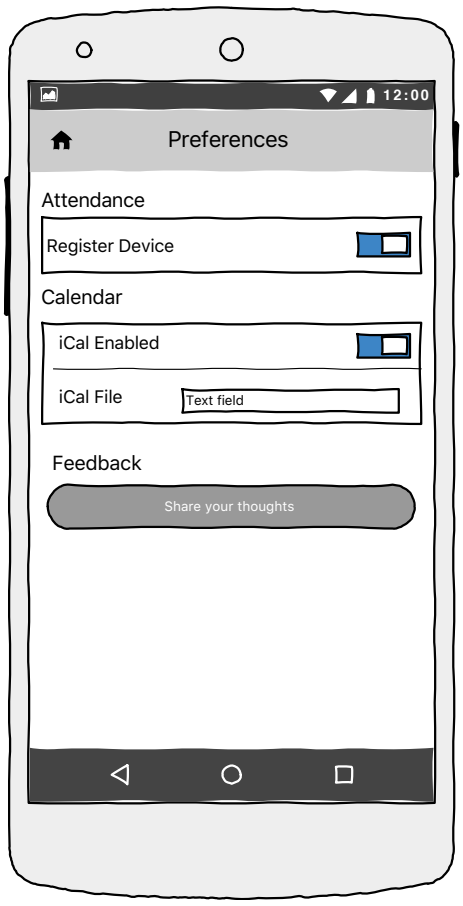


Figure 11 - Preferences Page Prototype

Finally, through the “Preferences” page the user can register/unregister the device on the system to enable/ disable the check-in feature. By taping on the switch while the check-in feature is disabled, a redirection to a login page appears. Figure XX, describes the design of the login page.

In addition, on this page the user can enable/disable the calendar feature. To do so, the user is required to enter the link of the .ICS file on the text field and then tap on the toggle switch to enable it.

At the bottom of the page, there is a button which allows the user to email the developer of the “WiAttend” application and share thoughts or possible bugs.

At the very top of the Login page there is an “X” button on the status bar which returns to the preferences page. Underneath the status bar, two textfields are added, which require from the students to enter their username and password and submit them to the API Server for verification, to register their device and enable the check-in feature. If the verification succeeds, the switch on the “Preferences” page opens.

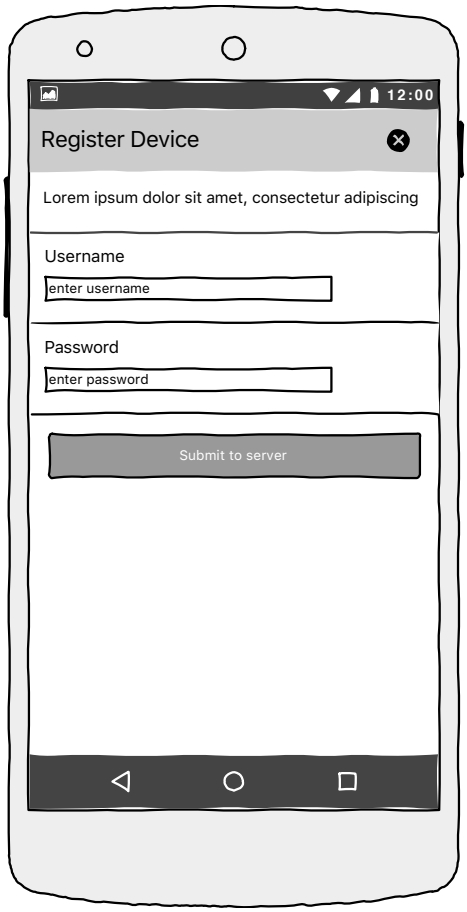


Figure 12 - Login Page Prototype

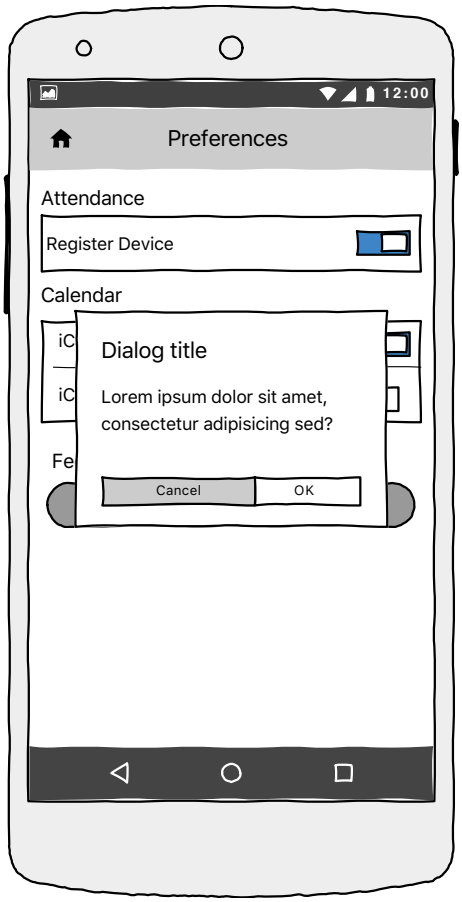


Figure 13 - Dialog Pop-up Prototype

If the user for any reason decides to disable the check-in feature, a tap on the switch is required and a prompt pop-up is shown on the screen. The pop-up requires from the user to confirm that decision by taping on the 'OK' button, or cancel to keep the current settings.

By taping on the 'OK' button, the device will automatically be deleted from the server database and switch the toggle off.

During certain procedures, notifications are required to inform the user on the success or the failure of a process, as well as general warnings. The notification pop-up consists of a title, an icon which visualises the notification's status and at the end a description of the notification. All the elements of the notification are dynamically changed according to the needs of the application.

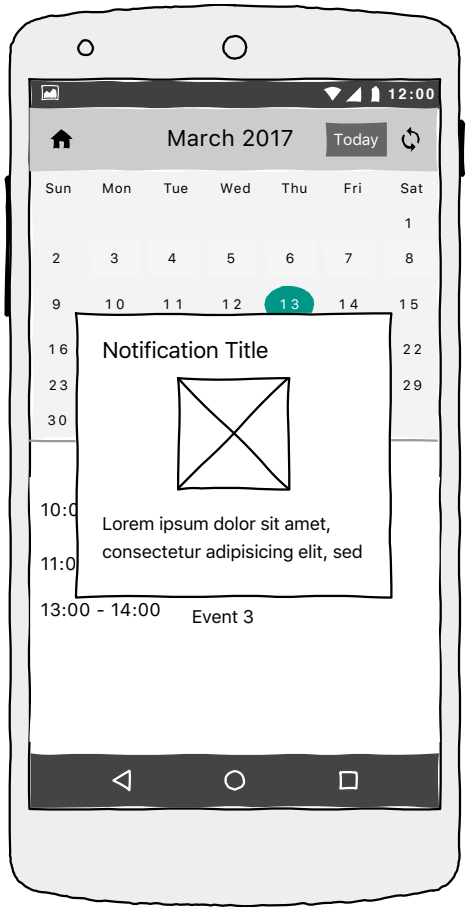


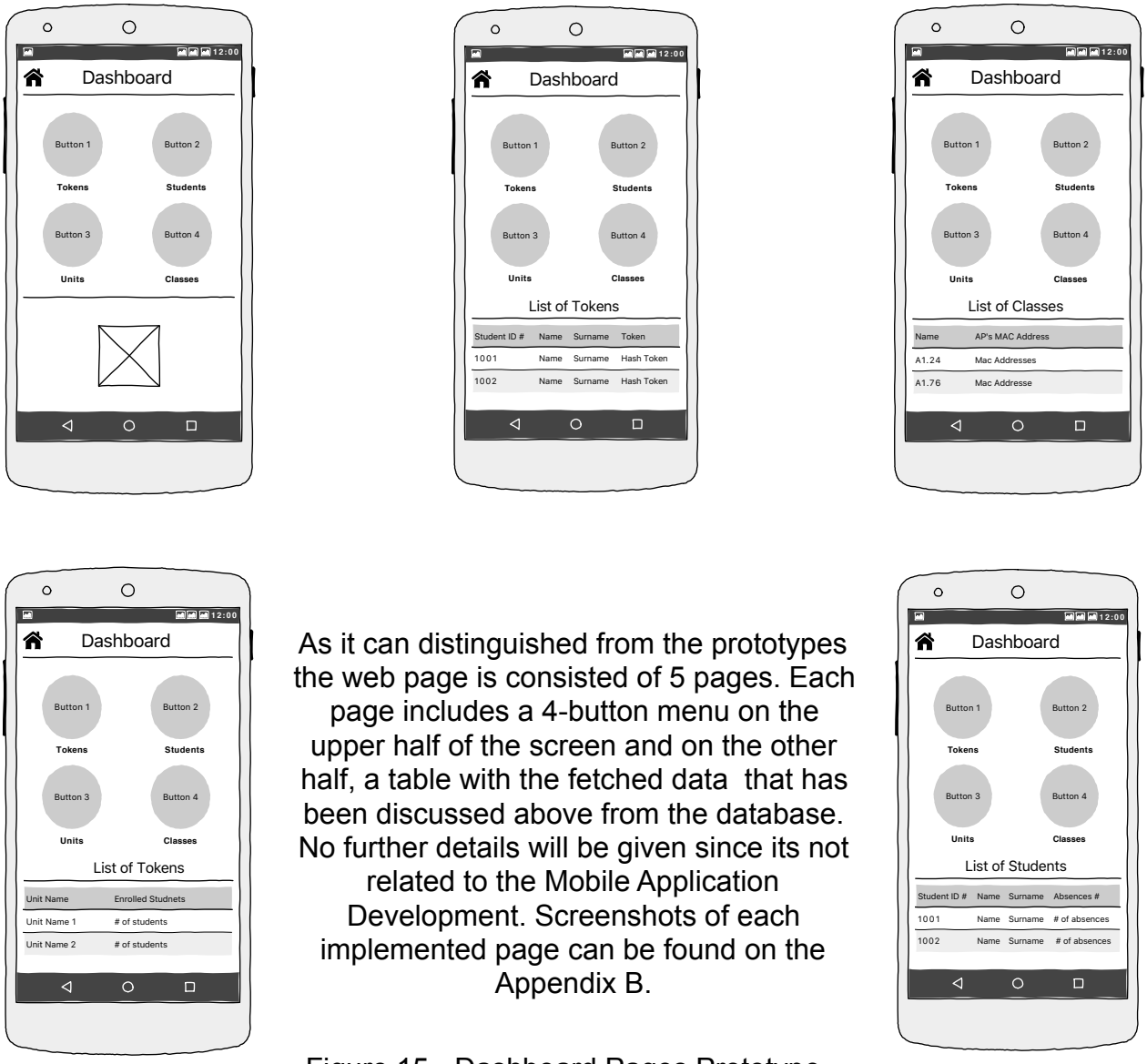
Figure 14 - Notification Pop-up Prototype

viii.Dashboard Web Page Design

For demonstration purposes a live database overview was needed. The reason for that was to demonstrate the changes that occur into the system when a student for example attempts to submit a presence. The Dashboard web page was required to show details about:

- When a student registers a device into the system
- The total number of absences that each student has
- The total number of the enrolled students of each Unit
- The list of total classes and their assigned Access Points in each class.

For the design of the dashboard no special requirements were needed because as it has already been said this is for demonstration reasons only. In order to save some time and effort that can be really useful in different aspects of the project, bootstrap has been decided to be used for the UI. The figure go through all the screens' prototypes along with some explanation.



As it can distinguished from the prototypes the web page is consisted of 5 pages. Each page includes a 4-button menu on the upper half of the screen and on the other half, a table with the fetched data that has been discussed above from the database. No further details will be given since its not related to the Mobile Application Development. Screenshots of each implemented page can be found on the Appendix B.

Figure 15 - Dashboard Pages Prototype

ix.Database Design

The majority of the “WiAttend” features are based on the data that are fetched from a database. For the implementation of the application no database was given, so a new one needed to be designed and act as the UoP’s current database system. Using that database the application can send, receive and process required data for each feature of the new system. Since, this database is for demonstration and testing purposes and not an actual database that will be used in the feature, the design is focused more on the needed by the “WiAttend” application data and not on the data that an actual attendance monitor system needs. The database design can be found on the Appendix C.

x.The name of the App

The name of app came up by putting together two words, Wi-Fi and Attendance. Wi-FI because of the technology it is using, and Attend because of the functionality it provides. By putting those two words together and a slight modification on the pronunciation of those words, “WiAttend” came up.

5. IMPLEMENTATION

5.1 IMPLEMENTATION OVERVIEW

According to the chosen methodology that has been discussed on section 3.2.3, it allows the implementation of the project to be divided into sprints that last one or two weeks each. The implementation process has been divided into 5 iterations and each iteration includes testing and evaluation.

The software of the project is structured into 4 different parts:

- The actual “WiAttend” Application which acts as a client to send, receive data and inform the user about the outcome of the requested function.
- The Database that keeps the data organised, so the system’s functions knows exactly where to look for the requested data.
- The Custom API that is the “man-in-the-middle” that sends and receives data from the mobile application to the database server.
- The Dashboard Web Page that shows an overview of the Database.

5.2 ITERATION ONE

The initial iteration of the project, involves the preparatory work for the future iterations which covers the installation of the Apache Cordova, producing the application UI by following the initial prototypes using the Ionic creator, populate the database and finally set up the API Server.

5.2.1 SETTING UP APACHE CORDOVA

By following the documentation manual of the Apache Cordova the installation took several minutes. The installation involves the use of several command lines on the terminal, and the creation of a directory that will house all the required files that have been created on the future iterations.

5.2.2 CREATING AND POPULATING THE DATABASE

As it has already been discussed, a database for the system is required for future features. By the end of this step, a small database was created and populated with random data. The database was created based on the initial database design that was produced on the initial database prototype on section 3.2.4. The source code of the database is located inside the CD-ROM that is attached to the report.

5.2.3 PRODUCING THE UI OF THE MOBILE APPLICATION

Ionic framework provides its users a WYSIWYG creator that makes the creation of the UI of any app simpler. The creator provides the developer with a list of elements such as text boxes, labels and buttons which can be dragged and dropped on to the preferred position of the phone’s screen and then, can be exported into the Cordova directory that has been created in the previous section for further development of the functionality. Following the prototypes that have been previously discussed on the section 3.2.4 the UI of the application was produced and imported into the Cordova directory for the next iteration. Screenshots of each page can be found on the Appendix A.

5.2.4 TESTING

At the end of the first iteration, the Cordova environment was ready for further development and the UI of the application was in a working condition allowing the user to navigate through all the specified pages that have been created. In addition, the database was ready to be used on future iterations. On the next iteration, partial functionality will be given to application.

5.3 ITERATION TWO

The second iteration covers the device registration with the system, which includes the integration of the “WiAttend” application with the API Server. In addition, during this iteration the demo pages “My Marks” and “My Details” were implemented as-well.

5.3.1 REGISTERING THE DEVICE

The registration process involves a series of procedures and data verification. At the begging, the user navigates to the “Preferences” pages and taps on the “Registering Device” toggle. Then a login page appears that asks from the user to enter the username and password. On submit, the entered details along with the device Wi-Fi Mac address are sent to the API Server. The Server then confirms that the entered data are correct, and inserts a new row into the Tokens table of the database. At the end of this procedure the device is registered and a Token/Hash is generated and stored on the device. If the entered details are incorrect then the user is automatically redirected into the “Preferences” page. It is also worth mentioning that during the data exchange process with the server, MD5 encryption has been used in order to encrypt all the exchanged data. By encrypting the data, the system ensures the security and the integrity of the sensitive data provided by the user.

It has been proven that MD5 encryption is no longer secure which results to the data being exposed when sent over the network (Brown, 2013). An alternative safer way to encrypt data during an exchange is by using the well known HTTPS/SSL tunnelling. This method though, involves the purchasing of signed SSL certificate, which costs about £180 according to GoDaddy.com (GoDaddy, 2017). Since “WiAttend” is a conceptual project, MD5 encryption has been used to simulate the encryption, but it is strictly not recommended.

The figure 16 illustrates a diagram that explains the registration process in action.

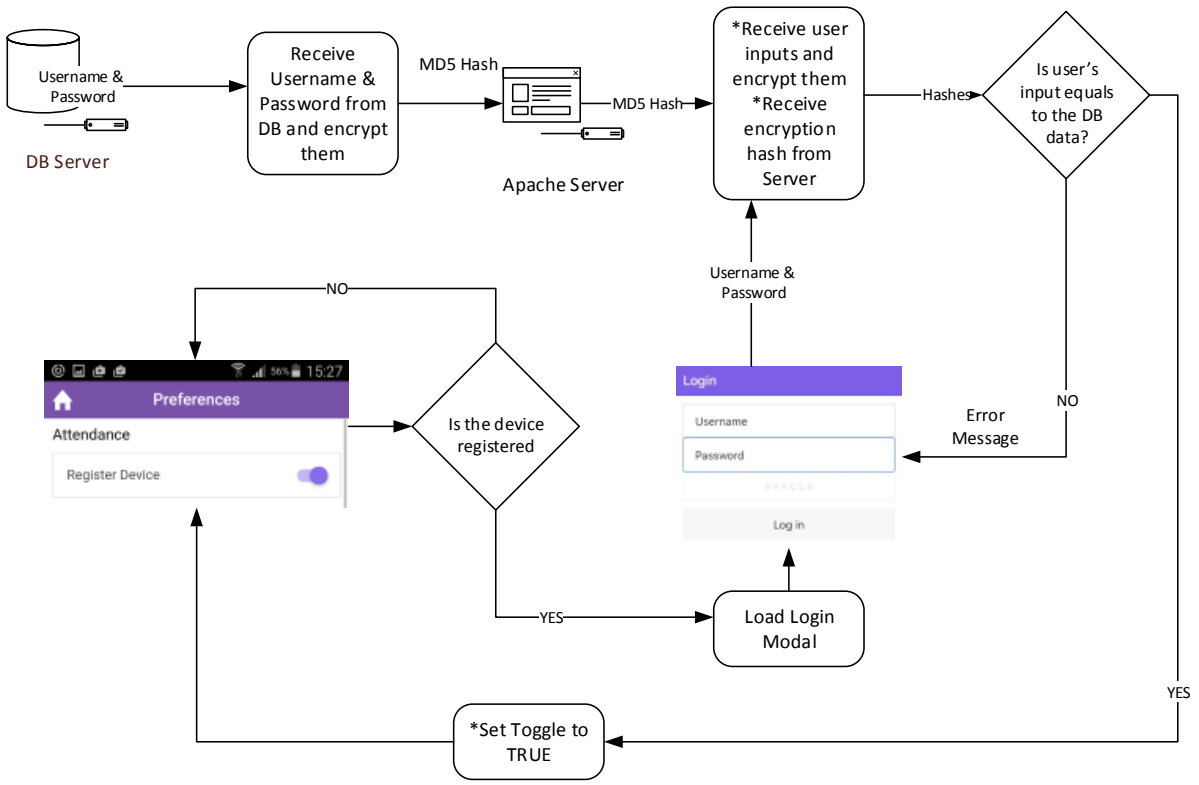


Figure 16 - Registration Process Diagram

5.3.2 MY MARKS PAGE

For this page a JSON File has been created that has a list of different courses along with their modules. When the user loads the “My Marks” page, a random course is selected, and its modules are listed in a table each along with a random number that represents the achieved mark on that module. None of the displayed data are valid, the data are shown there just for demonstration, and the reason is to show the easy expendability of the “WiAttend” application.

5.3.3 MY DETAILS PAGE

At the end of the second iteration, the system was able to register a device with the API Server and update the database records. In addition, random data could be generated for the pages “My Marks” and “My Details” using custom JavaScript/JSON scripts and the RandomUser.Me API.

5.3.4 TESTING

At the end of the second iteration, the system was able to register a device with the API Server and update the database records. In addition, random data could be generated for the pages “My Marks” and “My Details” using custom JavaScript/JSON scripts and the RandomUser.Me API.

5.4 ITERATION THREE

The third iteration covers the calendar feature, which involves the download of an external calendar file, processing the file and outputting the calendar events on the UI. In reality, instead of providing a link with the calendar file, the calendar could be downloaded automatically when the user logins into the system. As has been already mentioned above, no API was provided by the UoP, so in this case the calendar file will need to be manually imported into the “WiAttend” application.

5.4.1 DOWNLOADING THE ICAL FILE

The first step was to download the iCal file into the device’s storage which was quite simple. The complicated part of this step was the security measures that were implemented on the background of this process to prevent any possible endless loops or importing a malicious file. The security measures taken were as follows:

- The initial step requires from the user to enter a link to the iCal file. The app then check whether the provided file is reachable.
- Then it checks whether the file is in an .ics format
- Once the validations are passed, the file is downloaded and a random name is given to the downloaded file. This measures is not eliminating but is reducing the chances of the file to be trackable into the system. In addition the file is downloaded into a read-only directory and is inaccessible by the user.
- Finally, once the file is downloaded the Calendar feature in the preferences page turns on and the user is now able to load the Calendar page.

It is worth to be mentioned that, the user can disable/delete the calendar file at any time by switching the Calendar toggle in the “Preferences” page off. Figure 17 represents the background process diagram of the calendar feature.

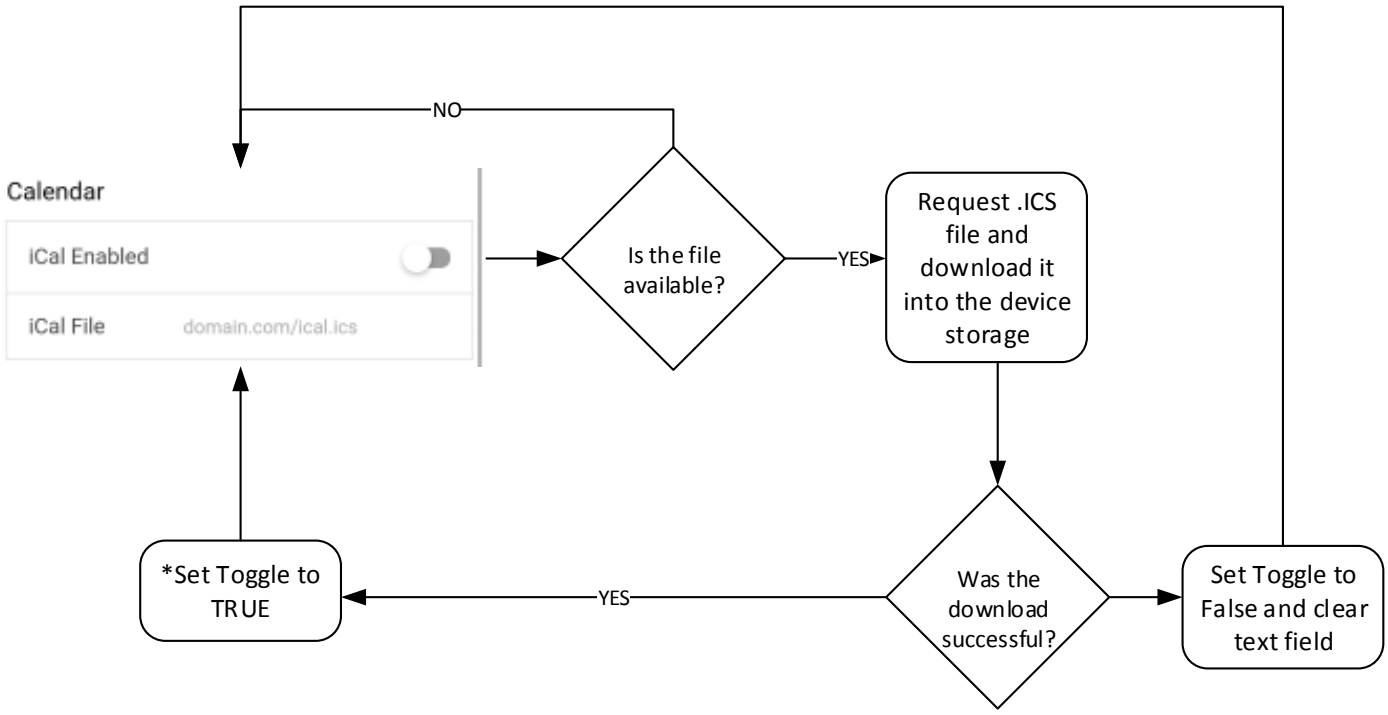


Figure 17 - Calendar Background Process Diagram

5.4.2 SETTING UP THE CALENDAR DIRECTIVE/UI

The set up process was quite straight forward due to the installation guidelines provided by the developer. The installation involved copying required files and directories into the "WiAttend" Cordova environment and minimal modifications into the index.html page of the Ionic interface. According to the structure of this plugin, a list of events has to be imported into the $scope.loadEvents functions. In this case the events are located into the downloaded iCal file, so a new function must be added to read the events from the file and put them in a list so the $scope.loadEvents function can read them.

5.4.3 ICAL PARSER FUNCTION

The aim of this step is the creation of the function that reads the calendar events from the iCal file. Luckily, Carl Saggs published a JavaScript file that does exactly what this project needs which is called iCal Parser. One issue that had to be resolved is that the iCal file that can be downloaded from MyPort, in each row of event includes the timezone. The Carl's script though could not recognise the timezone line, so a minor modification needed to be made so the iCal Parser could ignore that line. The timezone line for this project is not really required since it is a UK based application, and by default it is known that the UoP API Server is using the GMT London TimeZone. Figure 18, illustrates the structure of on iCal event.

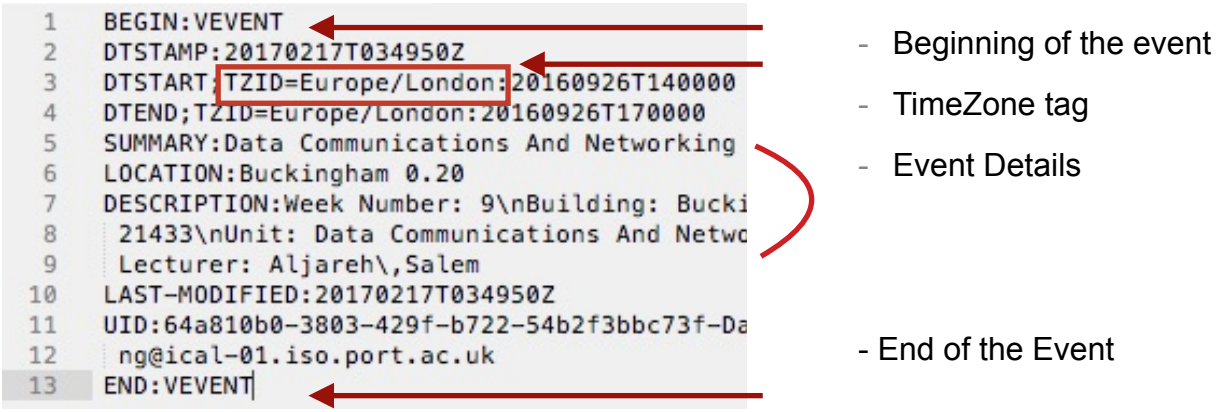


Figure 18 - Structure of an iCal event

As it can be distinguished, *DTSTART* and *DTEND* includes the TimeZone tag, which needs to be ignored by the iCal Parser. By ignoring those TimeZone tags, the event should be read as follows:

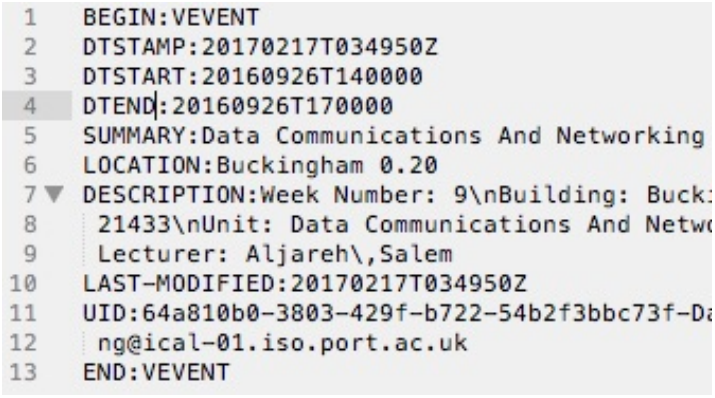


Figure 19 - Required Structure of the iCal event

The modification was quite simple; it needed just one line to be included that removes everything after the semicolon on the *DTSTART* and *DTEND* sections. The line *type = type.split(';')[0];* did actually work. The figure 20 shows a snippet of the modified code.

```
//If we are in an event
if(in_event){
    //Split the item based on the first ":"
    idx = ln.indexOf(':');
    //Apply trimming to values to reduce risks of badly formatted ical files.
    type = ln.substr(0,idx).replace(/^\s\s*/, '').replace(/\s\s*$/, '');//Trim
    val = ln.substr(idx+1,ln.length-(idx+1)).replace(/^\s\s*/, '').replace(/\s\s*$/, '');
    type = type.split(';')[0]; // <-- and here I am removing everything
                               // after semicolon in types
```

Figure 20 - Modified Code Snippet

At the end of the iCal Parser script, a list of all the events is generated for further processing.

5.4.4 LOADING THE CALENDAR EVENTS

Now that the calendar interface is ready, the iCal file is able to be downloaded and processed into the right format to be read by the Calendar plugin. What remains is to put everything together. At the beginning, the interface is loaded and the user is required to tap the reload button on the screen to load the events. The reload button calls the iCal Parser that reads the iCal file and outputs a list of events. That list is imported into the calendar interface, and the events can be seen on the screen. The functionality of this feature it can be distinguished from the figures 21 and 22.

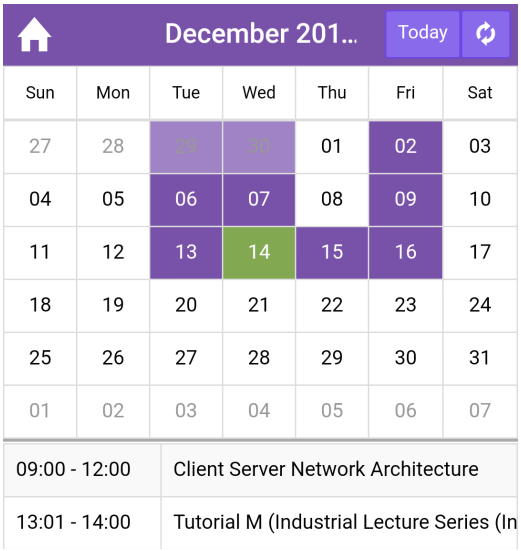


Figure 21 - Calendar UI Screenshot

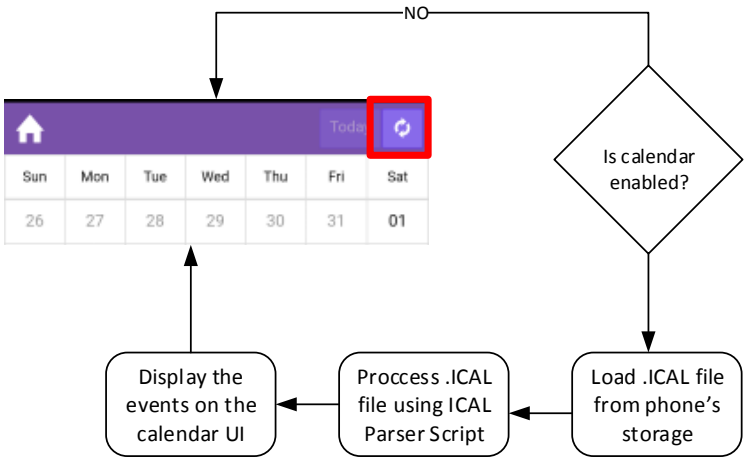


Figure 22 - Calendar Background Process Diagram

5.4.5 TESTING

At the end of the fourth iteration, testing was conducted and the calendar feature was in a working condition as planned. This iteration was successfully completed but it did not end on time. The modifications on the iCal Parser script took more than the expected time. The reason of the delay was that it needed to completely understand every single line of the script in order to adjust it to the project's requirements.

5.5 ITERATION FOUR

The fourth iteration covers the implementation of the core feature of the project, which is the summation of the student presence. This section covers the algorithm and the steps that were followed during the implementation.

5.5.1 PRESENCE SUBMISSION ALGORITHM

The submission process begins with the device scanning the surrounding area for Wi-Fi networks. Once the scanned list is ready, validation rules are applied before the device contacts the API Server. The validation rules are as follows:

- First it checks whether the device is registered with the API Server. This validation is done by checking if the device has a Token, which is generated after the registration with the API Server (Section 5.3.1).
- Then from the scanned list networks with signal strength less than -50 are removed.
- The list then is sorted in a deciding order.
- Finally all the networks are removed from the list except for the first 3, which are the signals with the strongest signal strength. That means that the device is closer to those networks.
- In case that the list is empty, the submission process is terminated which implies that all the scanned networks have signal strength less than -50 or no networks were found at all.

At the end of this process if the scanned network list is not empty, then the list is sent over to the API Server along with the device's generated Token for further internal validation. The internal validation rules are as follows:

- Checks again using the Database this time if the device is registered.
- Checks using the current timestamp if the student has an ongoing class/session.
- Then using the network list, to check if any of the Mac Addresses in the list belongs to the class that the student has an ongoing session.
- Finally, it checks whether the student has already submitted their presence. If not, it updates the database with the student's presence record and terminates.

A better overview of this process can be seen on the figure 23 bellow.

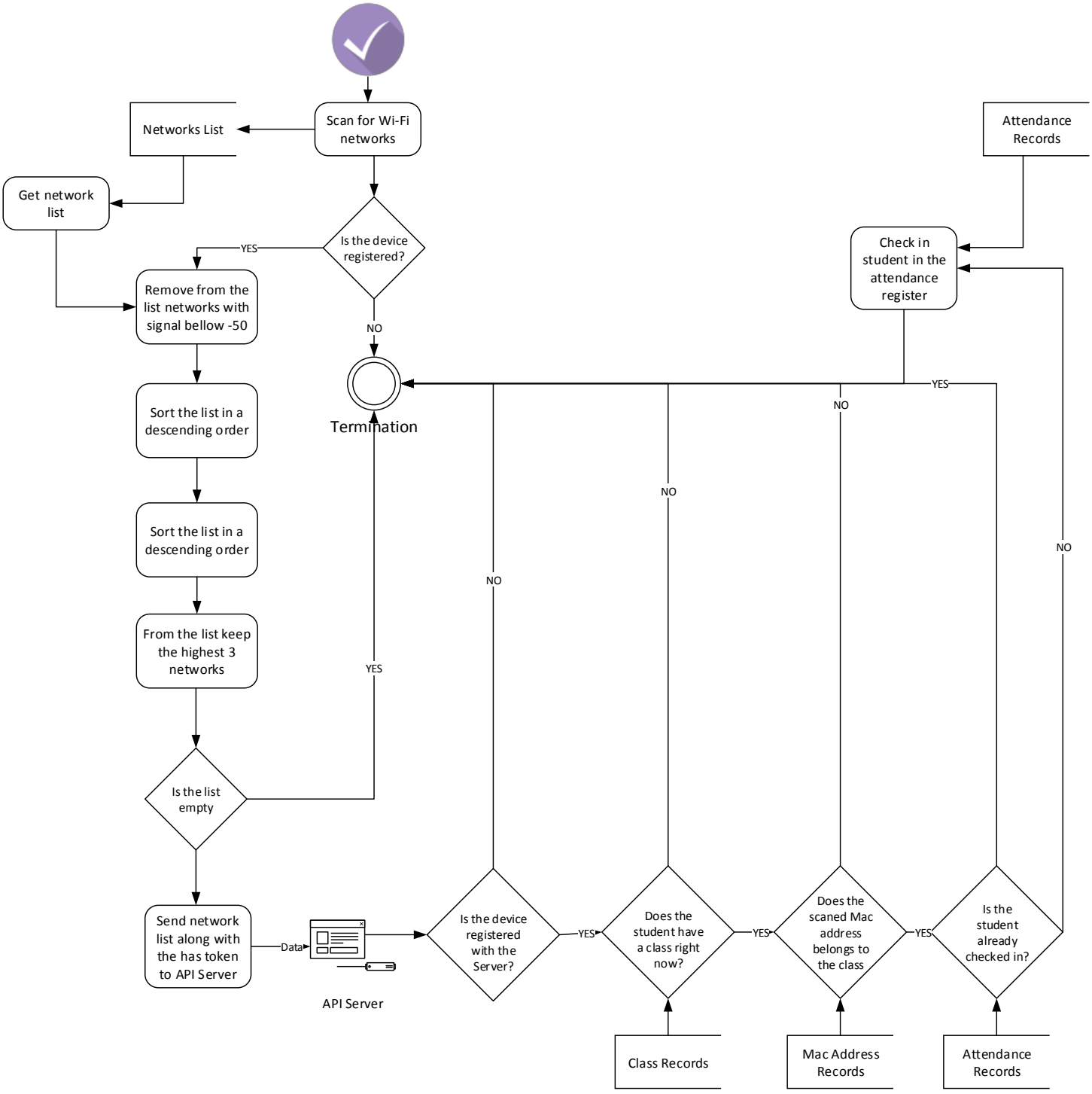


Figure 23 - Presence Submission Process Diagram

5.5.2 ABSENCE SUBMISSION

Due to the fact the the “WiAttend” application accepts submissions only from the present students, an algorithm needed to be implemented to record the students that have been absent from the class. According to the database data, the system holds on data of all the students that need to be in the class, and the students that have submitted their presence.

In order to get the list of students that have been absent, a schedule MySQL procedure needed to be done to execute every hour. This procedure needed to subtract the students that have marked as present from the list of students that needed to be in class. What remains from this subtraction is the list of the absent students.

Due to the lack of time, and limited knowledge of MySQL scheduled procedures, this task was not implemented. The concept of the task though was considered and it can be implemented later on, in future iterations. The database graph below illustrates the subtraction of data that was discussed above.

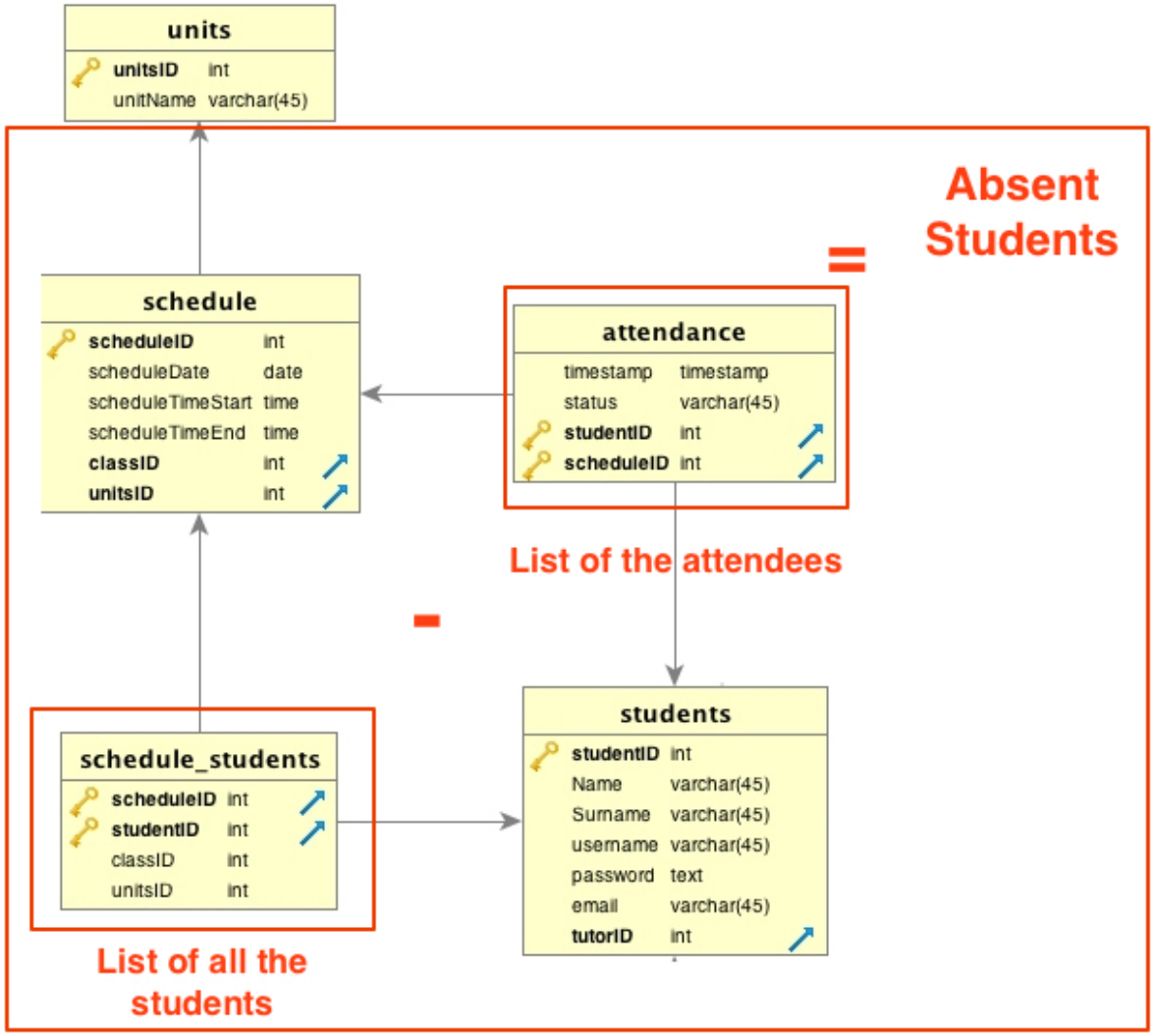


Figure 24 - Absence Calculation

5.5.3 KEY DATES PAGE

For the “Key Dates” page a web browser container was implemented, redirecting to the original web page of UoP. This page can be considered as a web page frame that loads an external web page. This was implemented just for demonstration purposes only, so no further explanation is given.

5.5.4 PORTRAIT ORIENTATION

According to section 3.2.2, the chosen orientation of the “WiAttend” app is portrait. This setting could be set on the *config.xml* file, which is responsible for all the configurations of the Cordova environment. What was needed to be done was to add the line *<preference name="orientation" value="portrait" />* into that file and then reload the application.

5.5.5 TESTING

At the end of this iteration presence submission though the “WiAttend” app was possible, the Key Dates page was accessible and the orientation of the app was locked on portrait. This iteration can be considered as successful, besides the fact that the absence submission was not possible for the moment.

5.6 ITERATION FIVE

The fifth and final iteration involves the implementation of several notifications that inform the user about the succession or failure of the requested procedure. In addition, the mathematical formula that has been used to calculate the TX Rate of the Access Point is explained in this section.

5.6.1 NOTIFICATIONS

One of the requirements of the project was the ability of the user to use the app without the need of any written manual. It has also been discussed on section 3.2.1 that this requirement can be achieved by providing the user with well-informed notifications at the end of any procedure. For example, when the user submits a presence, a notification pops up and informs the user about the succession or failure of the submission.

At the end of every function that has been implemented, a code is returned and each code has a different meaning. Then based on that code an appropriate notification is shown up on the screen to inform the user. The figure 25 below, represents the output codes and their meaning.

CODE	MEANING
200	Success
404	Request Not Found
403	Invalid input was given by the user
408	Request Timeout (Internet Connection Error)
500	API Server Error

Figure 25 - Function Output Codes

Once the codes were determined, three HTML templates were created. One template for successful request, one for a general warning/information and finally one for failed requests.The figure 26 illustrates the HTML templates:

```
<!-- Dynamic Error PopUp Messages -->

<script id="success.html" type="text/ng-template">
<div class="text-center"><img ng-src="img/icons/successicon.png"></img><br><p>{{msg}}</p></div>
</script>

<script id="error.html" type="text/ng-template">
<div class="text-center"><img ng-src="img/icons/erroricon.png"></img><br><p>{{msg}}</p></div>
</script>

<script id="warning.html" type="text/ng-template">
<div class="text-center"><img ng-src="img/icons/warning.png"></img><br><p>{{msg}}</p></div>
</script>

<script id="info.html" type="text/ng-template">
<div class="text-center"><img ng-src="img/icons/info.png"></img><br><p>{{msg}}</p></div>
</script>
```

Figure 26 - HTML Notification Templates

As it can be viewed from the figure 26, the {{msg}} is a dynamic variable that contains the output message. At the end of every function, based on the output code that was mentioned on the table above, an appropriate message is generated. The figures 27, 28 and 29 below shows examples of the generated notifications' pop-ups.

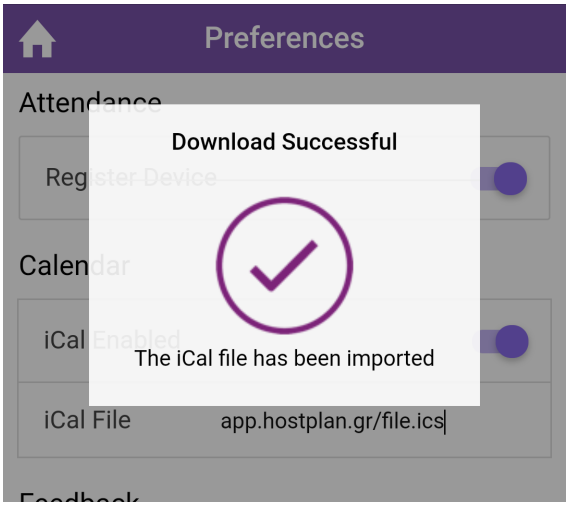


Figure 27 - Success Notification Pop-up

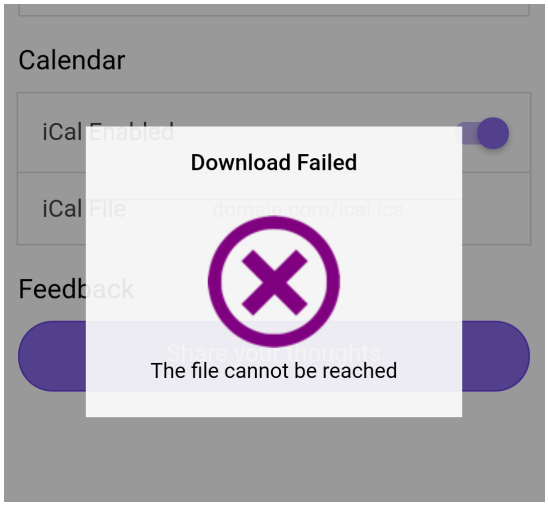


Figure 28 - Failure Notification Pop-up

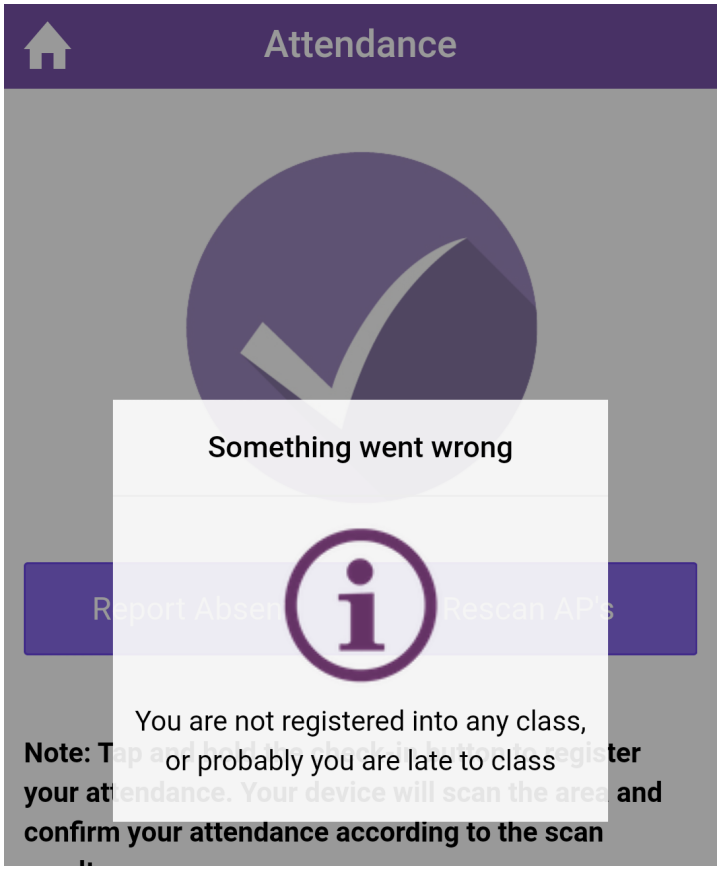


Figure 29 - Warning/Information Notification Pop-up

5.6.2 SETTING UP THE ACCESS POINTS

During the presence submission, the location of the student needs to be determined. According to iteration four, the system keeps in the scanned list the first 3 Access Points with the highest signal strength. The issue that is raised here, is that the Wi-Fi signal of one class is transmitted into another, which makes it difficult for the “WiAttend” application to determine the actual location of student. What needs to be done, is to set boundaries on the Wi-Fi signal power, so the signal is not transmitted outside of the class. The figure 30 represents the scenario of a class A and a class B.

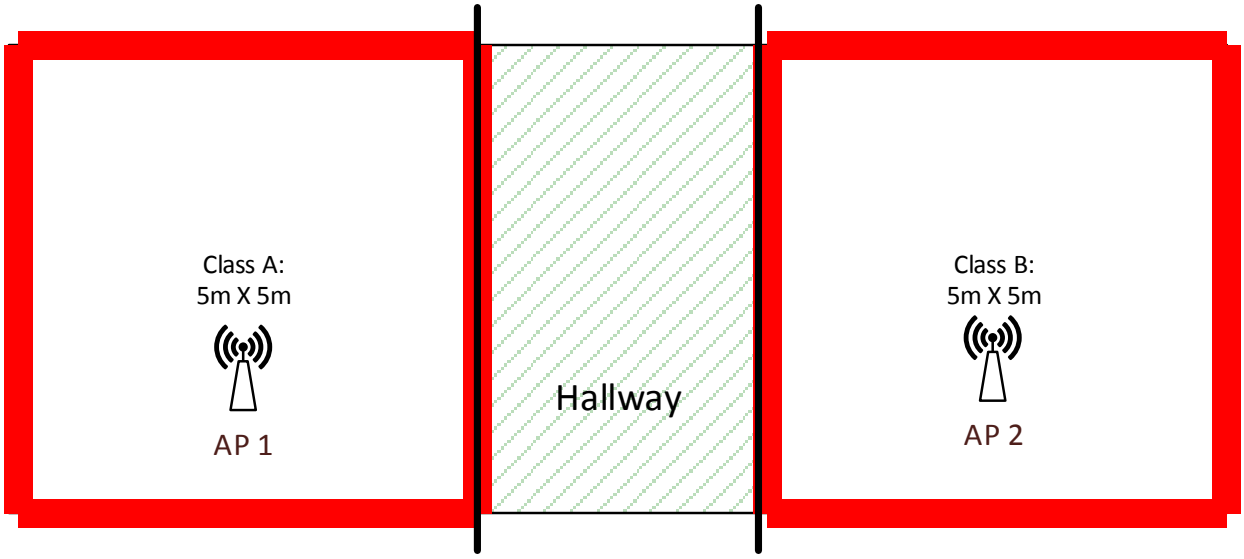


Figure 30 - Two classes scenario

In this case the signals of the AP1 in class A should be limited until the red walls, and the same with the class B. The signals of the AP1 and AP2 should be very weak or even undetectable in the hallway area. In order to calculate the needed transmitter power (Ptx) mathematical equations are required to be used. The mathematical equations take into account the following variables:

- K - Is Constant 32.44 which is the speed of light in a vacuum (metres per second).
- FSPL - Free Space Path Loss which is calculated below.
- CLtx, CLrx - Cable loss at transmitter and receiver (set to 0 if no cables)
- AGtx, AGrx - Antenna gain at transmitter and receiver (dBi). The provided AP uses 5dBi antenna and the Samsung Galaxy S4 makes use of a 2.5 dBi antenna.
- Prx - Receiver Sensitivity (dBm). In this case the minimum signal strength is required is -50 dBm.
- FM - Fade Margin (dB). For a 2.4GHz band radio usually requires a minimum of 15dB.
- f - Signal Frequency (MHz). The provided AP makes use of 2442MHz.
- d - Distance. The calculated distance is 5m according to the figure 29.

The calculation of the transmitting power consisted of two different equations. The first equation is the calculation of the Free Space Path Loss (FSPL), which “is the loos in signal strength that occurs when an electromagnetic wave travels over a line of sight path in free space” (Poole, 2016). The second one is the calculation of the Ptx which needs the FSPL in order to be calculated. The figures 31 and 32 represent the formulas that have been used during the calculation.

$$FSPL(dB) = 20log_{10}(d) + 20log_{10}(f) + 32.44 - Gtx - Gtr$$

Figure 31 - FSPL(dB) Formula

At the end of this calculation, the FSPL value was found to be 46.67 dB. This value is been used on the Ptx calculation formula that can bee found on the figure XX bellow.

$$Ptx(dB) = FSPL + CLtx - AGtx - AGrX + CLrx + Prx + FM$$

Figure 32 - Ptx(dB) Formula

At the end of the Ptx calculation, it was found that the needed Ptx value was 4.17 dB, which was later rounded to 4 dB.

The default Ptx value of the given AP was 20 dB, which is way too powerful and the signals were exceeding the distance limit. By changing the Ptx value at 4 dB, the signals were powerful enough to allow the student to submit a presence inside the specified room and weak enough to reject the student’s submission if the attempt was made outside of the room.

5.6.3 FINALISATION

This was the final step of the development of the Wi-Attend application. At this stage, cosmetic changes were made such as changing the default icon of the app, commenting on crucial segments of the source code and exporting the source code of the app into a signed APK file, which then can be installed on any device.

5.7 ISSUES FACED

During the development of the app several issues were faced.

- Cordova needed approximately 1-2 minutes to compile the source code and run it on the testing Android device. This process was very time consuming when testing was required and compilation was needed to be carried out several times in a row. This was an issue at the beginning of the development, but soon this was just a normal development routine and with good time management the project completed on time.
- As it has already been discussed at the beginning of the implementation section, “WiAttend” is a client service of an already existing system. Due to no existing system being given to run on the background so that the app can exchange data, one needed to be developed as well. The issue here was that, for every single function of the app, a background function on the API Server was required. This was very time consuming because a function on the API Server involved PHP Functions and MySQL Queries. To overcome this issue, limited functionality was given to the application and several functions were developed for demonstration reasons so no API Server was necessary.
- The final stage of the implementation which involved the configuration of the AP, required signalling engineer skills. Due to the lack of those skills, further research needed to be conducted which required even more time.

At the end all the issues have been overcome and the project was completed successfully in time.

6. TESTING & EVALUATION

6.1 TESTING OVERVIEW

The testing section covers the testing procedure that was conducted, in order for the functionality of the final product to be determined. The Acceptance Tests methodology (Seroter, & Alliance, 2017) was followed, which tests the application from the end user's perspective and marks each feature as accepted or rejected.

6.2 TESTING RESULTS

Before the testing procedure began, the mobile device was restored back to the default factory settings and a copy of the "WiAttend" app was installed on the device. This procedure eliminates any interference of the new application with other applications that had been installed previously on the device. The figure 33 represents the results of the application's functionality, stability and reliability. Screenshots that have been taken during the testing procedure can be found on the Appendix A.

Test ID	Test Description	Expected Result	Result
T1	Run on any Android device.	"WiAttend" home screen should appear on the screen	**Pass**
T2	A student is able to login and logout.	Change the toggle's value accordingly and notifications should appear on the screen.	**Pass**
T3	A calendar file is able to be downloaded.	Change the toggle's value accordingly and notifications should appear on the screen.	**Pass**
T4	The calendar feature can be disabled.	Change the toggle's value accordingly and notifications should appear on the screen.	**Pass**
T5	Calendar UI is able to load the events.	The student's events appear on the screen.	**Pass**
T6	The "My Marks" screen is able to demonstrate random data.	Random marks appear on the screen.	**Pass**
T7	The My Details screen is able to demonstrate random data.	Random student's details appear on the screen.	**Pass**
T8	The Key Dates screen is loading the UoP key dates webpage.	The UoP key dates appear on the screen.	**Pass**
T9	A student is able to submit a presence.	Database is updated and a notification is appeared on the screen.	**Pass**
T10	A student is able to send an email to the tutor to report an absent.	Tutor receives the email.	**Pass**
T11	System rejects presence submission on low Wi-Fi signal level.	Reject submission.	**Pass**

Figure 33 - Testing results

6.3 TESTING ON SEVERAL ANDROID DEVICES

An important requirement that needed to be tested was the compatibility on several Android devices. Due to the lack of availability of Android devices, the Android Studio Emulator carried out the testing. Android Studio's emulator gives the ability to set some configurations like the screen resolution. The application was tested on several resolutions without any sight of issue. All the UI elements were in place as they should be. This testing can be considered as satisfying as well.

6.4 WI-FI SIGNALS INTERFERENCE

During the testing process a signal interference issue was determined. In detail, when an attempt was made to submit a presence, the submission failed without any known reason. The issue was analysed and found that sometimes during the day Wi-Fi signals coming from the neighbourhood routers, spike 15 - 20 dB higher than expected which causes interference with the project's AP.

This issue has been resolved by adding a simple segment of code on the submission process that ignores any unknown Wi-Fi signals. Testing was again conducted with another AP spiking 30-40 dB higher than the neighbourhood's router, another attempt for presence submission was conducted and no issue was raised.

6.5 EVALUATION OF THE RESULTS

At the end of the testing procedure, the application was determined to be fully functional and it also reacted as expected to invalid by the users' input. In addition, the reliability and stability was determined during testing, as no crashes occurred and all the output was as expected. The application does exactly what it was designed to do and supports the majority of devices and screen resolutions, however with some minor issues/ considerations for future work that are identified and analysed in the conclusion section.

7. CONCLUSION AND FUTURE WORK

The “WiAttend” application was successfully completed, covering all the functional and design requirements that were specified in the initial specification.

The aims of the project have been achieved successfully. A conceptual project of a remote attendance submission system has been developed, which allows the user to submit a presence from an android device. This project can save a lot of valuable teaching time that now is getting wasted by using the “pen & paper” system.

Besides the well designed and implemented project, there is still a lot of space of improvement and recommendations for future work. It has also been determined at the end of the application's development that, this project can not be used in a real environment yet, since it needs further research on accurate Wi-Fi positioning. Due to the fact that this is a conceptual project and not an actual product, the development process of this project, points out several aspects that need to be considered while implementing such a product.

The list that follows points out recommendations for future work:

- Integration with UoP API

  By integrating this app with the UoP’s API Server, it automatically expands the functionality of the app to it is full potentials and it makes the development process less complicated. The need of developing a database and a API service is eliminated, and the development can be focused more on the actual application.

- Personal student application

  If the integration with the UoP API Server is achieved, then the application can cover more of the students' and the staff needs. For example, the university can send mass notifications to students right on their phone’s screen. It can automatically synchronise emails, personal details and many more into the “WiAttend” app that the students can have access instantly from the phones' screen.

- Deeper Wi-Fi Positioning

  A deeper Wi-Fi positioning research needs to be conducted by signals engineers to come up with a more accurate indoor positioning algorithm that eliminates possible inaccurate positioning results. Due to the lack of signal engineering knowledge, no such research has been conducted in this project, nevertheless the way the project was structured allows the current algorithm to be easily replaced.

- iOS Compatibility

  As it has already been said on section 3.2.2, Apple has not released an API that gives access to the iPhone's Wi-Fi chip yet. A look out can be given on future Apple’s API releases, and if such API is ever released, then the “WiAttend” application can be easily developed for iOS devices as well, due to its hybrid nature.

The development of the application will be continued and based on the future work recommendations, the upcoming releases of the app will provide a more accurate and

enjoyable experience for students. In addition, the source code will be provided later on for free on GitHub.

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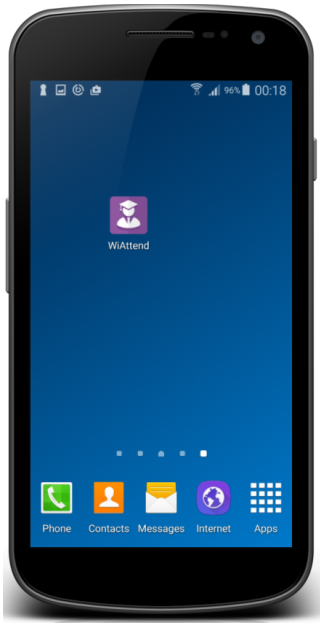
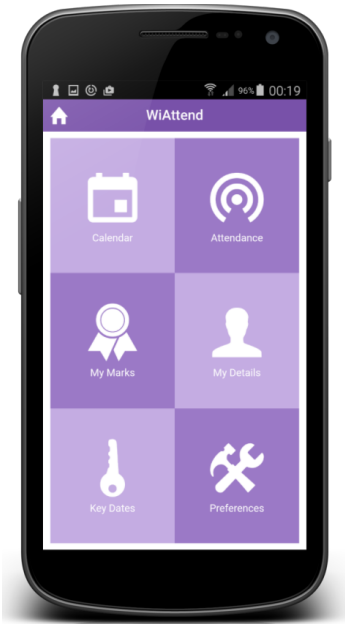
APPENDICES

APPENDIX A : TESTING EVIDENCES

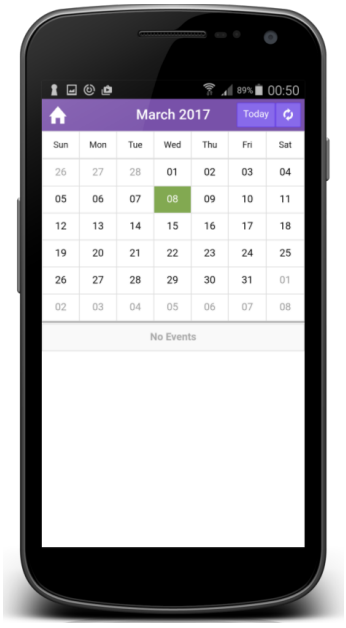


"WiAttend" installed

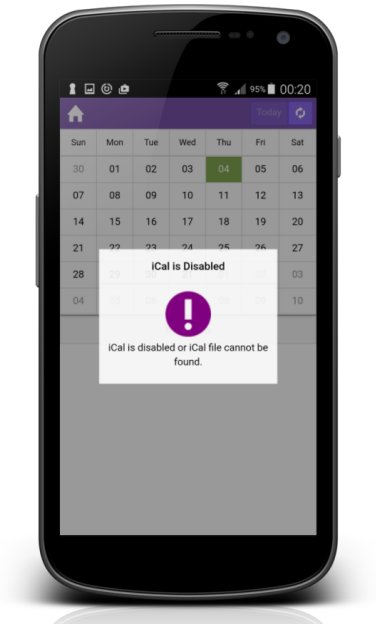
Initial home screen



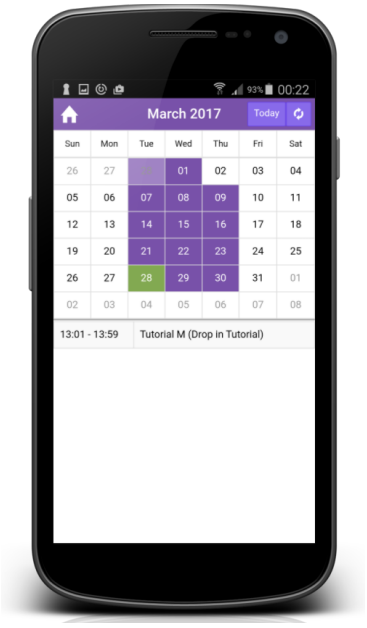
New home screen



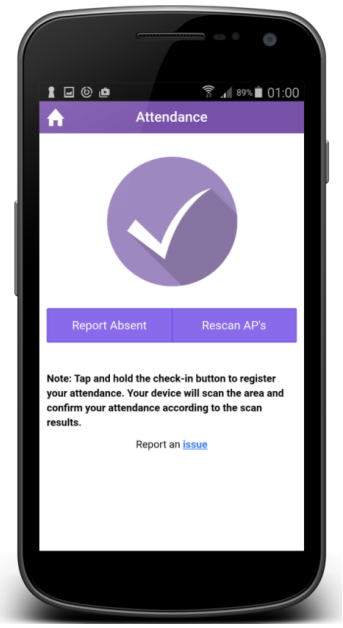
Calendar without any events loaded



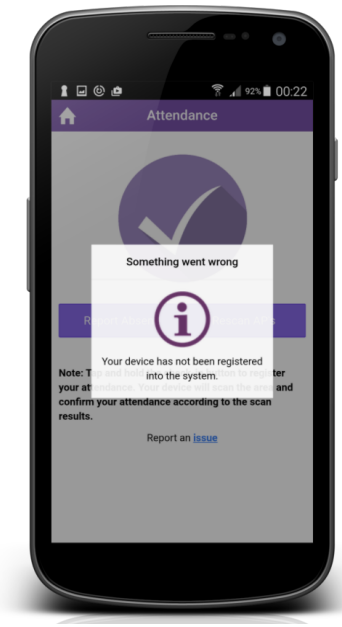
Disabled calendar error



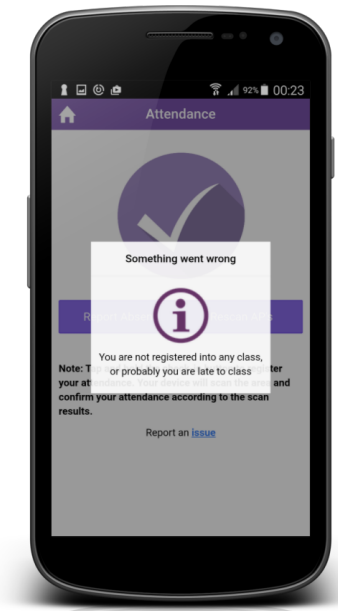
Calendar with events loaded



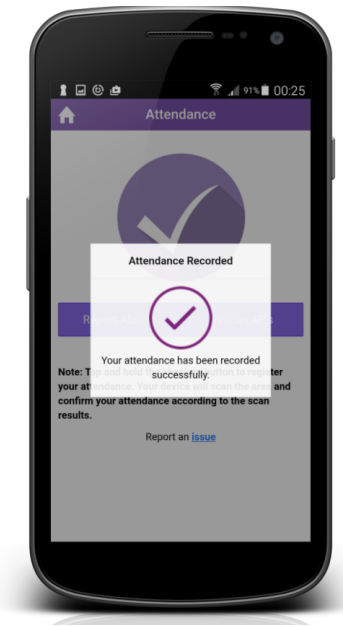
Attendance Page



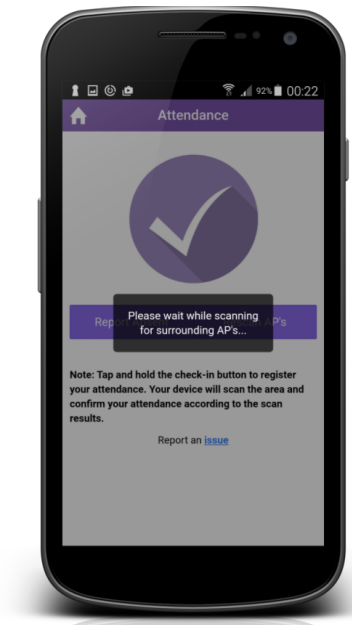
Unregistered device error



Attendance submission declined

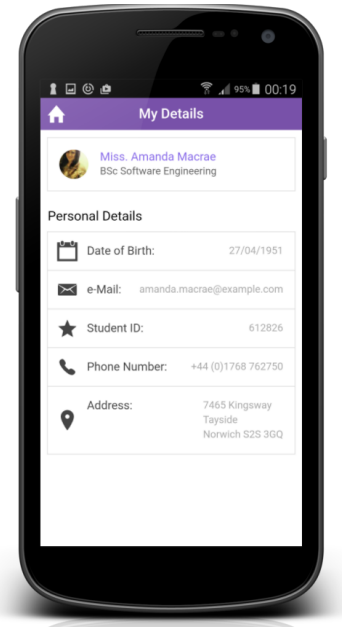


Attendance submission successful

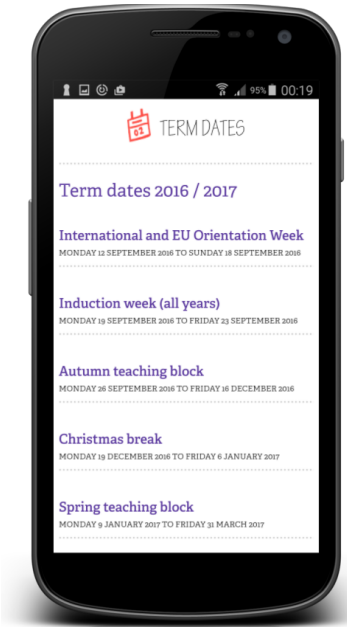


Scanning Wi-Fi networks

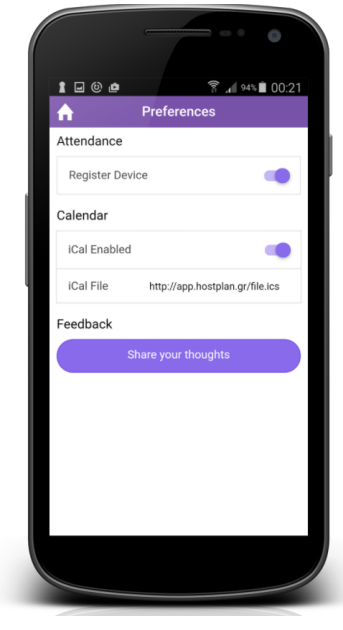
My Marks Page



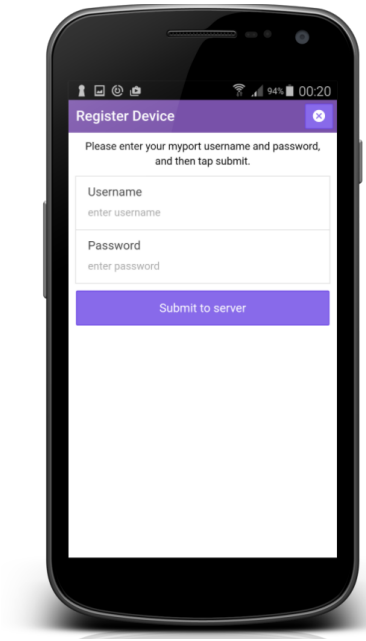
My Details Pages



Key Dates Page

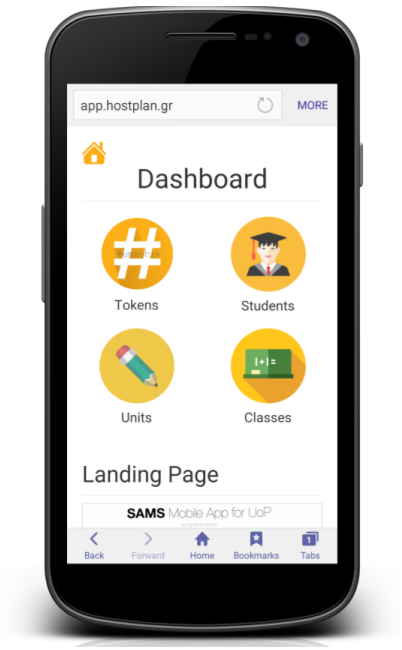


Preferences Page

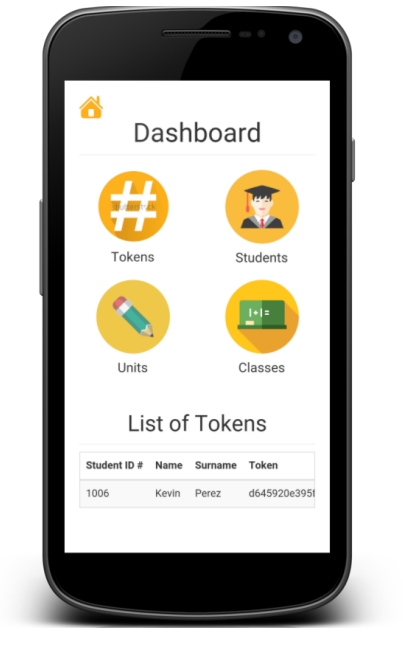


Student Login Page

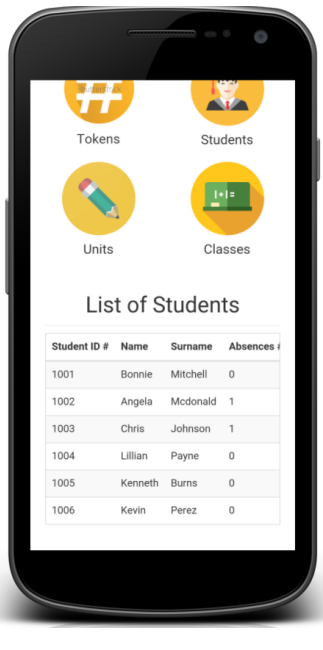
APPENDIX B : WEB BASED DASHBOARD SCREENSHOTS



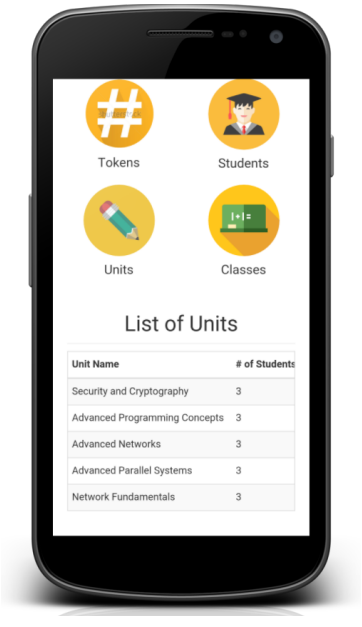
Dashboard home page



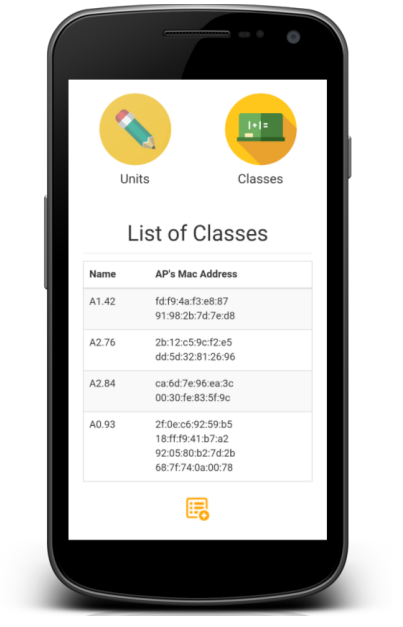
List of tokens



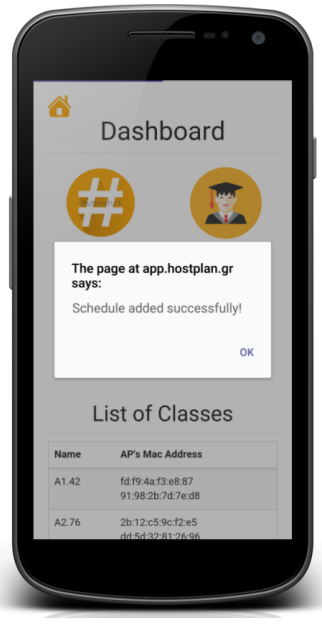
List of students



List of units

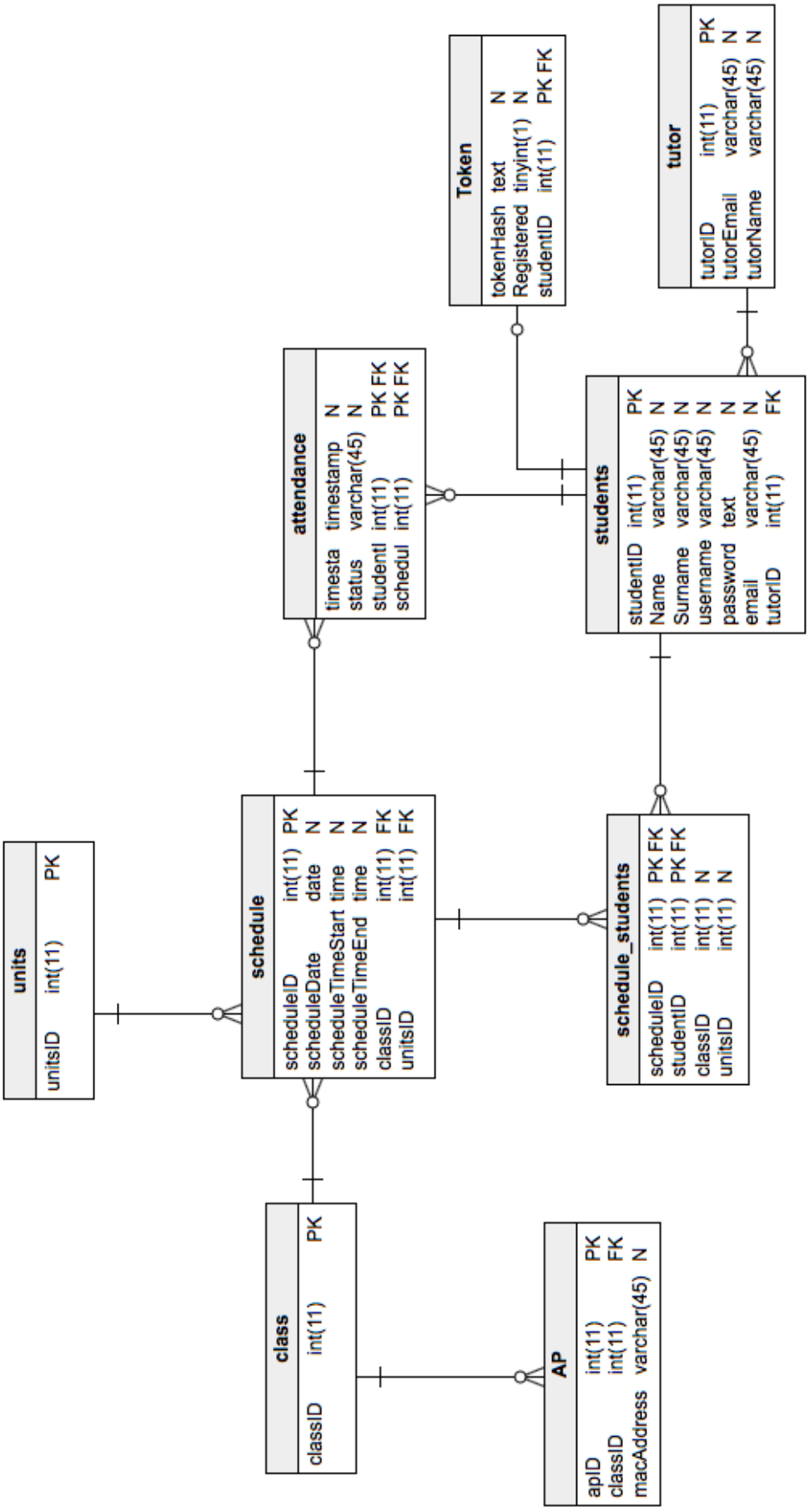


List of classes

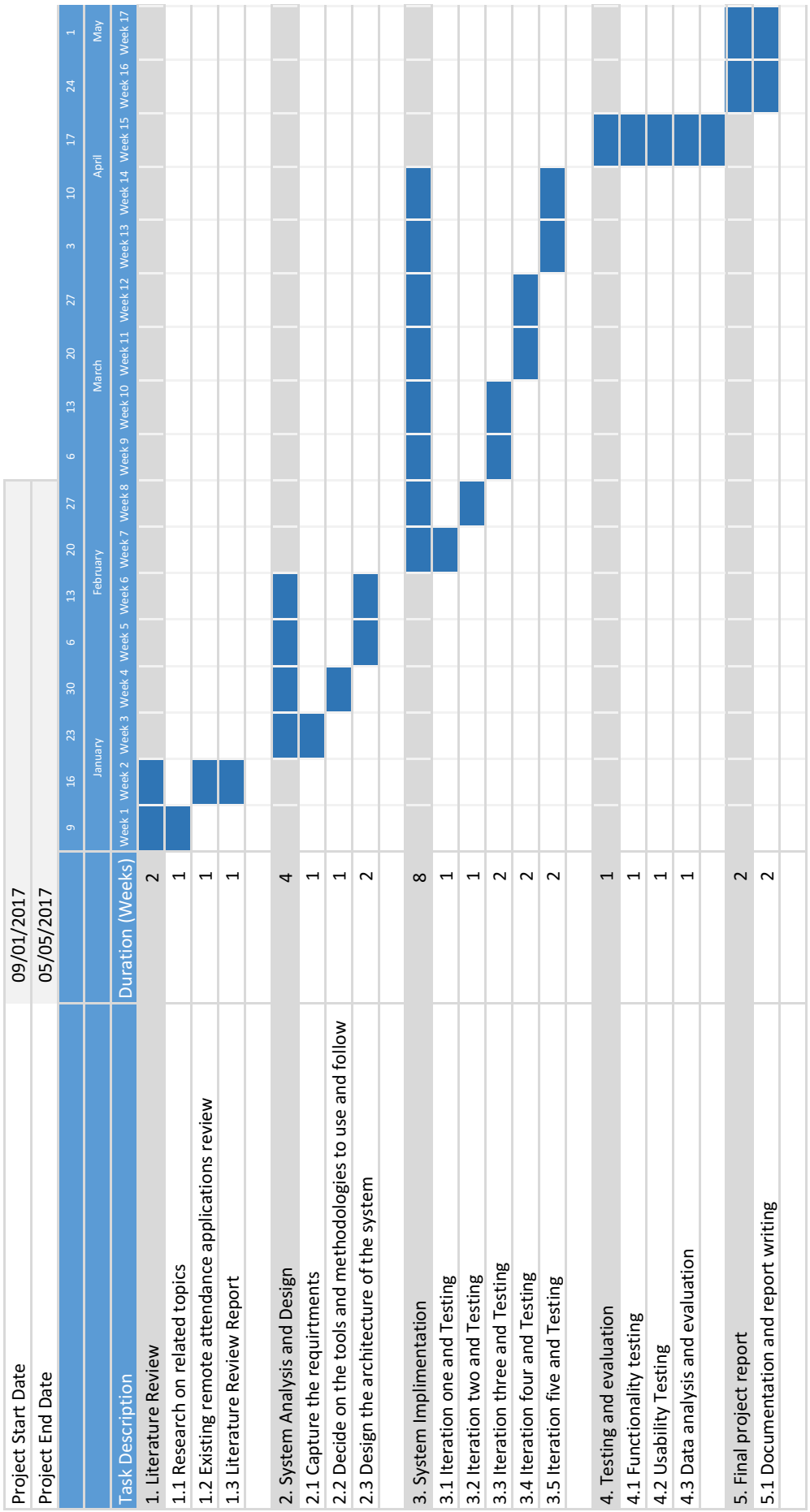


Enrolment of a student during testing

APPENDIX C : DATABASE DESIGN MODEL



APPENDIX D : GANTT CHART



APPENDIX E : ETHICS CERTIFICATE

Certificate of Ethics Review

Project Title:	"WiAttend" Classroom Attendance Detection over Wi-Fi for Android
User ID:	671018
Name:	Kyriakos Naziris
Application Date:	03/05/2017 23:33:29

You must download your referral certificate, print a copy and keep it as a record of this review.

The FEC representative for the School of Engineering is Giles Tewkesbury

It is your responsibility to follow the University Code of Practice on Ethical Standards and any Department/School or professional guidelines in the conduct of your study including relevant guidelines regarding health and safety of researchers including the following:

- University Policy
- Safety on Geological Fieldwork

It is also your responsibility to follow University guidance on Data Protection Policy:

- General guidance for all data protection issues
- University Data Protection Policy

SchoolOrDepartment: ENG
PrimaryRole: PostgraduateStudent
SupervisorName: Ioannis Kagalidis
HumanParticipants: No
PhysicalEcologicalDamage: No
HistoricalOrCulturalDamage: No
InvolvesAnimals: No
HarmfulToThirdParties: No
OutputsPotentiallyAdaptedAndMisused: No
HasSecurityImplications: No
Confirmation-ConsideredDataUse: Confirmed
Confirmation-ConsideredImpactAndMitigationOfPontentialMisuse: Confirmed
Confirmation-ActingEthicallyAndHonestly: Confirmed

Supervisor Review

As supervisor, I will ensure that this work will be conducted in an ethical manner in line with the University Ethics Policy.

Supervisor signature:

Date:

Certificate Code: 0764-2F71-4AC8-917F-1B48-D791-A534-AC61 Page 1