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| **Project Title Subtitle** |

**Supervisors:**

Ib Havn

Erland Ketil Larsen

Kasper Knop Rasmussen

Knud Erik Rasmussen

Lars Bech Sørensen

**Students:**

Angel Iliyanov Petrov – 266489

Christian Schou Sørensen – 267142

Diyar Hussein Hussein – 266352

Eduard Nicolae Costea -266078

Erika Monica- Szasz- 280201

Ionel-Cristinel Putinica – 266123

Josipa Babic – 266757

Kenneth Ulrik Petersen – 269379

Mihai Tirtara - 266097

Remedios Pastor Molines – 266100

**[Number of characters]**

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# Abstract

Owning plants requires a fair level of care and attention. For the purpose of simplifying plant tending, monitoring the external conditions of the plant such as the air humidity and temperature could play a key factor in providing it with the right care that includes tasks such as watering the plant and turning up the heat. The system that is the subject of this project has been designed from scratch in order to facilitate the growth and maintenance of plants. This project report has the purpose of describing all the methods, stages and iterations that went into implementation of this project, using Java, C, C# as the main programming languages.

The system has been fully designed with the end-user experience in mind, the purpose being to make the process of keeping track of the external conditions of plants as easy as possible and allow actions such as watering the plants remotely. The entire system was designed in three parts, by three different groups, with each one of them focusing on different tasks: Data Engineering, Embedded programming and the development of the Android Application.

# Introduction

When deciding to own plants, people should first consider what kinds of plants work best with their lifestyle and environment and what is the maintenance level required to keep the plants in a good condition. Indoor plants can be a great addition to homes because they present a multitude of benefits such as improving air quality by removing carbon dioxide while providing extra oxygen and the exposure to them reduces stress levels, boosts mental health, calms anxiety and lowers blood pressure. Also, they improve productivity and concentration, which is great for people who work from home and need a boost to focus on the work at hand. Plus, they help regulate humidity and increase levels of positivity. It is equally important to mention that plants can help diversify bacteria in our bodies to fight infections and allergies which is very crucial for city dwellers who are less likely to be exposed to nature daily, therefore their immunity can be influenced negatively without the presence of indoor greenery (Tobebright, 2018).

There is a multitude of benefits and positive aspects to owning plants, but there are some downsides as well. The responsibility of keeping a plant alive might not be very easy. Monitoring the external conditions of a plant and controlling them remotely through a system of sensors and actuators that notify the user about the current status of the plant is the subject of this project.

The developed product can be defined as 3 systems, all of which communicate to each other to a certain extent. The team took the task of developing an application, with requirements related to the programming languages that have to be used, the sensors that the embedded tier must use. This set some boundaries and limitations over what the group came up with as far as design went, but still there was a good amount of opportunities for creativity, inventiveness and originality.

# Requirements

## Functional Requirements

|  |  |  |
| --- | --- | --- |
| ID | User Story Description | Priority |
| 1 | As a customer, I want to be able to access plant’s data via mobile application. | High |
| 2 | As a customer, I want to be able to receive information about the plants’ conditions. | High |
| 3 | As a customer, I should be able to define and/or modify the range of the conditions in which the plant(s) must be kept. | High |
| 4 | As a customer I should be able to remotely water my plants (from mobile application) | High |
| 5 | As a customer, I should be able to create profiles for plants. | Medium |
| 6 | As a customer, I should be able to choose a preset for the most common type of plant. | Low |
| 7 | As a customer I should be able to remove the profile of a plant. | Low |
| 8 | As a customer I should be able to access tips regarding growing a plant | Low |
| 9 | As a customer I should be able to remotely control the light in the room where my plants are. | Low |
| 10 | As a customer I should be able to control the heat remotely to provide the best conditions for growth of the plants. | Low |
| 11 | As a customer I should be able to see the progress of a plants’ conditions over a period of time | Medium |
| 12 | As a customer I should have all my user data protected | High |

Table 1: User Stories

|  |  |  |
| --- | --- | --- |
| ID | Requirement | Priority |
| 1 | * The user should be able to access his data in real time via mobile application | High |
| 2 | * The user should be able to receive information about their plant(s) | High |
| 3 | * The user should be able to define/modify the range of the conditions in which their plant(s) must be kept | High |
| 4 | * The user should be able to remotely water their plants | High |
| 5 | * The user should be able to create profiles for plants | Medium |
| 6 | * The user should be able to choose a preset for each type of plant | Low |
| 7 | * The user should be able to remove the profile of a plant | Low |
| 8 | * The user should be able to access tips regarding growing a plant | Low |
| 9 | * The user should be able to remotely control the light in the room where my plants are | Low |
| 10 | * The user should be able to control the heat remotely to provide the best conditions for growth of the plants | Low |
| 11 | * The user should be able to see the progress of a plants’ conditions over a period of time | Medium |
| 12 | * The user should have all their user data protected | High |

Table 2: Functional Requirements

|  |  |  |
| --- | --- | --- |
| ID | Requirement | Division |
| 14 | The application must retrieve, parse and display relevant data from a webservice | Interactive Media |
| 15 | The application must have a responsive user interface | Interactive Media |
| 16 | The application should use lists to display data | Interactive Media |
| 17 | The application should include various options for visualizing sensor data | Interactive Media |
| 18 | The application should have a settings menu | Interactive Media |
| 19 | The application should persist some data locally on the device | Interactive Media |
| 20 | The application could utilize authentication to sign in | Interactive Media |
| 21 | The application could utilize Google Maps and Location API to display sensor data | Interactive Media |
| 22 | The application could be able to send data to a webservice to interact with actuators | Interactive Media |

Table 3: Functional Requirements – Android application

## Non-Functional Requirements

|  |  |  |
| --- | --- | --- |
| ID | Requirement | Team |
| 1 | You must use at least five tasks. | IoT |
| 2 | Some data must be used by more than one task. | IoT |
| 3 | You must use semaphores, mutexes and queues. | IoT |
| 4 | You must unit test parts of your application. | IoT |
| 5 | You must use at least five tasks. | IoT |
| 6 | Some data must be used by more than one task. | IoT |
| 7 | You must use semaphores, mutexes and queues. | IoT |
| 8 | Apply knowledge of dimensional database modelling | Data Engineering |
| 9 | Design and implement a dimensional model | Data Engineering |
| 10 | Design and implement an Extract, Clean up, Transform, Load process for the data flow | Data Engineering |
| 11 | Design and implement web services | Data Engineering |
| 12 | Create paginated reports in Reporting services | Data Engineering |
| 13 | Create analyses in Power BI | Data Engineering |
| 14 | The application must be under version control for the entire development process | Interactive Media |
| 15 | The application must be developed using the official Android framework | Interactive Media |
| 16 | The application must be developed with Java | Interactive Media |
| 17 | The application should follow the Google Material Design guidelines | Interactive Media |
| 18 | The source code should be structured using an architectural pattern (MVVM is advised) | Interactive Media |

Table 3: Non-functional Requirements

# Analysis

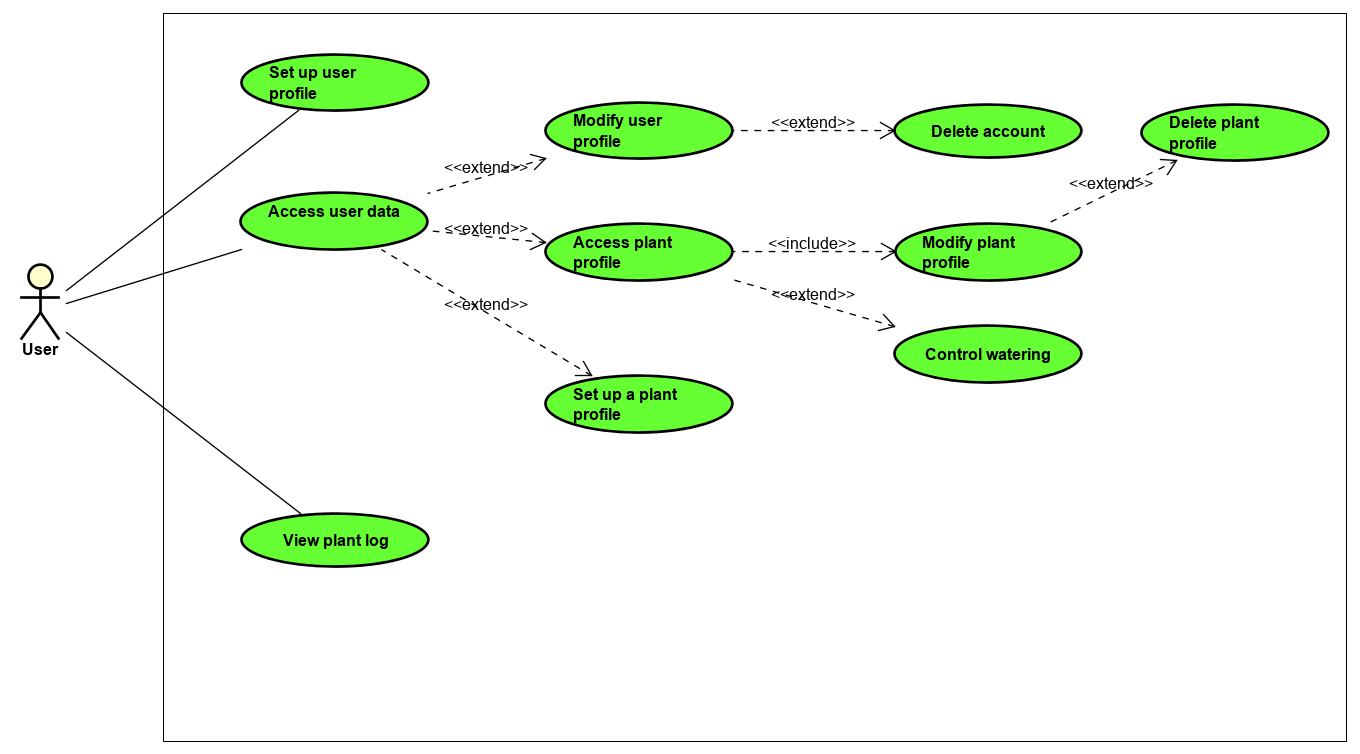


Figure 1: Use Case Diagram

## Use Case Diagram

The above Use Case diagram represents the various operations that the user can perform in the system. The Time actor represents the displaying of a watering notification on the Android part. This is handled locally in the Android implementation whilst the rest of the system is interconnected.

## Use Case Descriptions

The following Use Case descriptions explain how the functionality of the system was envisioned to function described thoroughly.

Table 4: Use Case - setting up a user profile

|  |  |
| --- | --- |
| Use Case | Set up user profile |
| Actor | User |
| Pre-Condition | The user needs to be on the startup page. |
| Post-Condition | A user profile will be added to the system. |
| Base sequence | 1. User inputs relevant information.  2. User presses the "Submit" button.  3. System verifies information.  4. System returns an OK status to the client. |
| Exception sequence | 2A: User gets timeout error if the server does not respond.  3A. The system will not create a new user profile if the email of the user is already existent in the system. |

Table 5: Use Case - Access user data

|  |  |
| --- | --- |
| Use Case | Access user data |
| Actor | User |
| Pre-Condition | The user needs to be on the startup page |
| Post-Condition | The system will display the relevant main screen. |
| Base sequence | 1. User inputs their username and password.  2. User presses the "Submit" button.  3. System verifies the inputted information.  4. System validates the inputted information.  5. System displays the dashboard page for the user. |
| Exception sequence | 2A. The user enters either wrong cpr or password and will be presented with an appropriate error screen.  2B. The request to the server is not successful, therefore, the application will display a timeout message box. |

Table 6: Use Case – View plant log

|  |  |
| --- | --- |
| Use Case | View Plant Log |
| Actor | User |
| Pre-Condition | User must be logged in the system. |
| Post-Condition | User is able to see the plant log. |
| Base sequence | 1. User clicks on Check Plant's log button.  2. System retrieves data from database.  3. System displays relevant data. |
| Exception sequence | 2.1. The system cannot retrieve data from database.  2.1.1 System displays "Request failed"  2.1.2 Use Case restarts |

Table 7: Use Case – Modify user profile

|  |  |
| --- | --- |
| Use Case | Modify user profile |
| Actor | User |
| Pre-Condition | User should be logged into their profile. |
| Post-Condition | User profile will be updated in the system. |
| Base sequence | 1. User accesses the "User Profile" section  2. User clicks "Modify Profile" button.  2.1 User modifies the fields they desire to modify.  3.1. User presses "Submit" button.  3.2 System saves any edits made by the user. |
| Exception sequence | 2. The system will reject to save empty fields. |

Table 8: Use Case – Access plant profile

|  |  |
| --- | --- |
| Use Case | Modify user profile |
| Actor | User |
| Pre-Condition | A plant profile needs to be already existing in the system. |
| Post-Condition | User has accessed the data successfully and can now modify it and set the profile so it works on his/her plant. |
| Base sequence | 1. User presses "Access plant profiles".  2. System returns a list of plant profiles.  3. User selects a certain profile that he/she wants to set for his/her plant. |
| Exception sequence | 2. There are no profiles stored in the system. |

Table 9: Use Case – Set up a plant profile

|  |  |
| --- | --- |
| Use Case | Set up a plant profile |
| Actor | User |
| Pre-Condition | A plant profile needs to be already existing in the system. |
| Post-Condition | User has accessed the data successfully and can now modify it and set the profile so it works on his/her plant. |
| Base sequence | 1. User presses "Access plant profiles".  2. System returns a list of plant profiles.  3. User selects a certain profile that he/she wants to set for his/her plant. |
| Exception sequence | 2. There are no profiles stored in the system. |

Table 10: Use Case – Access Plant Profile

|  |  |
| --- | --- |
| Use Case | Modify user profile |
| Actor | User |
| Pre-Condition | A plant profile needs to be already existing in the system. |
| Post-Condition | User has accessed the data successfully and can now modify it and set the profile so it works on his/her plant. |
| Base sequence | 1. User presses "Access plant profiles".  2. System returns a list of plant profiles.  3. User selects a certain profile that he/she wants to set for his/her plant. |
| Exception sequence | 2. There are no profiles stored in the system. |

Table 11: Use Case – Set up a plant profile

|  |  |
| --- | --- |
| Use Case | Set up a plant profile |
| Actor | User |
| Pre-Condition | User is at relevant section in system. |
| Post-Condition | The plant profile will be added to the system. |
| Base sequence | 1. User accesses the plant profile section.  2. User presses the "Create new plant profile" button.  3. User inputs relevant information.  4. User presses "Submit" button.  5. System saves information about profile. |
| Exception sequence | 4A. The system will reject a profile without proper user input. See base sequence 3.  4B. The system will reject a profile name that already exists. |

Table 12: Use Case – Delete account

|  |  |
| --- | --- |
| Use Case | Set up a plant profile |
| Actor | User |
| Pre-Condition | User must be in the "Modify profile" section. |
| Post-Condition | User is returned to the log in screen. |
| Base sequence | 1. User presses the "Delete my profile" button.  2. User presses the "Confirm" button.  2.1 System removes any information related to that user.  3. System returns user to login screen. |
| Exception sequence | 2.1 The user may cancel the action of deleting their profile. |

Table 13: Use Case – Modify plant profile

|  |  |
| --- | --- |
| Use Case | Set up a plant profile |
| Actor | User |
| Pre-Condition | The plant profile must already exist in the system. |
| Post-Condition | A user has changed plant profile to fit the specific plant he/she owns. |
| Base sequence | 1 .User modifies relevant profile fields.  2. User presses "Save" button.  3. System saves modified plant profile.  4. System returns status response to client. |
| Exception sequence | 2A: User gets error message when invalid information is entered. |

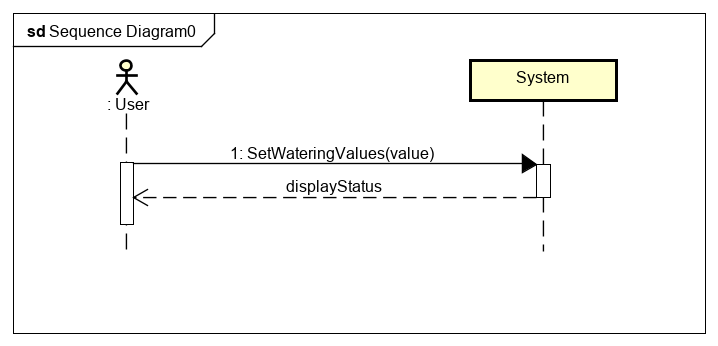
Table 14: Use Case – Control watering

|  |  |
| --- | --- |
| Use Case | Control watering |
| Actor | User |
| Pre-Condition | A plant profile must already exist in the system. |
| Post-Condition | 1. The updated information for the profile is stored in the system.  2. The system will display when the operation finishes. |
| Base sequence | 1. User presses the "Set watering options" button  2. User sets the amount of water.  3. System triggers watering of plant. |
| Exception sequence | 2A. Wrong input will cause an error dialog. |

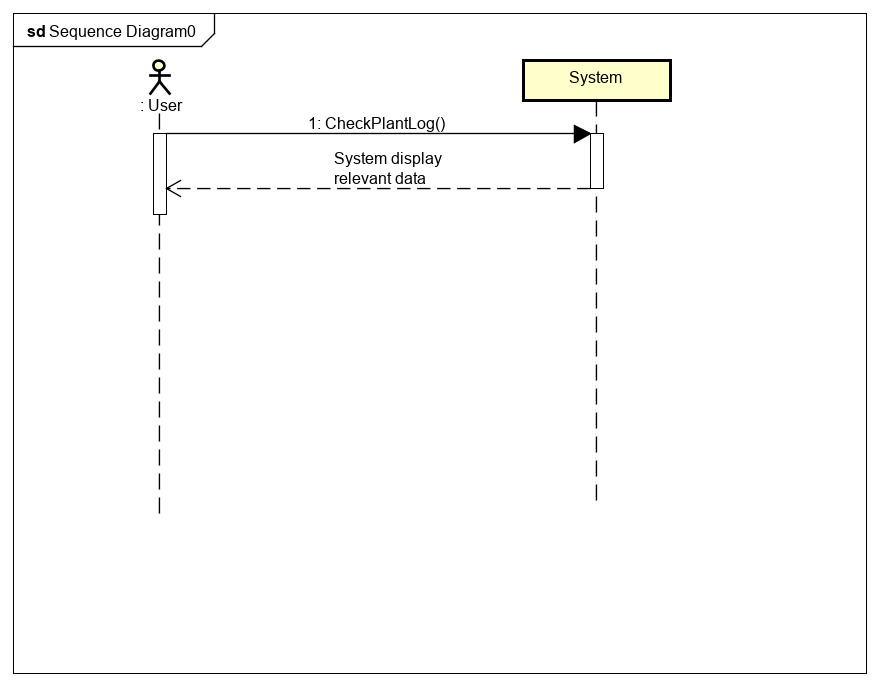
Table 15: Use Case – Delete plant profile

|  |  |
| --- | --- |
| Use Case | Delete plant profile |
| Actor | User |
| Pre-Condition | A plant profile should be selected. |
| Post-Condition | Plant profile removed from the system. |
| Base sequence | 1. User selects profile that they wish to delete.  2. User presses the "Delete profile" button.  3. System removes profile from database |
| Exception sequence | 2. User may cancel the deletion of a profile on the confirmation dialog. |

## Sequence Diagrams



## *Table 13: Use Case – Control Watering Values*

*Table 14: Use Case – Checking Plant Log*

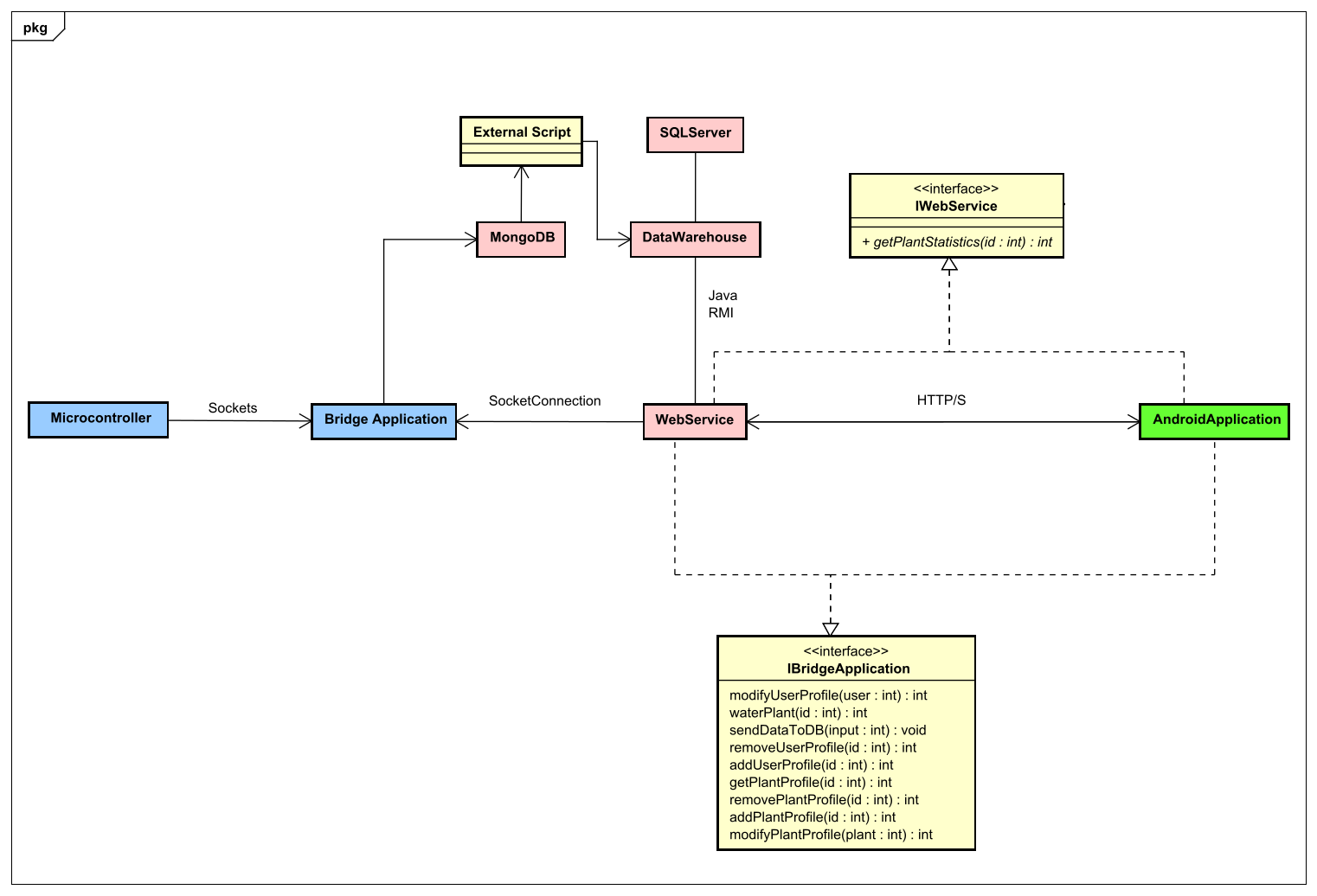
# Design

The purpose of this part is to define the architecture, technologies, design patterns and UI choosing of the system. For a better explanation, this part contains several pictures of class diagrams and sequence diagram.



Regarding the requirements of SEP4, the project was divided in three main sections, each having different specifications.

## Architecture Diagram

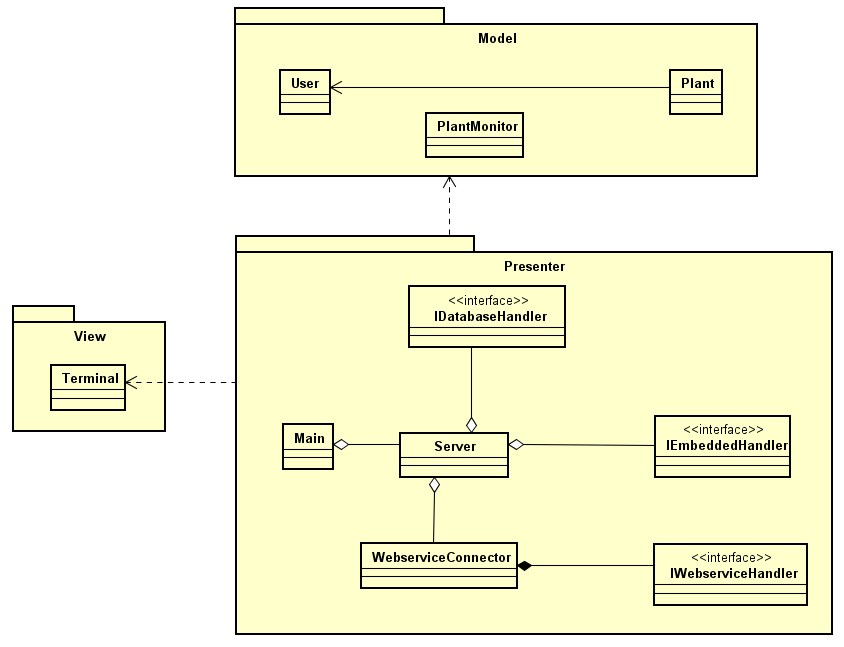


## Sequence Diagram

## IoT Implementation Design

**Bridge Application**

The bridge application consists of three handlers which will deal with the communication in each of the three parts of the system: the embedded system, the database and the webservice.



*Figure 1 in IoT – Bridge Application*

The communication with the database uses the MongoDB driver.

The communication with the embedded system is through a Socket protocol as well as the webservice.

The model classes are used to encapsulate data for users, plant profiles and plant sensors respectively.

The WebserviceConnector maintains the socket connection to the web service and uses the IWebServiceHandler to perform actions matching the protocol commands and writes a response to the socket.

The socket communication is based on json and the model objects are serialized to json and sent over the socket connection. The protocol for communication is as follows:

|  |  |
| --- | --- |
| **Message** | **Response** |
| getuser:id | json/null |
| adduser:json | id/null |
| modifyuser:json | true/false |
| removeuser:id | true/false |
| getplant:id | json/null |
| addplant:json | id/null |
| modifyplant:json | true/false |
| removeplant:id | true/false |
| getplantmonitor:id | json/null |

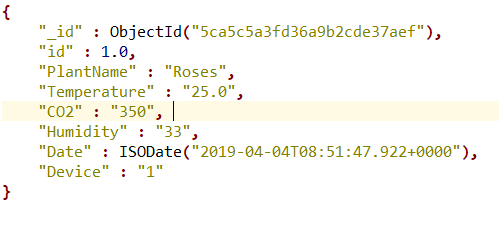
Zero byte is used for delimiting the individual messages and responses. All messages and responses are UTF-8 text.

## Data

**Cloud Based Data**

IoT system needs to exchange data with android application. To make it possible cloud-based database were necessary. MongoDB is chosen in this case and it fulfils all requirements. MongoDB is NoSql database program, it uses JSON like documents.

The collections are going to be caped. Caped collections support fixed-size collections. This type of collection maintains insertion order and, once the specified size has been reached, behaves like a circular queue. Capped collections will help with limited available space in the cloud.

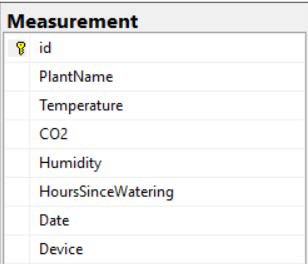


*Figure 1 in Data - Document in MongoDB*

**SQL Server**

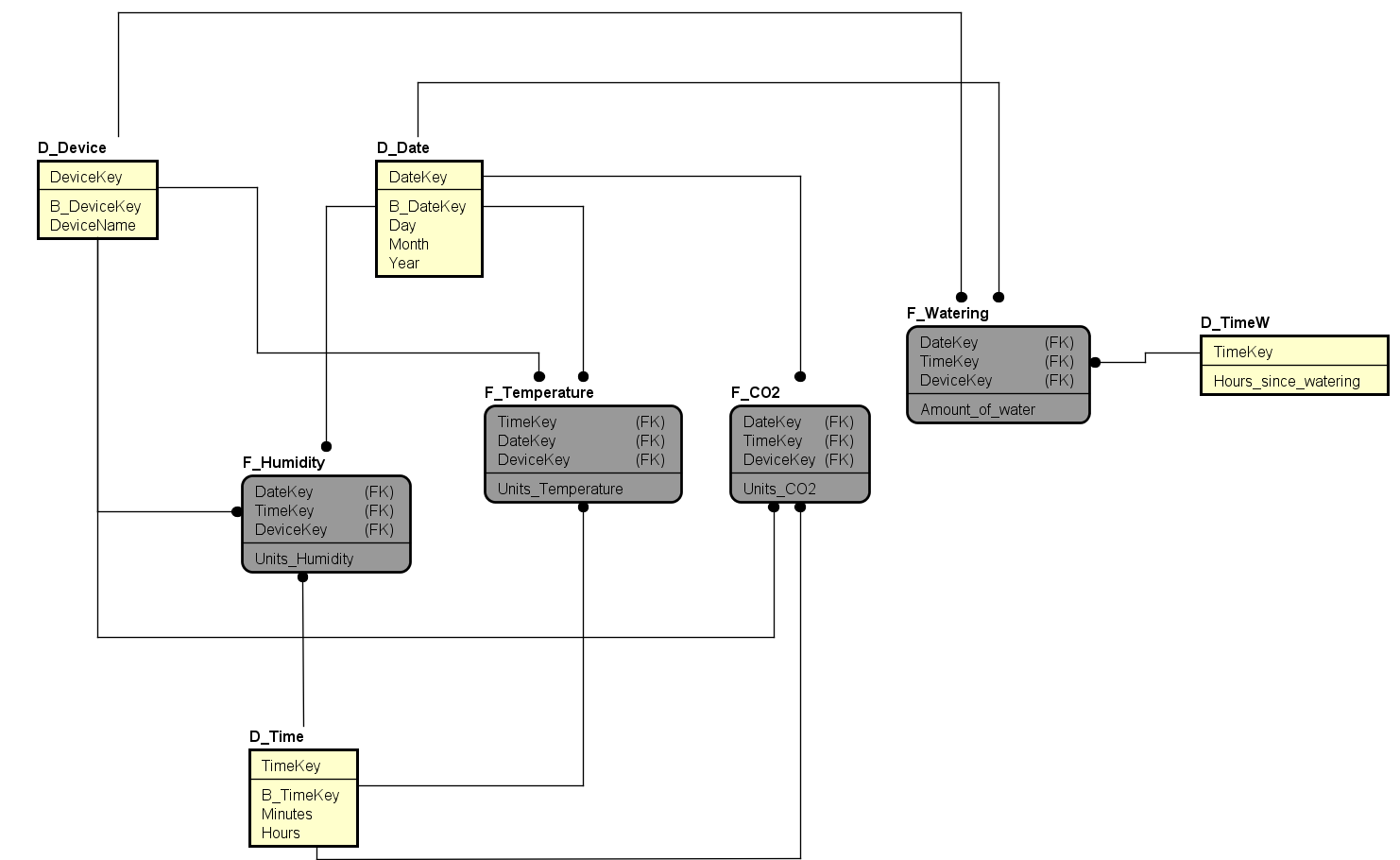
A document will be presented in the following format. It will contain the values of all sensors: temperature, CO2, humidity and watering since, as well as id plant name, date and device.

Data from MongoDB should have backup in Microsoft SQL Server. The main purpose of Server is to store all data from the sensors. The data from the MongoDB should be stored in a transactional database that serves as the source database for the ETL process.



*Figure 2 in Data - Source Transactional Database*

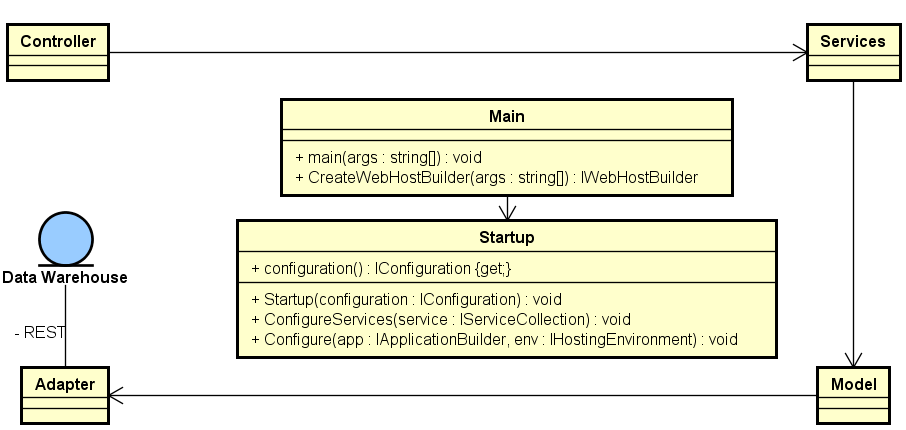
The source database follows the structure from Figure 2. Based on the structure the dimensional model is created. For the temperature the grain is units of temperature. For displaying temperature information’s about time, date and device are needed. For displaying watering, the information when was the last time of watering, date and device were needed. The grain is amount of water.



*Figure 3 in Data - Temperature Dimensional Model*

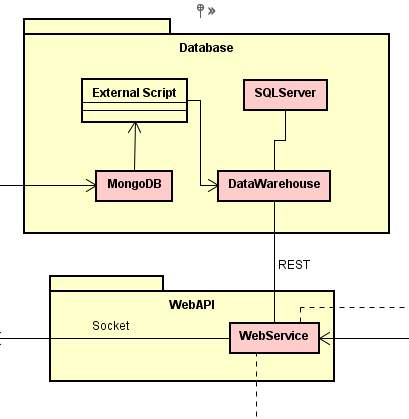
There are four dimensions in our database. The date, device, time and time of watering. These dimensions allow us to look for more specific details. The date dimension allows looking for the date or more specifically for month or day. The time dimension is separated from date dimension, so users can look for specific information at specific hour or minute. The device dimension helps to identify from which sensor information is coming. The dimension watering clearly represents when was the last time that plant was watered.

**Web API**



*Figure 4 in Data - Diagram for API Design*

1. The API makes use of rest server node.js



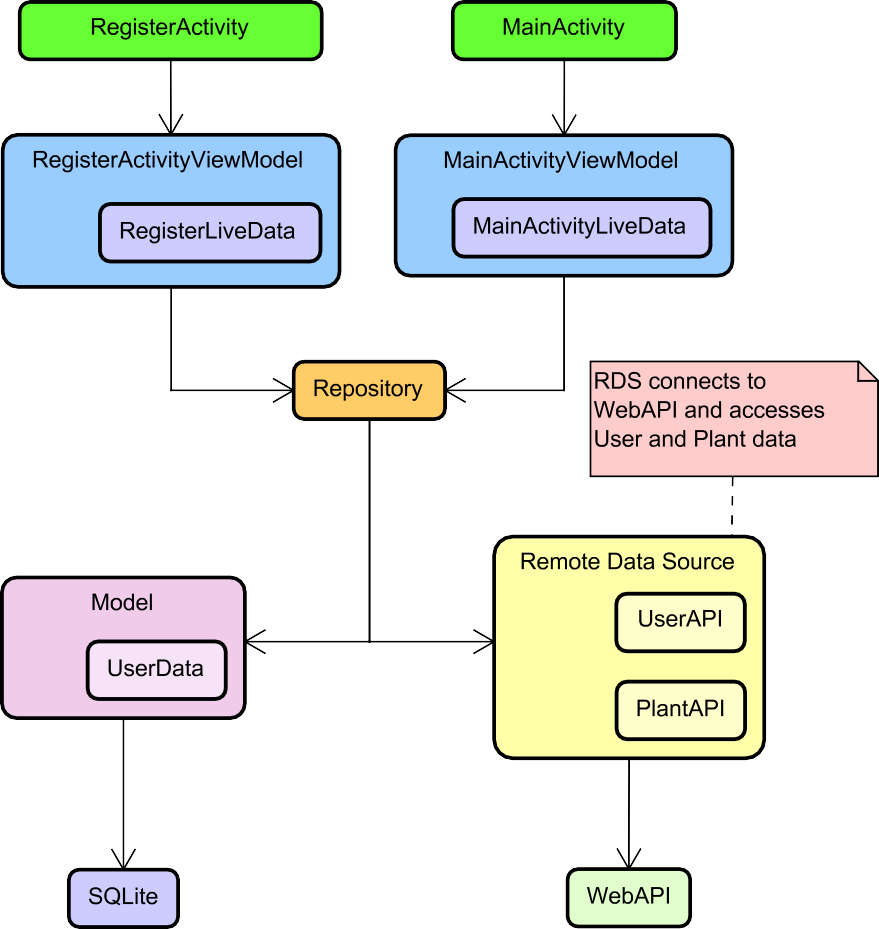
*Figure 5 in Data - Data - Part of an IoT System*

A result of the design is Figure 5 which is part of the bigger picture that consists the IoT System.

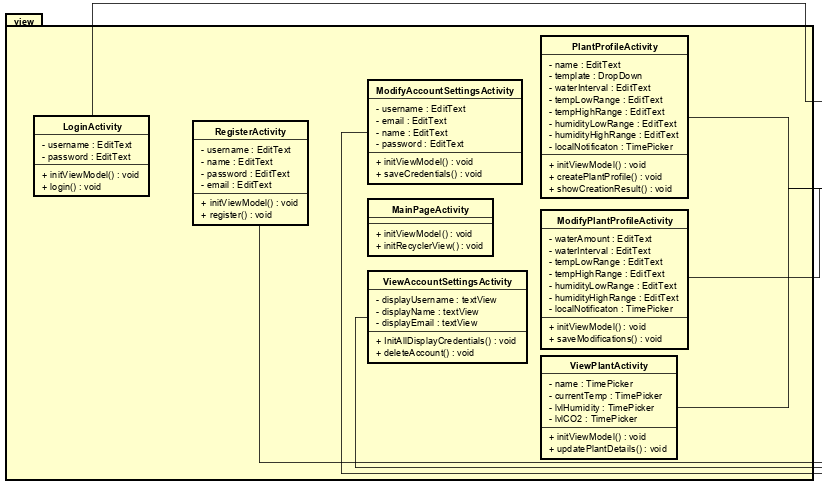
## Android Application

The responsibility of the Android application is to grant the end-user the possibility to control a plants’ environmental conditions. A user has the possibility to register and thus login afterwards. This gives them access to sections where they are able to see the list of their associated plants, they can register new plants and modify their account and profile settings.

The implementation of the application follows the MVVM – Model-View – ViewModel system architecture. The following diagram represents the use of MVVM:

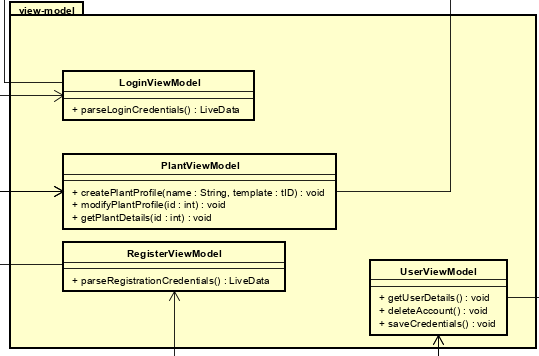


*Figure 1 in Android – MVVM Architecture Diagram (Simplified Architecture Class Diagram)*



*Figure 2 in Android - Design of MVVM Architecture Diagram – View*

In the View, there are the view controllers that are responsible for handling the View elements and updating them. The view is using ViewModels that are in the view-model package to perform actions in the system. ViewAccountSettingsActivity and ModifyAccountSettingsActivity are responsible for presenting the users’ details and making changes to them. PlantProfileActivity is responsible for creating the plant profile. ViewPlantActivity has the purpose of displaying plant data, whilst ModifyPlantProfileActivity changes only the waterAmount, waterInterval attributes as well as the temperature and humidity low-high ranges.



*Figure 3 in Android - Design of MVVM Architecture Diagram – View-Model*

The view-model’s purpose is to handle actions from the view and to serve as a bridge between the view and the model. All view-models pass data to their respective associated repositories. UserViewModel handles operations for user-related activities, PlantViewModel from plant related activities and finally, Login/RegisterViewModel – user specific credentials.

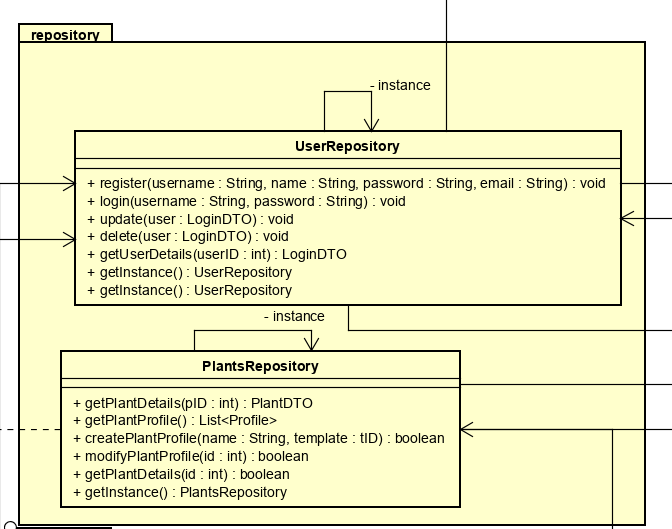
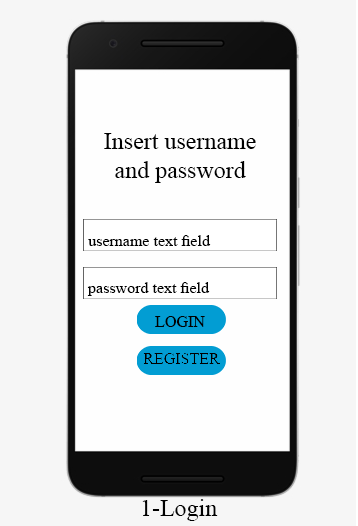


Figure 1 in Android - Design of MVVM Architecture Diagram – Repository

The repositories in the design implementation serve as a facade to the database and WebAPI. The User and Plants repositories are handling CRUD operations on model entities. They implement Singleton design pattern to ensure that there is only one instance of the mentioned repositories in the system. The repositories are using DTOs from the model to exchange data with the WebAPI.

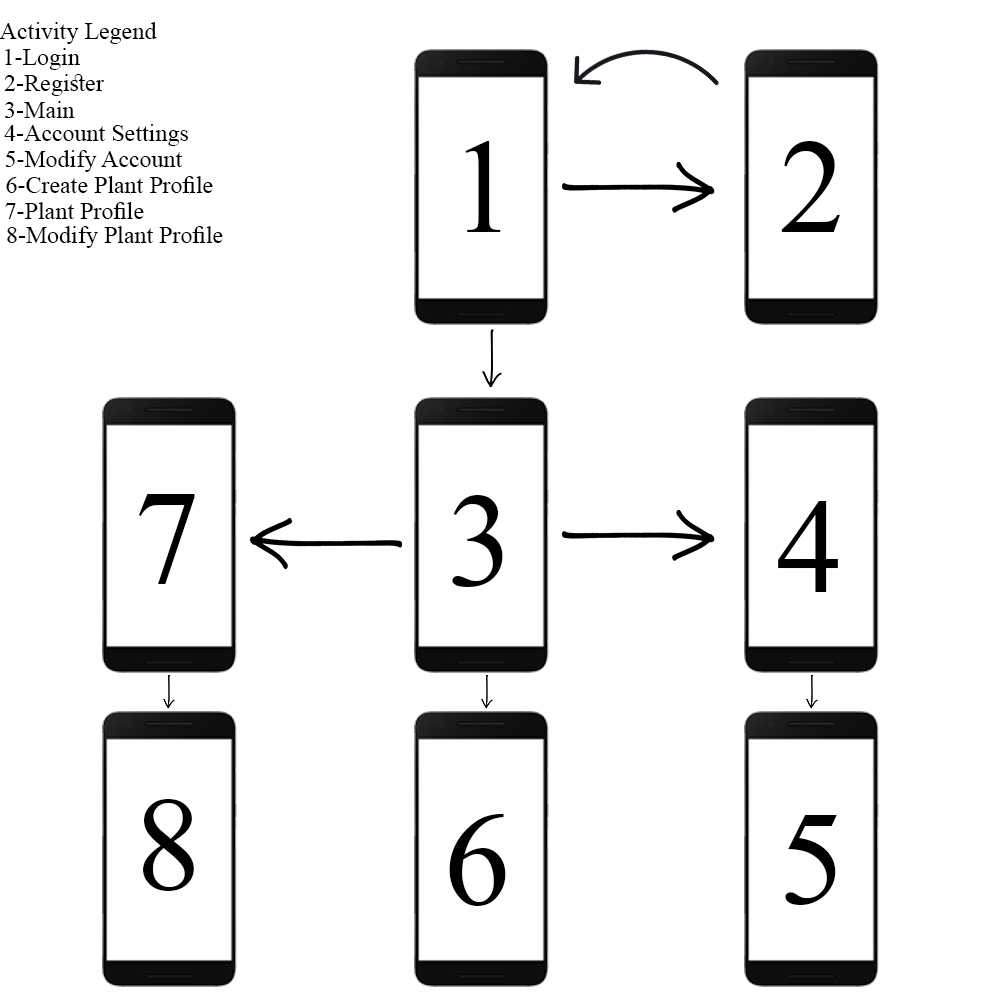
**UI Design and Navigation**

From the early stages of the project, the main focuses regarding the User Interface were to make every layout of every single activity in the Android Application simple, intuitive and eye-catching. In the Design phase, the Android group designed sketches of the layouts.



As it can be seen from the above represented sketches, the layouts have been designed to be as simple and straight forward as possible. Along with the layouts sketches, the group designed an interaction diagram for all the layouts, which has the sole purpose of giving a better understanding of how the flow of events in the application works.

As it can be seen from the interaction diagram, there are 8 activities that the application uses: **Login**, **Register**, the **Main activity**, **Account Settings**, **Modify Account**, **Create Plant Profile**, **View Plant Profile** and **Modify Plant Profile**.



**Login Activity**

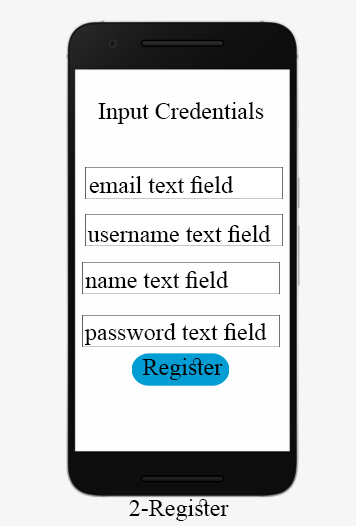
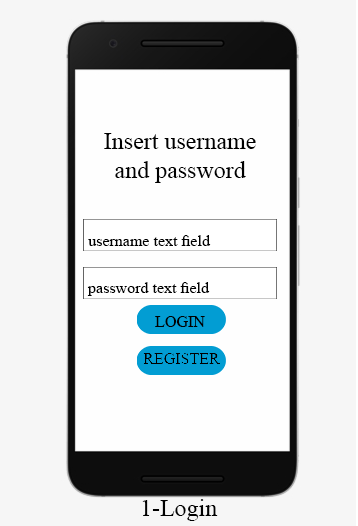
The **Login activity** is the one that the user is prompted with when first opening the application. From this activity, the user has two options:

1. Input his login details of a previously created account and then press the “Login” button, from which he will be sent to the **Main Activity.**

2. Press on the “Register” button, getting sent to the **Register activity** where he is able to create a new account.

**Register Activity**

The **Register activity** is oversimplified and it allows the user to input four text fields with his account details: username, email, name and password, after which the user presses the “Register” button which prompts him back to the **Login activity.**

****

**Main Activity**

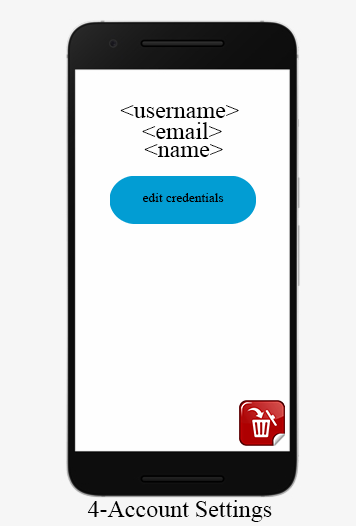
The **Main activity** displays a custom welcome message for the user, based on his name that he inputted when he created his account, and below that it displays a list with plants. This activity also features a bottom navigation bar, which is also present in all the other activities, apart from the **Login** and the **Register** ones, with 3 options:

* The button on the right sends the user to the **Account Settings activity**
* The option in the middle has the purpose of sending the user to the **Main activity**
* The option in the left redirects the user to the **Create Plant Profile activity**

One last thing the user can do from the **Main activity** is to click on one of the existing plant profiles, which sends the user to the **View Plant Profile activity**

**Account Settings Activity**

In the **Account Settings activity**, the username, email and name of the user are displayed on top, along with an “Edit credentials” button, which, if pressed, sends the user to the **Modify Account activity**. This activity encloses a “Delete Profile” button, which will delete all the data of the user from the database, including the login details.



**Modify Account Activity**

In the **Modify Account activity**, the user has 4 text fields where he can input his new details, in the case he wishes to change any, and then a save button, that, if pressed, saves and updates all the new data in the database.

**Create Plant Profile**

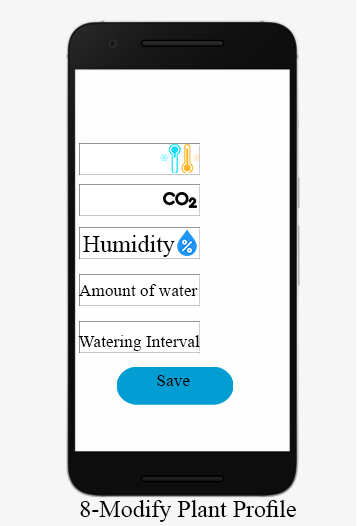
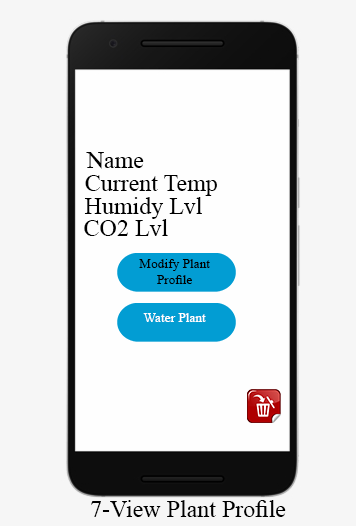
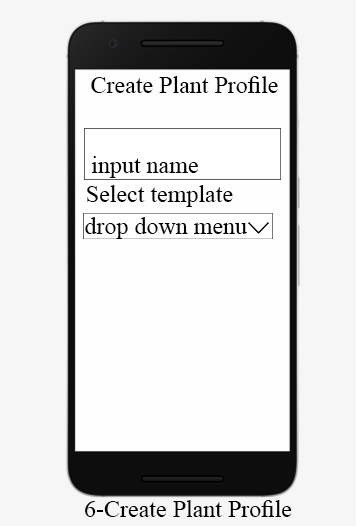
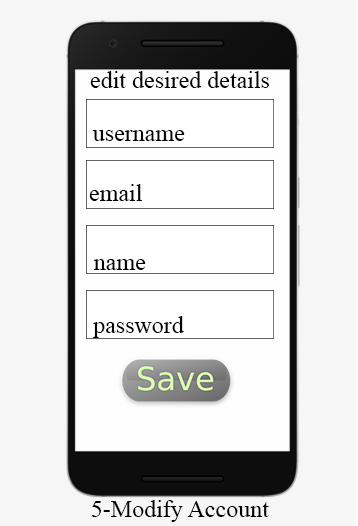
In the **Create Plant Profile activity**, the user is given to option to create a plant. He has to input a name for the Plant, and, in addition to this, he can select a predefined plant template (which defines the ranges of the temperature, humidity and carbon dioxide) from a drop down list.

**View Plant Profile**

In the **View Plant Profile activity**, the application displays the name of the plant, the current external temperature, the humidity level and also the CO2 level. There is also a “Modify Plant Profile” button, that the user can press, which sends him to the **Modify Plant profile Activity**. This activity also features a “Water Plant” button that can be pressed to remotely water the plant. Lastly, a delete button also appears in the bottom of the activity, which can be pressed to delete all the data regarding that certain plant from the database and remove it from the system.

**Modify Plant Profile**

In the **Modify Plant Profile activity**, there are multiple text fields, where the user is able to change the temperature range, the CO2 level, the humidity level, the amount of water and the watering interval. For the changes to apply to the database, the user has to press the “Save Button”.

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# Implementation

## IoT

## Data Engineering

## Interactive Media

**Application architecture**

Architecture was a main concern when the application was designed, as it represents the foundation for an app that is well maintainable, scalable and reliable. The aspects taken into account when deciding on an architectural pattern where the separation of concerns, the code reusability, testability and independence. Even though the term “good architecture” may sound slightly abstract, having these concerns in mind, the MVVM architecture was chosen for this project. It maintains a clear separation between application logic and the UI, therefore addressing numerous development issues and making the application easier to test and maintain. The emphasis is put on dividing the responsibilities, so the UI components are separated from the business logic and the business logic is separated from the data access.

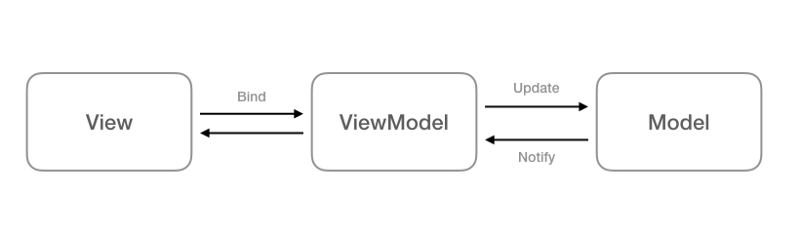
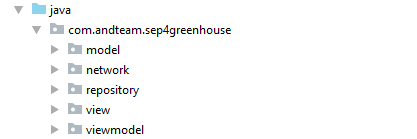
There are three core components in the MVVM pattern: the Model, the View and the ViewModel, each serving a distinct purpose. The figure below illustrates the relation between the components:

Figure 1 Data flow in MVVM

The ViewModel isolates the View from the Model, so it receives its data from the Model and exposes the data and command objects that the View requests. The Model is unaware of the ViewModel and the ViewModel is unaware of the View.

In the figure below, how the MVVM pattern was related to the application can be observed:



**The Model** represents the actual data that is dealt with in the application but it does not hold behaviours or services that manipulate the information. It does not have anything to do with the UI or with fetching any data. Business logic is kept separate from the Model as it belongs to other classes that act on the model.

**The View** is responsible for the structure and appearance of what the user sees on the screen. Each view is defined in an XML file containing code without any business logic. The View retrieves its data from the ViewModel thorough the use of binding.

**The ViewModel** is the component that connects the View to the Model by accessing the methods and properties of the Model that are then made available to the View.

**Firebase authentication**

Firebase is a platform that allows the development of web and mobile applications without server-side programming and it provides a series of built-in services. Firebase Authentication is very easy and quick to implement, has autoscaling built-in and provides real-time updates. It automatically stores users’ credentials securely by using bcrypt and it separates this sensitive user information from the application’s data.

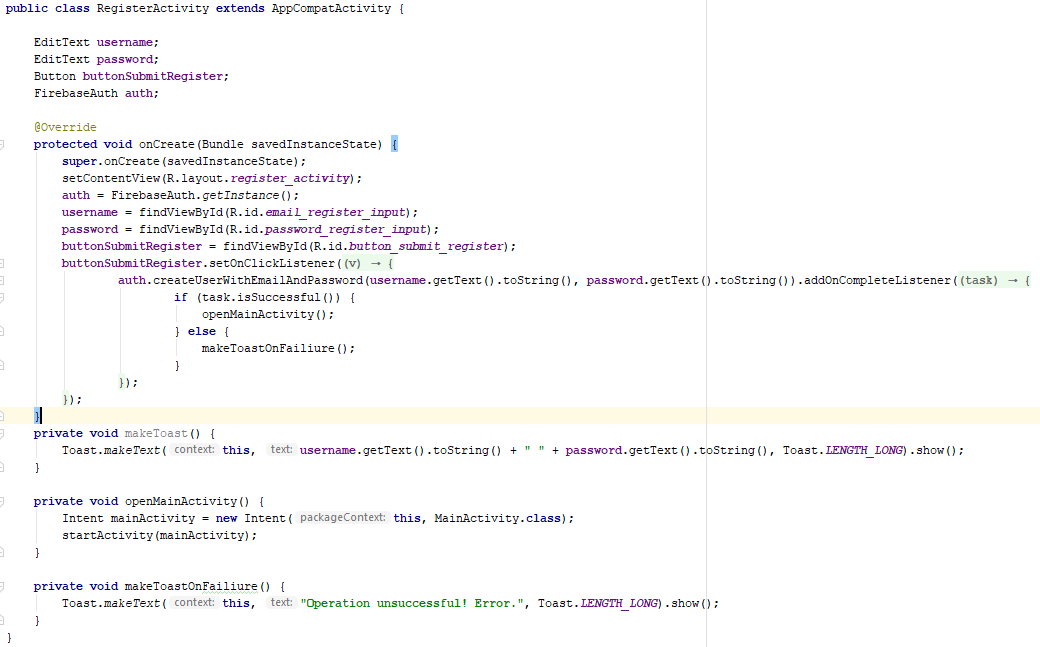
Setting up Firebase is a very intuitive, fast and easy process. Everything was set up by using a google account, creating a new project and adding a new app to it. For the authentication, the email/password sign-in method was enabled.

The main activity opens the app in the login screen where existing users can log in and new users can register. The logic behind the login activity and its connection to Firebase can be observed in the screenshot below.

The layout is set for this activity and the input fields and the buttons are identified. For the Register button an on click listener is attached which runs the method that opens the Register activity.

When the login button is pressed, the user data from the input fields is compared to the Firebase database and if the user was registered, the Main Activity opens up. Otherwise, an error message will be displayed on the screen.

The logic behind the Register activity is presented in the image below. Once the Firebase connection has been established and the layout was set, on the press of the “submit register” button, the user credentials are sent to the Firebase database and the Main activity starts. In the eventuality of a failed registration, an error message is displayed on the screen.



**The bottom navigation bar**

The bottom navigation bar makes it easy to explore and switch between views. It is convenient to use in cases where there are three to five top-level navigation items of alike importance as it will be omnipresent no matter which view was selected. For the app’s bottom navigation bar there are three main navigation items that correspond to Adding a new plant, Viewing the current list of plants and Modifying the user’s account settings. The smooth transition between views where the bottom navigation bar stays in place is done using fragments and each view has its own layout resource file and fragment class. The initial (default) fragment that is loaded is View list of plants.

In the onCreate() method in the main activity the BottomNavigationView object was defined as well as the listener for detecting the navigation item selection.

![A screenshot of a social media post

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDsRXhpZgAATU0AKgAAAAgABAE7AAIAAAALAAAISodpAAQAAAABAAAIVpydAAEAAAAWAAAQzuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEVyaWthU3phc3oAAAAFkAMAAgAAABQAABCkkAQAAgAAABQAABC4kpEAAgAAAAM1MQAAkpIAAgAAAAM1MQAA6hwABwAACAwAAAiYAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Cp6aiLGgWNVRR0CjAFOoAKKKKAOfskSD4hausNuFFxYWs00qAAFw8ygt3LFQADzxHgkYGegqrBp1tb6hdX0Sv9ouwgldpWbIQEKACSFAyThcDJJ6kmrVA3uFFFFAgooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAjtv+PWL/AHB/KpKjtv8Aj1i/3B/KpKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAjtv+PWL/cH8qkoooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooA//9k=)

The loadFragment() method deals with switching between fragments and it is called inside the onCreate() method to load the default fragment on start, as seen in the screenshot below.

![A screenshot of a social media post

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDsRXhpZgAATU0AKgAAAAgABAE7AAIAAAALAAAISodpAAQAAAABAAAIVpydAAEAAAAWAAAQzuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEVyaWthU3phc3oAAAAFkAMAAgAAABQAABCkkAQAAgAAABQAABC4kpEAAgAAAAMyMwAAkpIAAgAAAAMyMwAA6hwABwAACAwAAAiYAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Figure 2 Navigation item selected listener and loadFragment method

Each fragment class for the three main views extends the Fragment class and inflates the respective layout for each fragment.![A screenshot of a social media post

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDsRXhpZgAATU0AKgAAAAgABAE7AAIAAAALAAAISodpAAQAAAABAAAIVpydAAEAAAAWAAAQzuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEVyaWthU3phc3oAAAAFkAMAAgAAABQAABCkkAQAAgAAABQAABC4kpEAAgAAAAMzNwAAkpIAAgAAAAMzNwAA6hwABwAACAwAAAiYAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Figure 3 The Add Plant fragment class

**Retrofit HTTP Client Implementation**The Retrofit API serves as a data bridge for the WebAPI and the Android application. JSON object passing is established via HTTP and routed into a designated URI. The Retrofit declaration requires the type of request made to the WebAPI (GET, PUT, POST, DELETE). In the body of the request, the type of object is declared followed by a name declaration for calling this request.

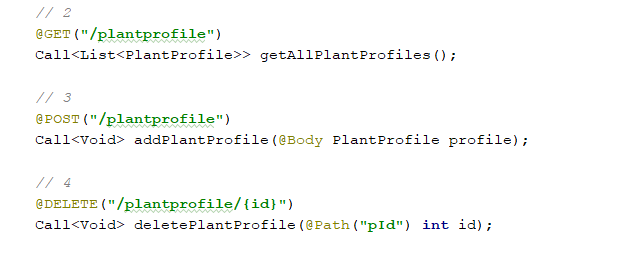
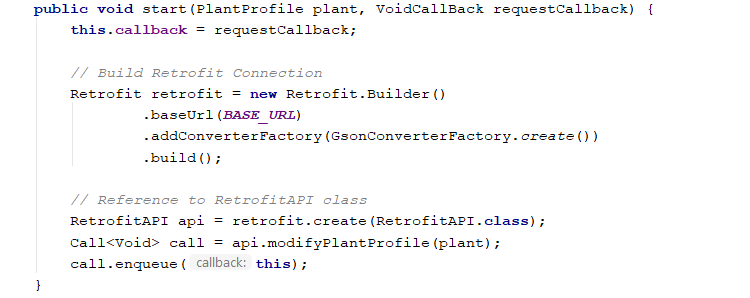


Figure X: Retrofit request type & parameters declaration

An example use case is calling the deletePlantProfile (number 4 in figure X) in the DeletePlantProfile class. A Retrofit object is declared on which the baseUrl method is called. This method takes the target location of the WebAPI to be consumed. Following that, the PlantProfile data object is passed into JSON and the request is made to the WebAPI (figure X).



# Test

The purpose of the test section is to document the result of your testing; to verify if the content of the requirements section has been fulfilled. How is the system tested, which strategy has been used; e.g. White Box (Unit Test), Black Box, etc.

Figure X: Retrofit connection build

## Test Specifications

For functional requirements, test specifications must be listed. These test specifications can be described as soon as the functional requirements have been completed (Use Cases including descriptions).

IEEE can be used as a template for test specification (IEEE Computer Society 2008). VIA Library can give you access to this standard.

# Results and Discussion

The “Green House” project was developed to meet the requirements of an Internet of Things project that can retrieve, analyze and visualize sensor data. The retrieving of data is conveyed through , the analysis is done by and finally the data is visualized on an app that was developed in Android Studio. Users are able to register and login in the app and see live data sent from the sensors that analyse their plants’ environmental conditions.

However, in terms of functionality, one task that the group did not manage to succeed was Furthermore, there are several points that can be improved such as

The group decided from the very first stage of the implementation that the main focus will the put on the top-priority requirements, the goal being fulfilling those rather than starting the work on the secondary ones, that don’t affect the functionality of the system in a great manner.

The implementation of the system, as expected, came out to be a complex task, the group having to work on three different “sub-systems”, an Android Application, an embedded system and also a Data Warehousing part.

The group realizes there are mistakes and there are a lot of improvements to be done, but since time was short, the system didn’t come up as the perfect one, but the group is pleased with the final result, and is prepared to do an improved job on the next project, with the experience gained from this one.

# Conclusions

The ultimate goal of every semester project is to facilitate everything learned through the semester, work on the project having the goal to spark the interest on the targeted topics, in this particular project the learning goals being Android Programming, Embedded Programming and Data Warehousing. Apart from applying concepts learned during the courses, the group is also motivated to research the subjects more in-depth. The group gained valuable knowledge in all fields, analyzed and designed all the features from scratch, along with also spending a good amount of time on implementing and testing these features. Ultimately, the group is pleased with the final result with the project, once again, feeling they gained valuable insight about different frameworks, technologies and programming languages.

# Project future

Reflect on your project from a technical viewpoint and describe what you would change if you could.

Suggest how the project could be improved or made ready for production. Discuss scalability, suggest possible spin offs, what is needed, missing, etc.?

# Sources of information

# Appendices

The purpose of your appendices is to provide extra information to the expert reader. List the appendices in order of mention.

Examples of appendices

* Project Description
* User Guide
* Source code – source documentation
* Diagrams
* Data sheets
* Etc.

**Appendix A Project Description**

Insert the original Project Description here