Indoor Parameter Monitoring System

Students

Alexandru Dima Mircea: 266006

Alexandru Vieru: 267013

Rares Dumitru Bunea: 266983

Liviu Lesan: 241737

Ionut Boitan: 266869

Alexandru Ciornea: 266875

Alexandru Mihai Serb: 266913

Raul Pologea: 266240

Supervisors

Ib Havn

Lars Bech Sørensen

Erland Ketil Larsen

Knud Erik Rasmussen

Kasper Knop Rasmussen

ICT Engineering, VIA University College, Horsens

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Abstract

The purpose of this project is to create a room monitoring system which will monitor and retrieve sensor data of CO2 emissions, humidity and temperature from an IOT device and send them to a data storing unit. The measurements will be retrieved using an Android application and will make the data available for a given user.

This system will increase efficiency in managing monitoring tasks for the given location and will allow users to retrieve data in a fast and reliable manner.

The benefit of using this system is that the information will be stored on a database which provides scalability and a more fast and efficient manner.

Using this system technical staff will be able to view different data from different units at the same time and will be displayed to them in a fast way by just a click of a button.

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1 Introduction

One of the greatest focus of the modern society is to educate people that will be able to improve it. Studying or teaching are difficult activities that require a good ambiance, so that the evolution of an individual will be noticeable.
Many students work hard to acquire good study skills, but not many realize that having the right place to study is just as important. The study environment can be a big factor in how successfully some people learn and retain information and be able to apply it in their assessments and on the job. For a short time, you may be able to stay focused in hot or humid places, but after a while, these circumstances can become unbearable. Similarly, if you're too cold, that quickly becomes all you can think about, and studying suffers.
A human being that will pursue his duties in a balanced environment will show higher productivity.
Living in a time when technology is at its peak, most people have access to a mobile android device.
Having a system that will help monitor a certain room or group of rooms on their CO2, temperature and humidity parameters and eventually alert the users about surrounding conditions out of normal, is a good start in helping the community progress.

2 User stories and requirements

2.1 User stories

1. As a technician I want to be able to collect information from all the sensors (air temperature, CO2 and humidity) so that I can oversee the environment inside a room using a phone.
2. As a technician I want to see the minimum and maximum standard values for optimal living/working/studying conditions so that I could be able to take certain actions before the conditions break the optimal ranges.
3. As a technician I want to get push notifications assessed before and when the sensor's readings reach unfavorable parameters so that I can prevent or fix different problems.
4. As a technician I want to be able to have the data stored in a database so that I can access both current and past information about the environment state.
5. As a technician I want to be able to control the motor that controls the window so that I can open or close a window as much as it is required using a phone.
6. As an administrator I want to be able to add, edit and remove users.

2.2 Functional requirements

Cross Media Requirements

1. The application must retrieve and parse relevant data from a webservice
2. The application must be able to send data to a webservice to interact with actuators
3. The application must have a responsive user interface
4. The application should utilize authentication to sign in
5. The application should have a settings menu
6. The application should persist some data locally on the device
7. The application must be under version control for the entire development process
8. The application must be developed using the official Android framework
9. The application must be developed with Java
10. The application should follow the Google Material Design guidelines
11. The source code should be structured using an architectural pattern

Embedded Requirements

1. The system should measure the level of CO_2.
2. The system should measure the ambient temperature.
3. The system should measure the humidity in the air.
4. The system should send gathered data to MongoDB.

Data Engineering Requirements

1. Users must be able to collect information from all the sensors (air temperature, CO2 and humidity)
2. Users could be able to see the maximum and minimum standard parameters
3. Users should be able to get push notifications
4. Data must be stored in a database
5. Users should be able to control the actuator
6. Administrators must be able to add, edit and remove users

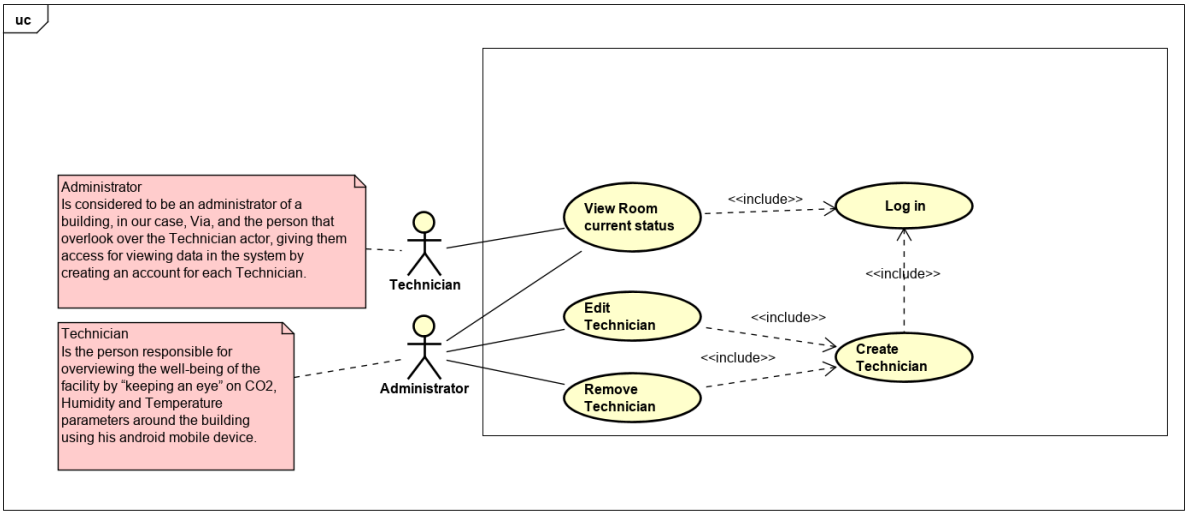
2.3 Nonfunctional requirements

1. The system must use at least five tasks.
2. Some data must be used by more than one task.
3. The system must use semaphores, mutex and queues.
4. Part of the system must be tested by using unit test.
5. The system should use LoRaWAN and Bridge application to transfer the data to database from device.
6. SCRUM & AUP must be use for the development process
7. The project and process report must include authors for each section
8. Links must be handed in to the source code on GitHub
9. A link to a video demonstration on YouTube must be presented

3 Analysis

3.1 Use case diagram

The system has two types of actors. One is at a basic usage level-the technician- and the other the Administrator having an extra capabilities such as user administration, as it is shown in the diagram bellow.



3.2 Use case description

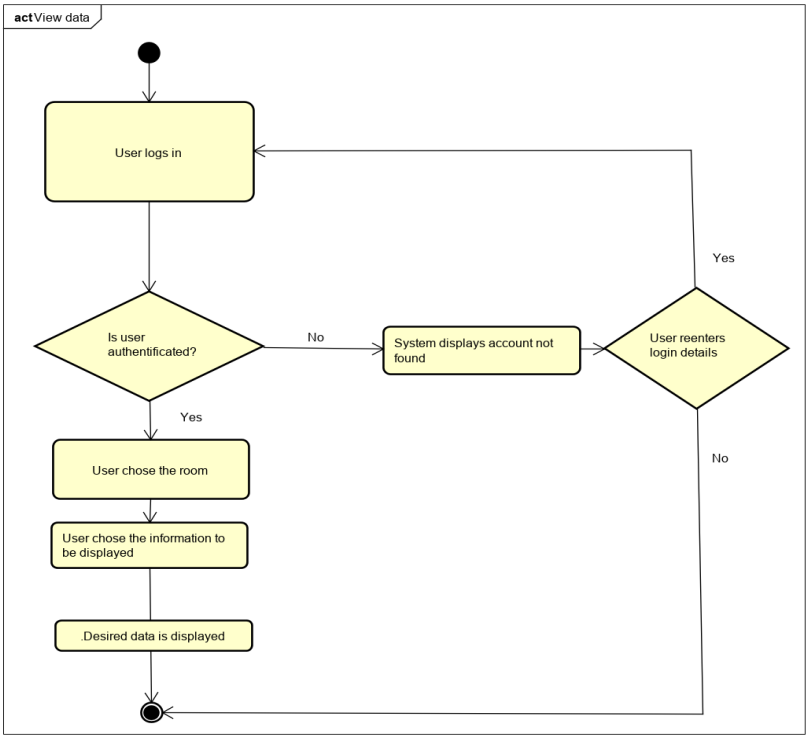
ITEM	VALUE
UseCase	Remove Technician
Summary	Administrator deletes an account for a user
Actor	Administrator
Precondition	User has been created Administrator is autentificated
Postcondition	User credentials are deleted from persistance
Base Sequence	1.Administrator accesses the list of tehnicans. 2.Administrator selects technicians to have credentials removed 3.Administrator removes credentials 4.Administrator updated the technician list
Branch Sequence	
Exception Sequence	
Sub UseCase	Create Technician
Note	

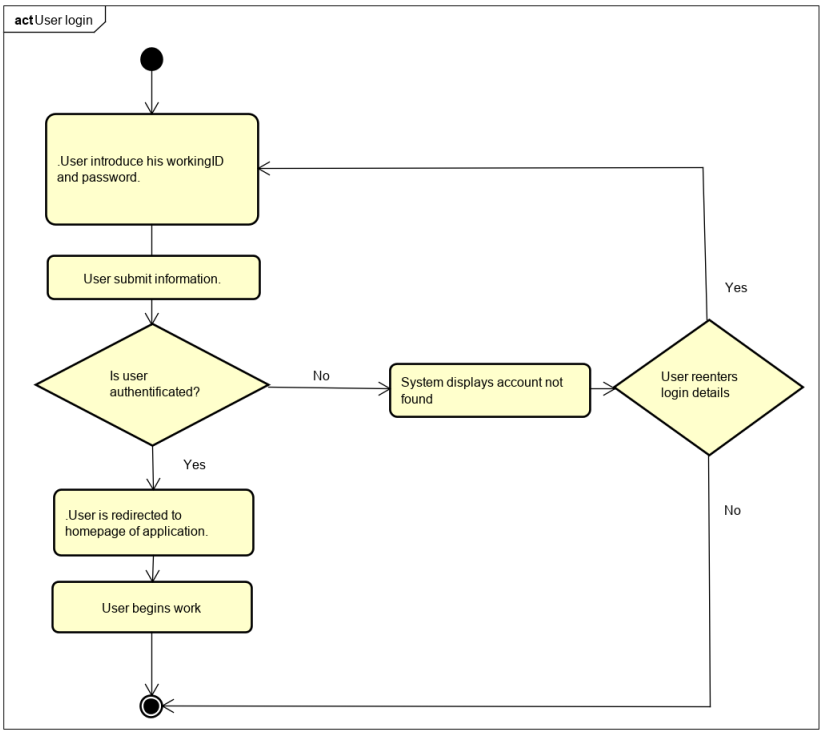
ITEM	VALUE
UseCase	Log in
Summary	User use his id and password to log in application.
Actor	
Precondition	User must be registered
Postcondition	After succesuful log in user can use application.
Base Sequence	1.Technician introduce his workingID and password. 2.Technician submit information. 3.Technician is redirected to homepage of application. 4.The use case ends
Branch Sequence	2a Information is missing from workingID and/or password is missing. 1.Application is asking for wokingID and/or password. 2.Use case is resumed form 1 base sequence. 2b Inofrmation from workingID and/or password fields is invalid. 1.Application is asks for a valid workingID and/or passord. 2.Use case reume from 1 step from base sequence.
Exception Sequence	
Sub UseCase	
Note	extend Display Login Error

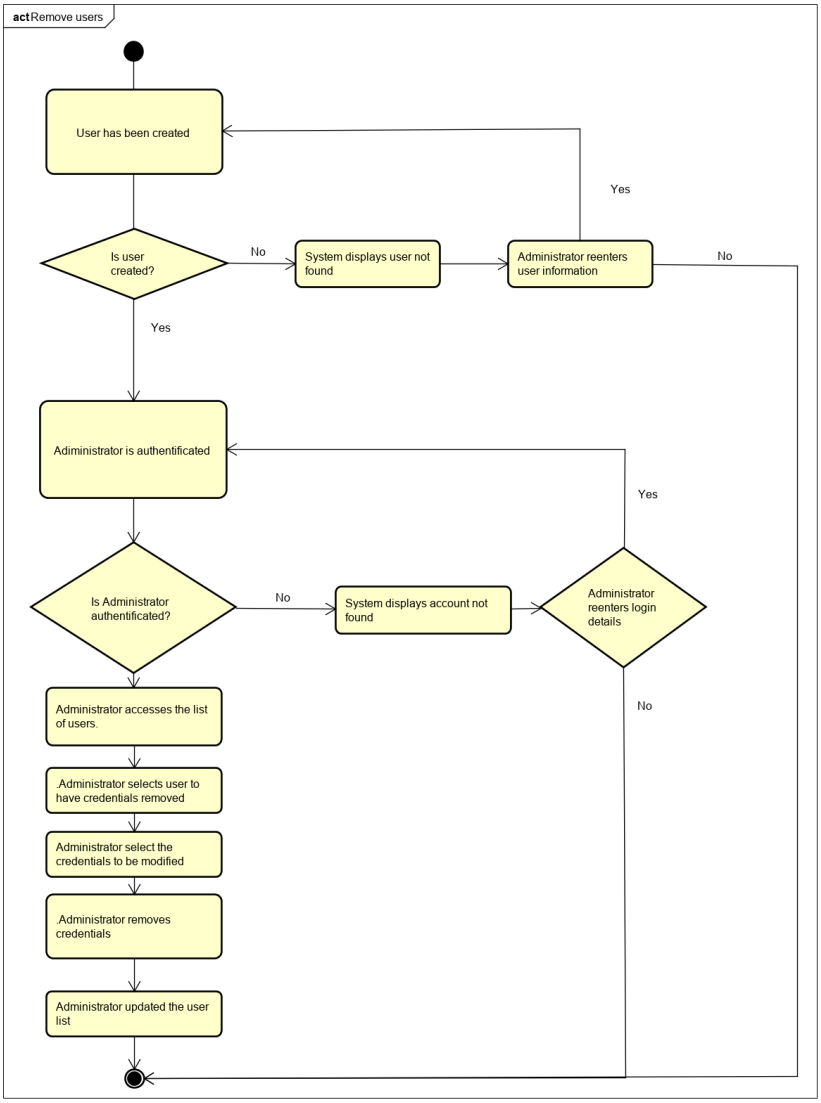
ITEM	VALUE
UseCase	Edit Technician
Summary	Administrator modifies an account for a user
Actor	Administrator
Precondition	User has been created Administrator is autentificated
Postcondition	Technician is saved with new credentials
Base Sequence	1.Administrator accesses the list of users. 2.Administrator selects user to have credentials modified 3.Administrator select the credentials to be modified 4.Administrator modifies credentials 5.Administrator saves user data 6.System updates user data to persistence
Branch Sequence	
Exception Sequence	
Sub UseCase	Create Technician
Note	

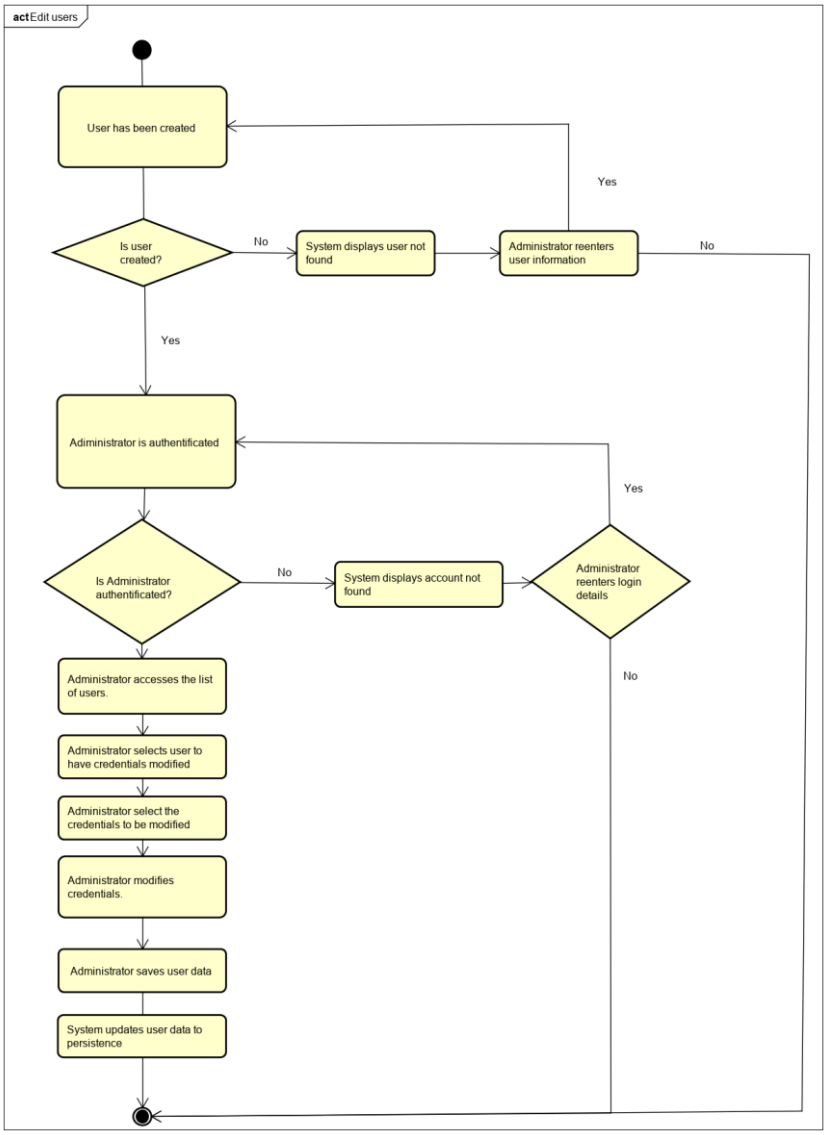
ITEM	VALUE
UseCase	Create Technician
Summary	Administrator creats an account for a technician
Actor	Administrator
Precondition	Aministrator is autentificated
Postcondition	The users credidentials will be added to the system
Base Sequence	1. Administrator enters desired username. 2. Administrator enters desired password. 3. Administrator confirms password by re-entering it. 4. Account is created and stored in the system.
Branch Sequence	
Exception Sequence	None
Sub UseCase	Log in
Note	

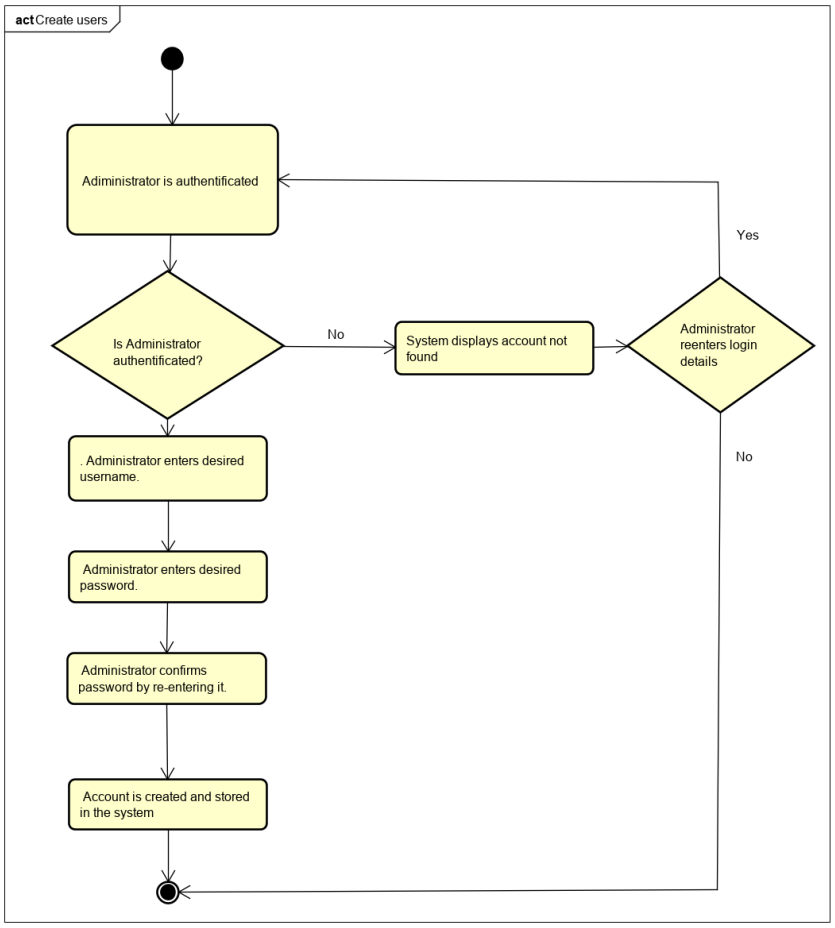
3.3 Activity diagram



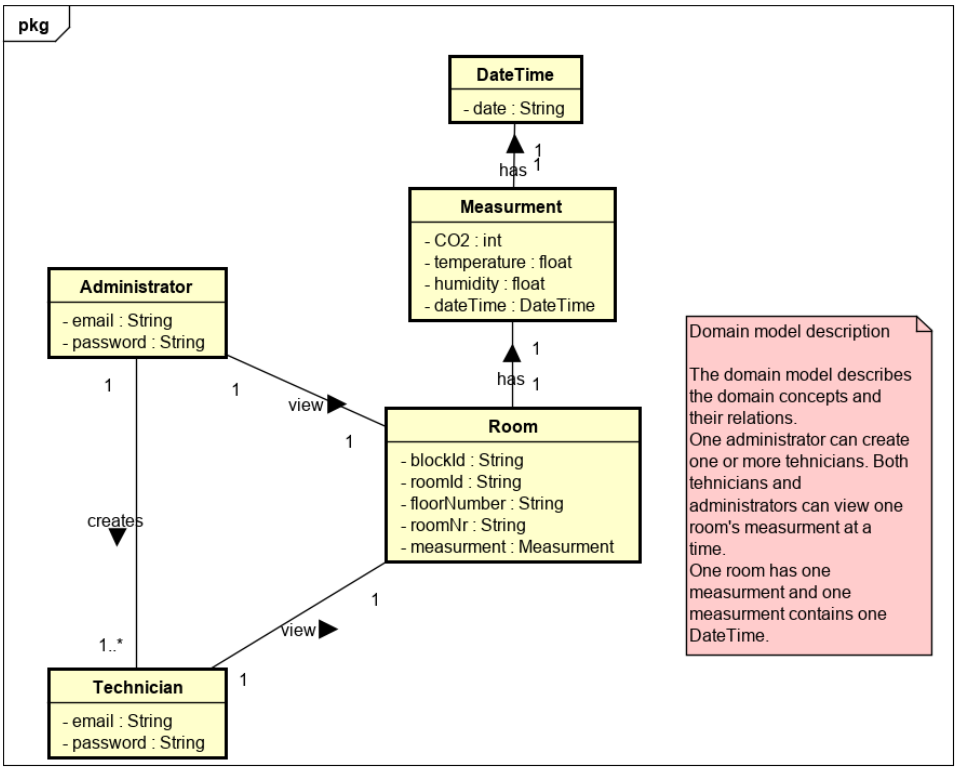

actUser login
.User introduce his workingID and password.
User submit information.
Is user authentificated?
No
System displays account not found
User reenters login details
Yes
Yes
No
.User is redirected to homepage of application.
User begins work


actRemove users
User has been created
Is user created?
No
System displays user not found
Administrator reenters user information
Yes
No
Yes
Adiministrator is authentificated
Is Administrator authentificated?
No
System displays account not found
Administrator reenters login details
Yes
No
Administrator accesses the list of users.
.Administrator selects user to have credentials removed
Administrator select the credentials to be modified
.Administrator removes credentials
Administrator updated the user list

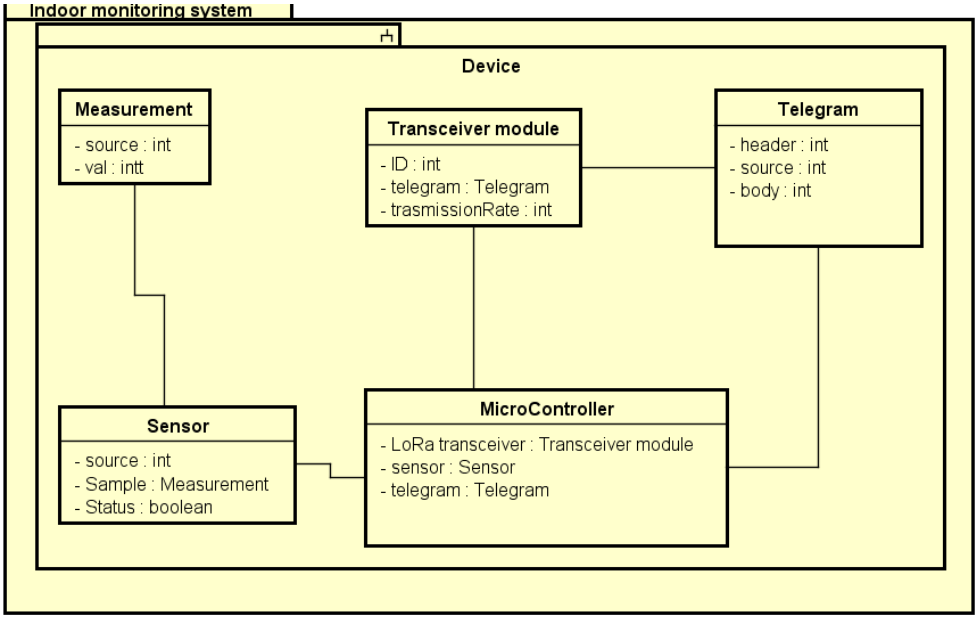

actEdit users
User has been created
Is user created?
No
System displays user not found
Administrator reenters user information
Yes
No
Yes
Adiministrator is authentificated
Is Administrator authentificated?
No
System displays account not found
Administrator reenters login details
Yes
No
Administrator accesses the list of users.
Administrator selects user to have credentials modified
Administrator select the credentials to be modified
Administrator modifies credentials.
Administrator saves user data
System updates user data to persistence


act Create users
Adiministrator is authentificated
Is Administrator authentificated?
No
System displays account not found
Administrator reenters login details
Yes
No
. Administrator enters desired username.
Administrator enters desired password.
Administrator confirms password by re-entering it.
Account is created and stored in the system

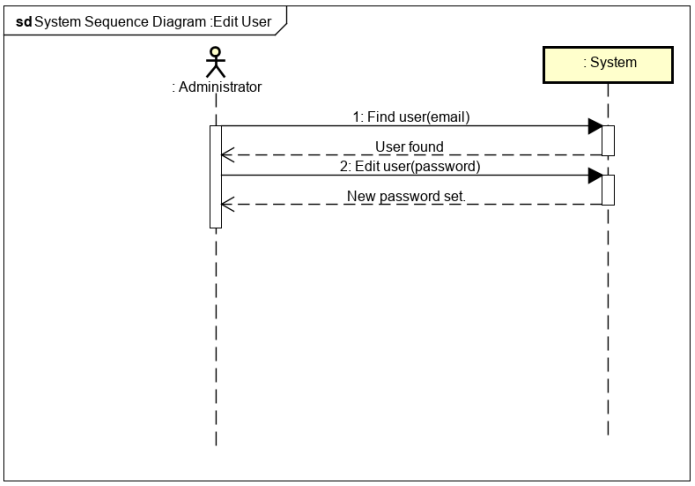
3.4 Domain model diagram

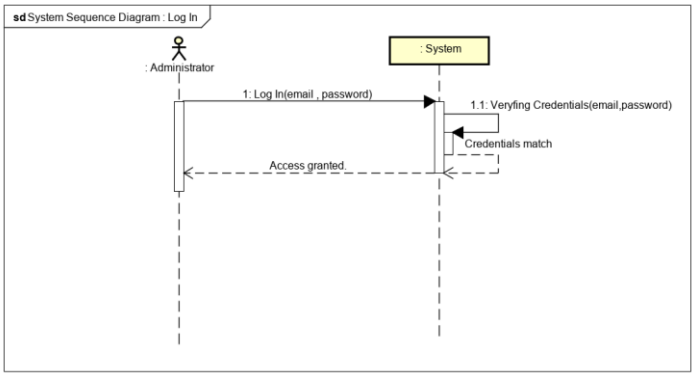


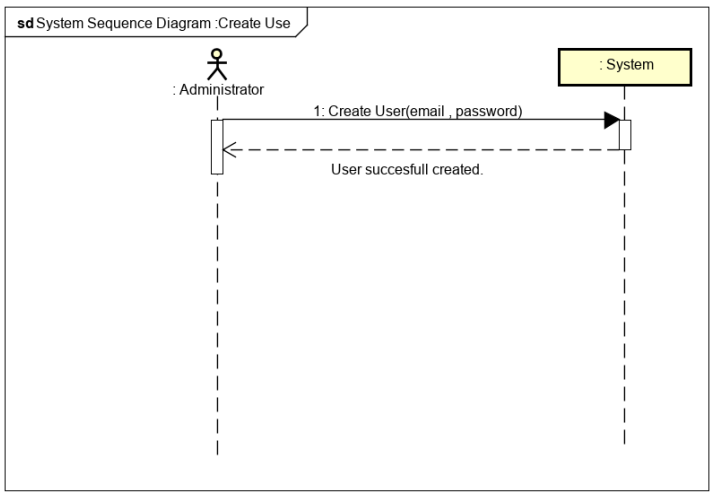
From the viewpoint of embedded engineering, the system can be represented as in the diagram bellow. The center entity in this block is the MCU which is connected to sensors from which measurements are retrieved, processed and stored in a telegram to be delivered by the transceiver module on a network. From further analysis, is concluded that another subsystem is required in order to facilitate the data transfer to a permanent storage so that it can reach a final user.

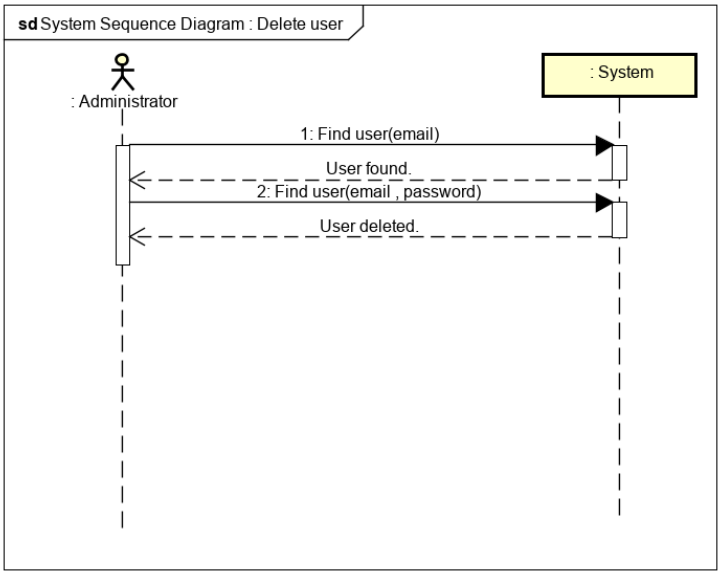


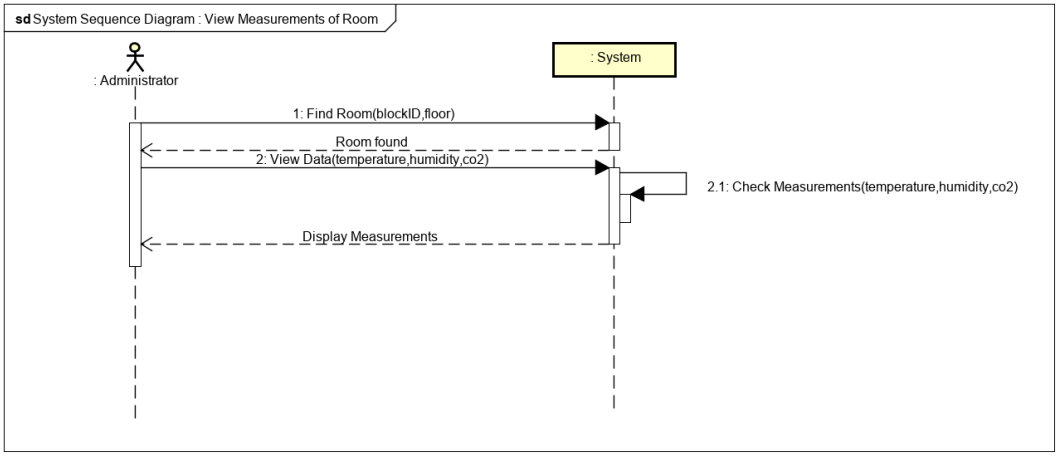
3.5 System sequence diagram





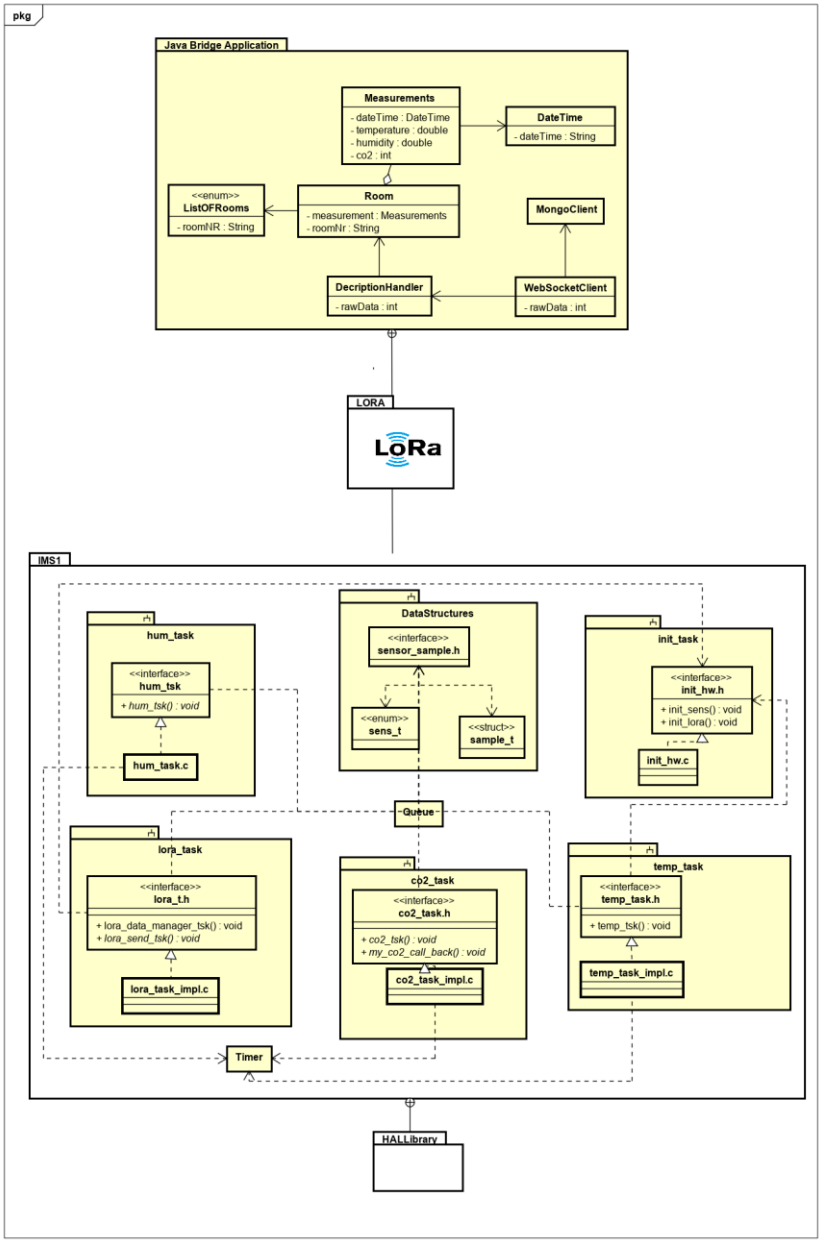



sd System Sequence Diagram : Delete user
: Administrator
: System
1: Find user(email)
User found.
2: Find user(email , password)
User deleted.


sd System Sequence Diagram : View Measurements of Room
: Administrator
: System
1: Find Room(blockID,floor)
Room found
2: View Data(temperature,humidity,co2)
2.1: Check Measurements(temperature,humidity,co2)
Display Measurements

4 Design

4.1 IOT Design



This subsystem is divided in two modules responsible for the transfer of data to and from the LoRaWAN network. First module, represented in the above diagram by the IMS1 package, is responsible to acquire data from the three sensors mounted on an Arduino shield and transmit it to the LoRaWAN network making use of an LoRa module mounted on the same shield. The second module, represented in the above diagram by the Java Bridge Application package, has the responsibility to retrieve the data from Loriot.io server, decoded in a readable format and send it to a MongoDB sever.

The module responsible for data retrieval and sending to LoRa network is designed so that the samples from the sensors are stored in a data structure that is protected from corruption while

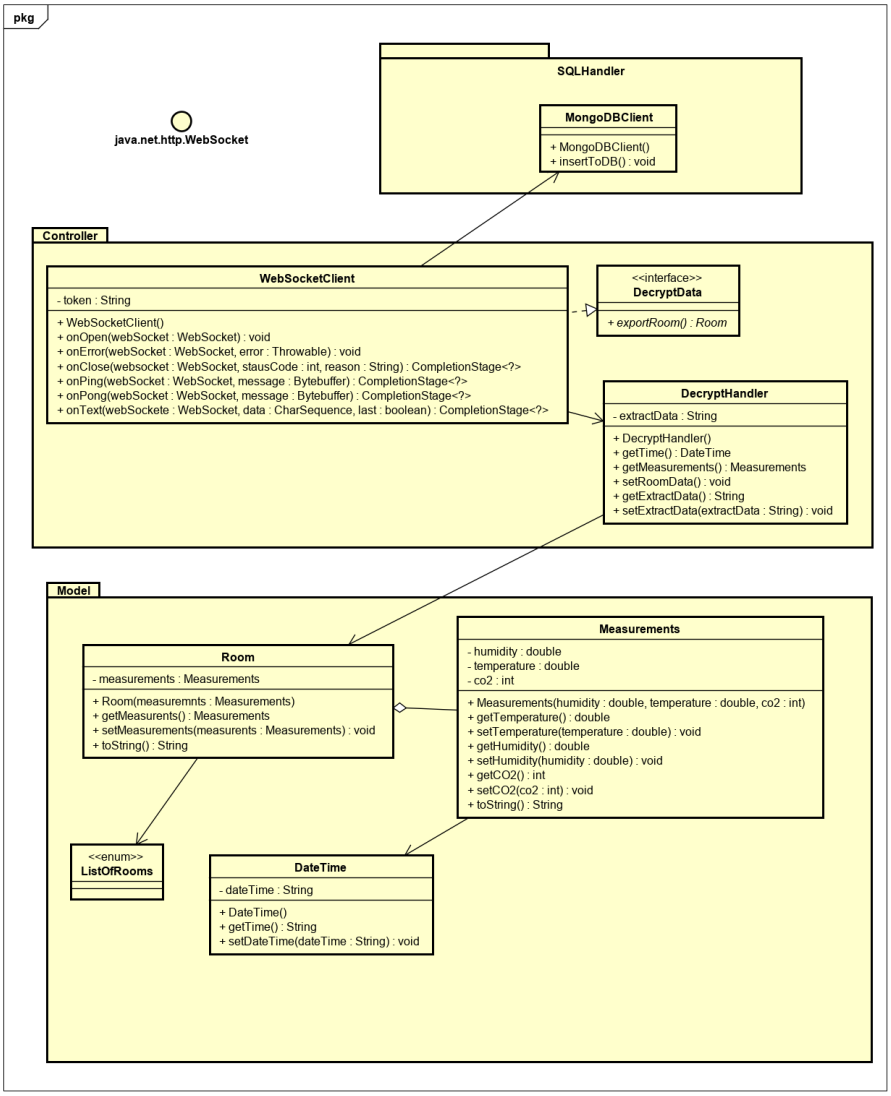
writing the values in a queue. A telegram to be sent is constructed after all sensors have been queried for data and is ready to be delivered on the server. Each measurement is handled by different task. The tasks are running based on a cycle controlled by a timer so that the frequency of this operations is matching the requirements of the LoRa network. Each operation specific to a data source is contained in its own submodule so that encapsulation is achieved. The communication between the submodules is realized using interfaces.
Java Bridge Application should be thought as a significant part of the project in order to visualize data obtained from sensors on Atmega2560, reflecting on how you get desired data and serialization of it in a suitable object following requirements, afterwards to be sent furthermore, ended up with this concept. WebsocketClient class which has responsibility as a listener should connect to LoRaWan socket for retrieving data. DecryptionHandler takes role of decrypting data and make a new model object of Room following Room object requirements (Room has measurements where it has date when it was retrieved). Responsibility of MongoDBClient class isto make connection with mongoDB and to upload retrieved data formatted in suitable Object in order be sent toward database.

4.1.1 Class diagram IOT

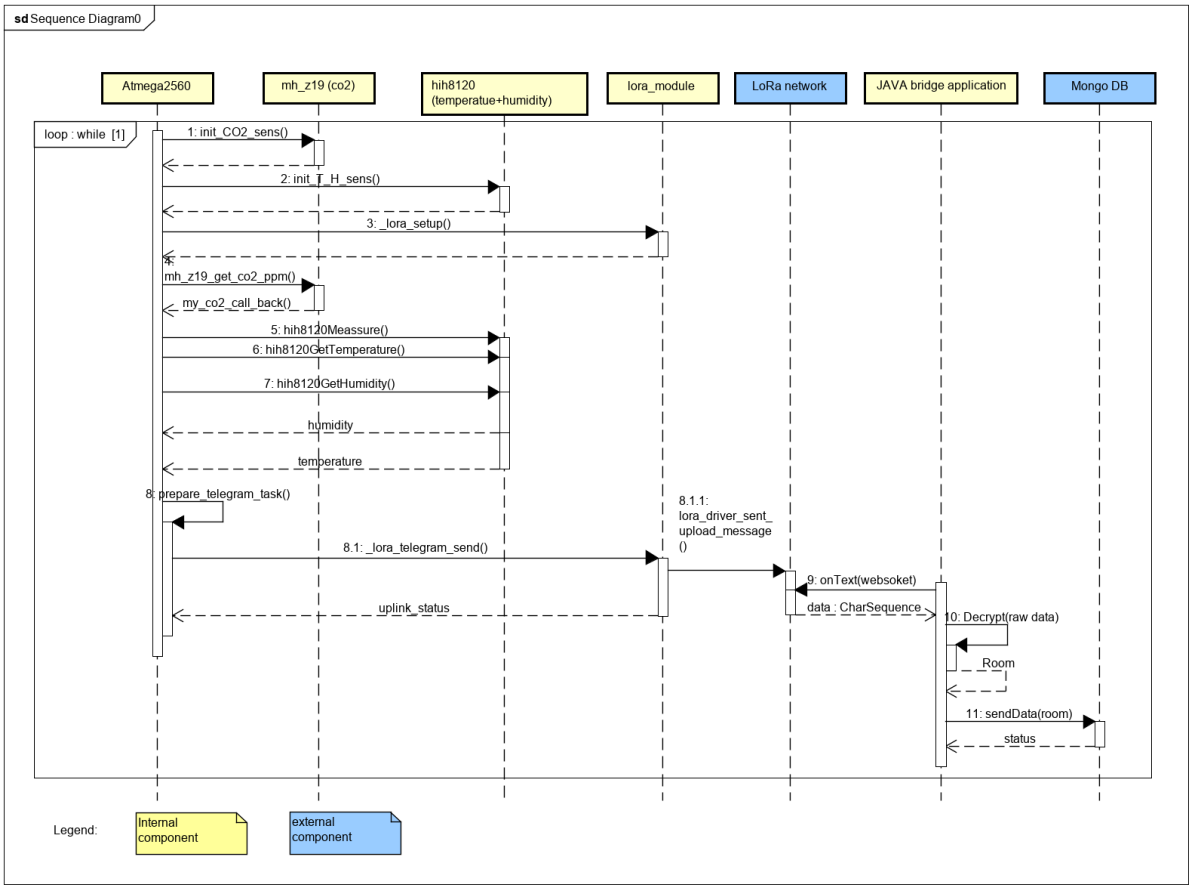
Java Bridge Application

Conceptual design had a starting point in generating the actual design. Following basic principles of designing, every class should have one responsibility. WebSocketClient implements interface (ExtractData) as responsibility has to retrieve and return it as a suitable object from Loriot where it uses DecryptionHandler tools of transforming obtained data in a Room model, DecrtypionHandler has a role of a middleman in this case.

MongoDBClient responsibility is to use implemented method of WebSocketClient(extractData) to parse it further to database.



4.1.2 Sequence diagram IOT

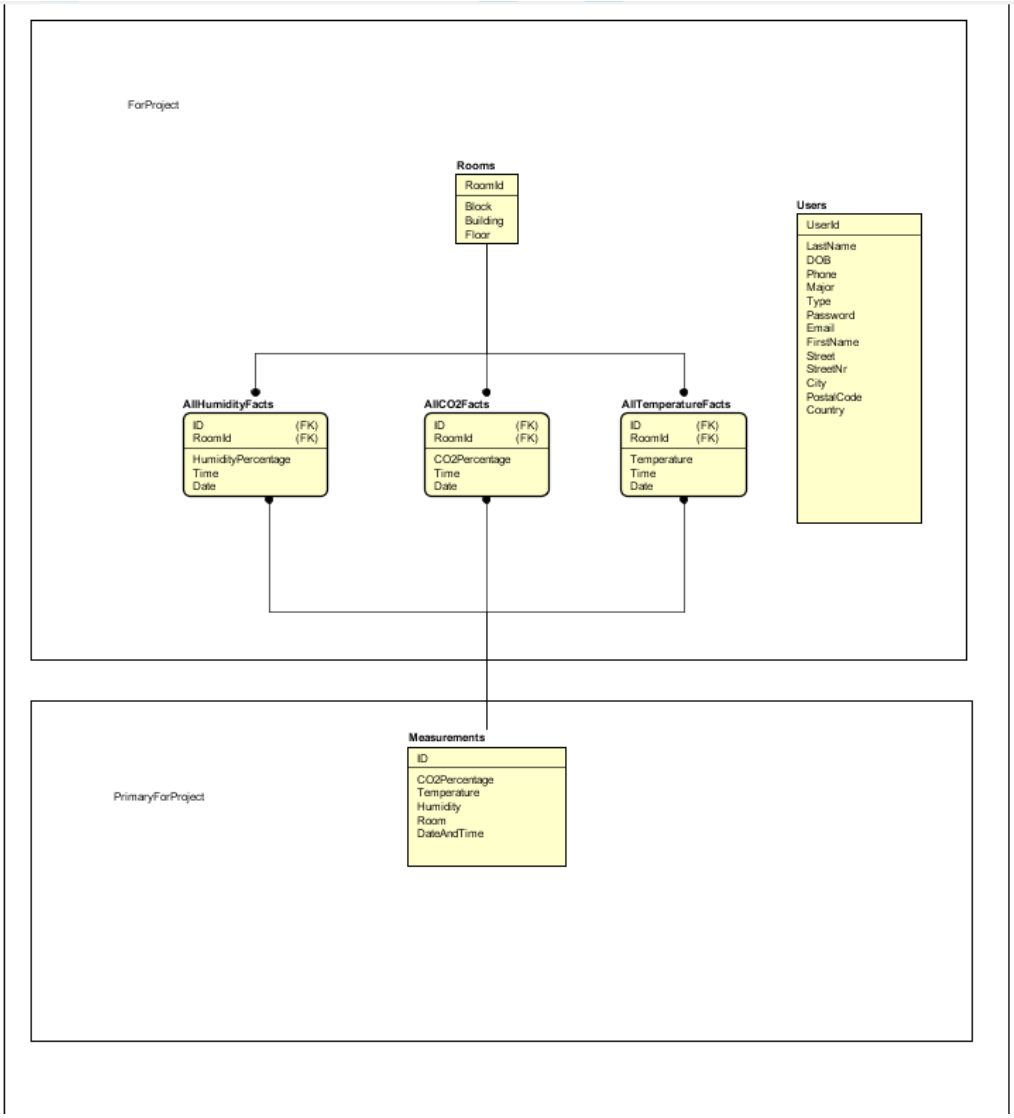


4.2 Database design

4.2.1 ER Diagram

Its purpose is to allow the user to create a design that will enable the said user to see a high level view of the database before actually implementing it. Therefore, it allows the use to capture all the needed information in different tables and makes changes big or small, before actually creating the database.

The ER Diagram helps the user to communicate a design to a client that has no technical knowledge in such a way that they can understand. By doing this, the user can easily understand where the communication went poorly or entirely misunderstood.


ForProject
Rooms
RoomId
Block
Building
Floor
Users
UserId
LastName
DOB
Phone
Major
Type
Password
Email
FirstName
Street
StreetNr
City
PostalCode
Country
AllHumidityFacts
ID (FK)
RoomId (FK)
HumidityPercentage
Time
Date
AllCO2Facts
ID (FK)
RoomId (FK)
CO2Percentage
Time
Date
AllTemperatureFacts
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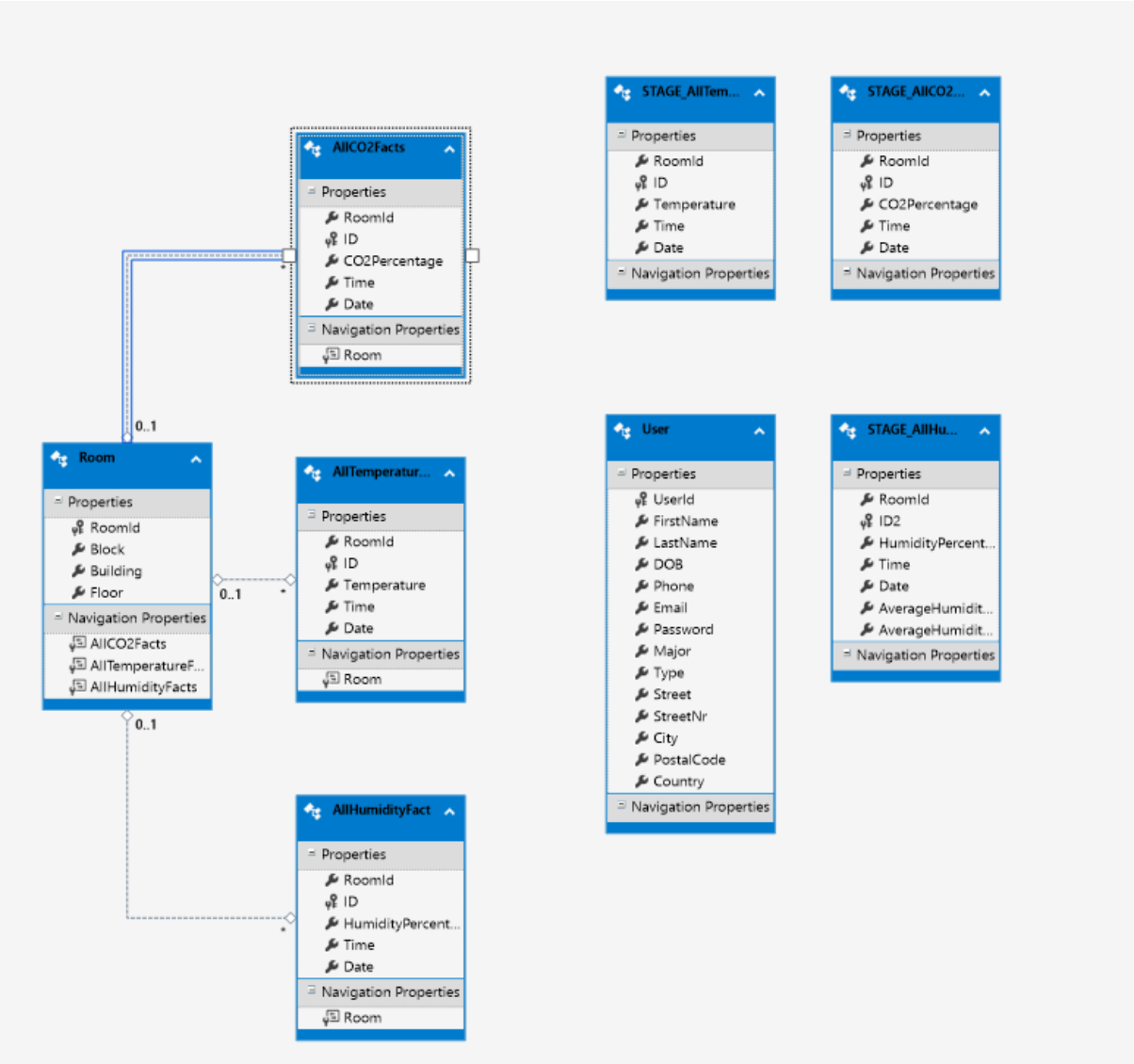
Time
Date
PrimaryForProject
Measurements
ID
CO2Percentage
Temperature
Humidity
Room
DateAndTime



(Model.edmx API)

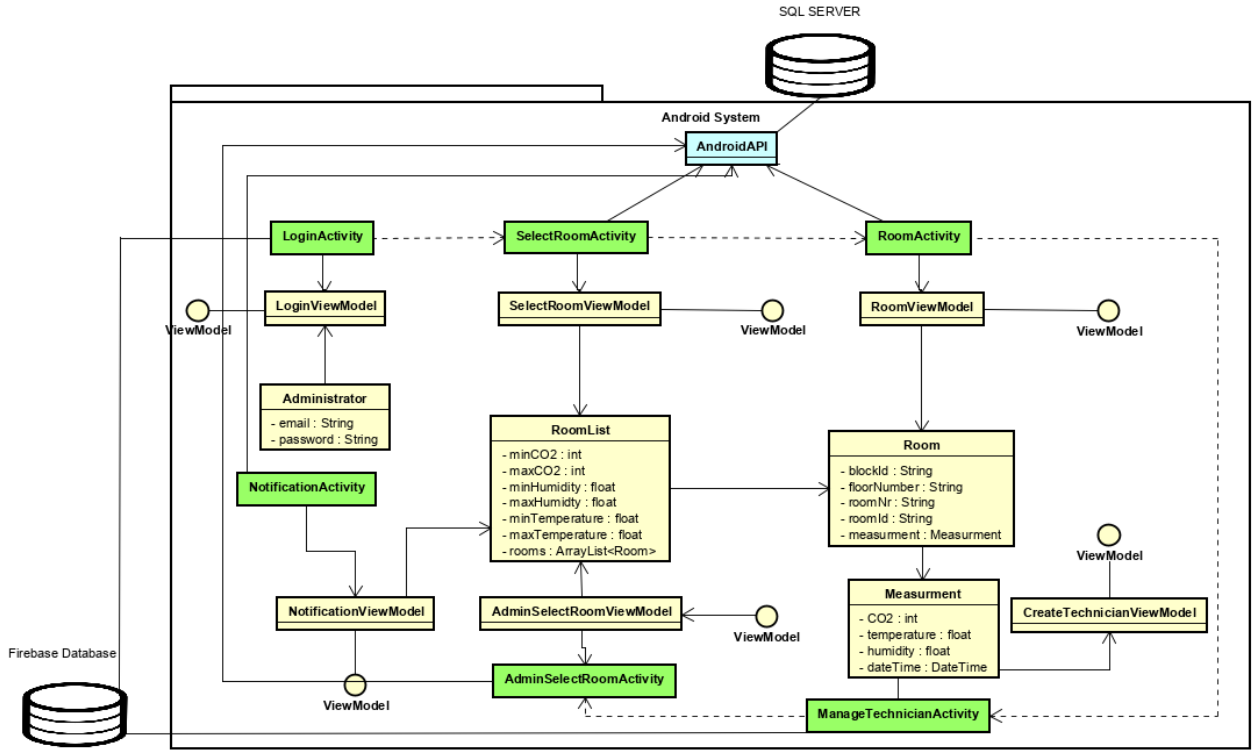
4.3 Android design (A. V. and R. D. B.)

In this chapter the android design part of this report will be explained. This stage of the report is crucial since it shows how the actual Android system was conceived. In this part of the report design patterns will be discussed, a conceptual diagram will be illustrated and explained, same with the class diagram and finally will be ended with the presentation and explanation of a sequence diagram.

4.3.1 Conceptual diagram Android (A. V. and R. D. B.)

This subchapter will present the conceptual diagram for the Android app. This part is essential since it is the starting point for the developed code. It shows the way the application has been structured for it to function more efficiently and to be able to be further developed in the future.

Figure 4.3.1 Conceptual diagram

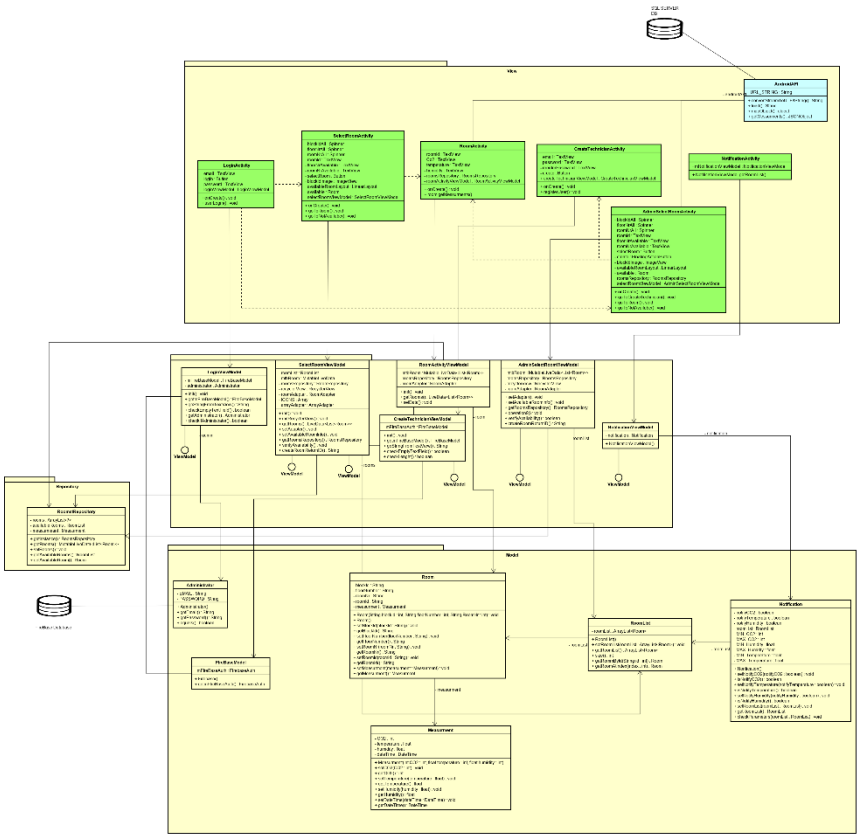


As seen in the above figure, a view model class such as "**RoomViewModel**" will take all the information from the model class "**Room**" and adapt it such that it will become fit to be displayed in the view class "**Room Activity**". The same can be said with respect about the rest of the entities since the all follow a similar pattern.

4.3.2 Class diagram Android (A. V. and R. D. B.)

This subchapter will focus primarily on illustrating and explain the class diagram that was made for the Android app. The diagram is the main blueprint for the code that has been developed. It showcases class interactions and implementation of methods which create functionality for the written code.

Figure 4.3.2 Class diagram Android



The figure above shows the class diagram created for this assignment. The design consists in separating the code into 4 packages. The model package which contains all the class models such as the Administrator class, Firebase class, Room object and so on.

One of the most important classes in this package is the Administrator class which is responsible for creating user object that will serve as user accounts.

In the **ViewModel** package, the **CreateTechnicianViewModel** class is responsible for instantiating the Firebase class as an object since it is needed to authentificate when registering user accounts since it contains methods such as **checkEmptyTextField**().

Finally, the last package it needs to access is the **View** package where the **CreateTechnicianActivity** will instantiated the **createTechnicianViewModel** as an object. By doing so, the methods it contains can be used by simply calling the **"object.method".** In here an **onCreate()** method will load all the layouts, items and initialize the needed attributes. And finally, the **registerUser()** will be set as an **onclickListner** for the register button and if all conditions are met it will register a user account in the **FireBase**.

4.3.3 Sequence diagram Android (A. V. and R. D. B.)

The sequence diagrams for the given app will be showed and explained. They show the interaction between classes and give a clear view what Life Cycles exist in the code and what

methods are invoked to perform a given task successfully. Only one diagram will be explained and that will be the login sequence diagram.

Figure 4.3.3.1 Create technician account sequence diagram

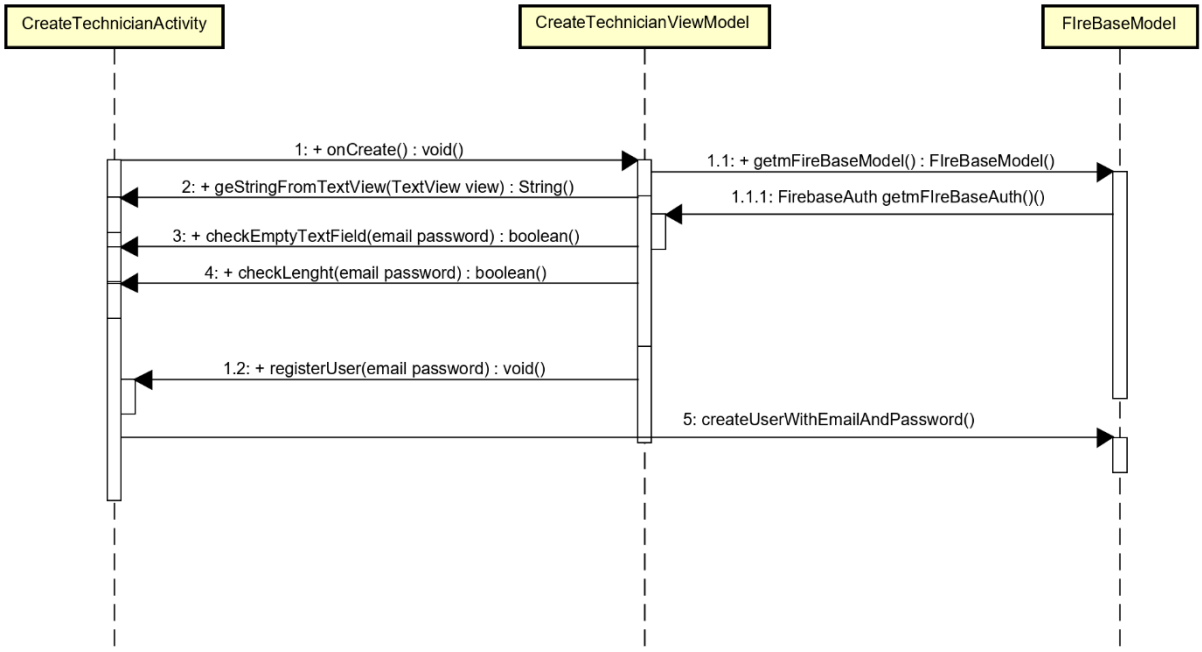
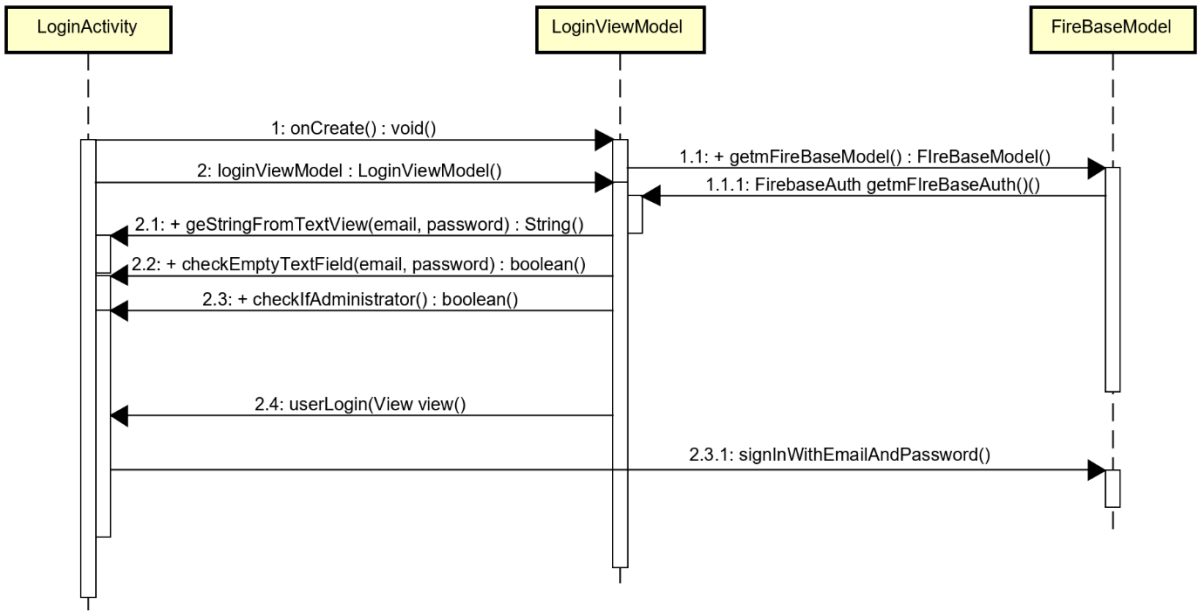


Figure 4.3.3.2 Login user sequence diagram



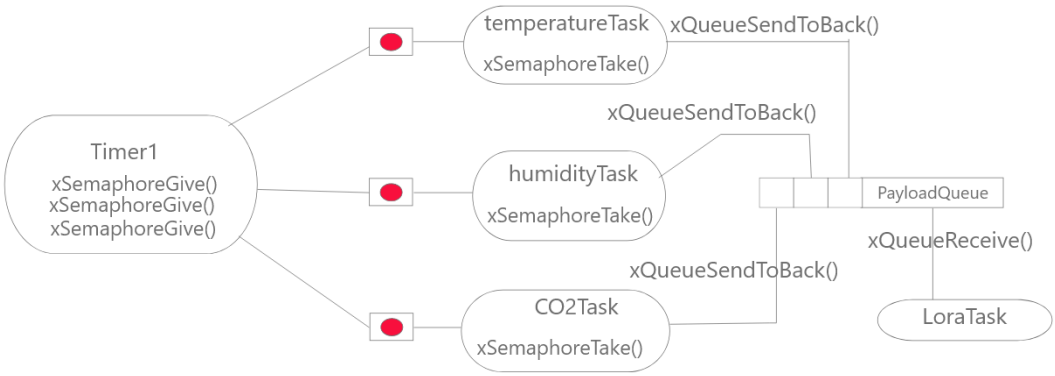
The cycle starts from the LoginActivity which resides in the View. This is when the user interaction starts. Once the user enters the necessary input, this will send an onCreate request to the ViewModel which will in term request to get a Firebase object from the FireBase model class. This class contains a FireBaseAuth method which is responsible for authentication. The model will send this object back to the ViewModel. This will invoke methods that will get the

imputed values and check to see if they fit the established conditions. It will execute a method called signInWithEmailAndPassword which will perform the user request of login.

5 Implementation

5.1 IOT Implementation

Considering the design approach described above, the following diagram describes the process flow in the subsystem following well known Producer-Consumer design pattern.



The subsystem is hosted on an ATmega2560 processor, that runs FreeRTOS operating system. Taking advantage of software timers already existing in the libraries, the operating cycle designed in the previous stage is achieved.

First step is initialization of the drivers controlling the sensors and the Lora module.

The timer is responsible to release three semaphores, one for each sampling task and after expiration is auto reloading with a period enough for data sampling and telegram construction and forwarding while making sure that the network is not overloaded.

The tasks responsible for data acquisition are implemented with the same priority(3) and blocking time, while delivering data to a shared data structure queue as it can be seen in the code snipped bellow. Taking advantage of the queue capabilities, easy synchronization is established.

```
xTaskCreate(temp_tsk,"Task1",configMINIMAL_STACK_SIZE,NULL,3,NULL);
xTaskCreate(co2_tsk,"Task2",configMINIMAL_STACK_SIZE,NULL,3,NULL);
xTaskCreate(hum_tsk,"Task3",configMINIMAL_STACK_SIZE,NULL,3,NULL);
```

The measurements are stored in a data structure incapsulating the value as well as the source it comes from, allowing the telegram construction based not only on the sensor's value, but the source also, as it can be seen in the following snippet.

```
values[recValue.s_src]=recValue.s_value;
```

```
test_payload.bytes[2*recValue.s_src] = values[recValue.s_src] >> 8;
test_payload.bytes[2*recValue.s_src+1] = values[recValue.s_src] & 0xFF;
```

A receiving task is implemented, also having same priority as the sampling tasks, so that each time a measurement is stored in the queue, this event notifies the task allowing it to perform. This task has the responsibility of constructing the telegram and forwarding it to the Loriot server after establishing a successful connection.
Running the tasks in parallel results in energy saving.

5.2 Database Implementation

In this chapter of the report the implementation for the Data will be explained and examples will be illustrated. This chapter will start with presenting the Transferring of data from MongoDB to Microsoft SQL Server.

5.2.1 Transfer to SQL

In order to transfer data from the NoSQL database (MongoDB) to the Microsoft SQL Server it was use a script written in C#.

1. First part will retrieve the information from the MongoDB database and add objects into a list of "Read"

```
static void Main(string[] args)
{


    var mongoClient = new MongoClient(@"mongodb+srv://sep4xyz:<123456Sepxyz>@sep4xyz-ye3jp.azure.mongodb.net/test");

    var mongoDatabase = mongoClient.GetDatabase("Sep4xyz");
    var Measurements = mongoDatabase.GetCollection<Readings>("Measurements");
    var Final = Measurements.AsQueryable<Readings>().ToList();

    var Read = new List<Readings>();

    Final.ForEach(read => Read.Add(read));


    SqlConnection SqlConnection;
    SqlCommand SqlCommand;
```

1. Second part was to make a connection with the Microsoft SQL Server and add data . (not active MongoDB Database in the example)

```
try
{
    for (int i = 0; i < Read.Count; i++)
    {

        string sql = "Insert into [PrimaryForProject].[dbo].[Measurements] (CO2Percentage,Temperature,Humidity,Room,ID,DateAndTime)" +
            " values (@CO2Percentage,@Temperature,@Humidity,@Room,@ID,@DateAndTime);";
        SqlConnection.Open();
        SqlCommand = new SqlCommand(sql, SqlConnection);
        SqlCommand.Parameters.Add("@id", SqlDbType.Int).Value = Read[i].id;
        SqlCommand.Parameters.Add("@roomID", SqlDbType.nchar).Value = Read[i].roomID;
        SqlCommand.Parameters.Add("@humidity", SqlDbType.decimal128).Value = Read[i].humidity;
        SqlCommand.Parameters.Add("@temperature", SqlDbType.decimal128).Value = Read[i].temperature;
        SqlCommand.Parameters.Add("@co2", SqlDbType.Decimal128).Value = Read[i].co2;
        SqlCommand.Parameters.Add("@dateTime", SqlDbType.DateTime).Value = Read[i].dateTime;
        SqlCommand.ExecuteNonQuery();
        SqlCommand.Dispose();
        SqlConnection.Close();

        Console.WriteLine("Data added succesfully");
    }
```

Model:

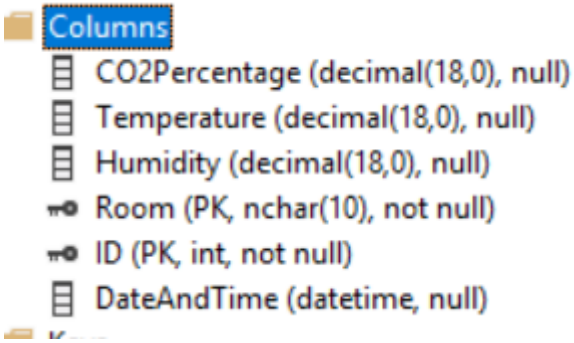
```
using System;
using System.Collections.Generic;
using System.Text;
using MongoDB.Bson;
using MongoDB.Bson.Serialization.Attributes;

namespace Folder
{
    4 references
    public class Readings
    {
        [BsonRepresentation(BsonType.ObjectId)]
        0 references
        public string _id
        {
            get; set;
        }

        [BsonRepresentation(BsonType.Int64)]
        0 references
        public string Id
        {
            get; set;
        }


        [BsonRepresentation(BsonType.Int64)]
        2 references
        public int roomID
        {
            get; set;
        }

        [BsonRepresentation(BsonType.Decimal128)]
        2 references
        public string humidity
        {
            get; set;
        }

        [BsonRepresentation(BsonType.Decimal128)]
        2 references
        public double temperature
        {
            get; set;
        }
```

5.2.2 Data warehousing

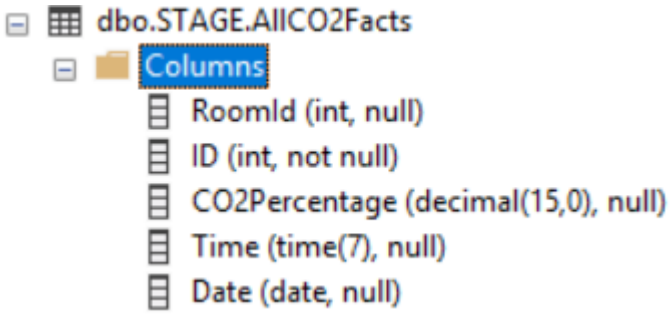
Data from the NoSQL database was added on "PrimaryForProject" Database(Microsoft SQL Server) . From here we made the stages on "ForProject" , splitting DateTime in Date and Time. The Final facts tables were created based on Stages and "Rooms" Table.

A local server was created in order to allow different members of the team to get access on data. There were also created users that were granted the rights to read and write in any tables.

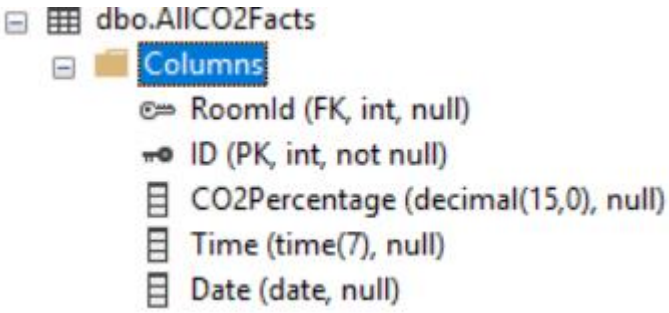
PrimaryForProject, Measurements Table:



Stage for CO2:

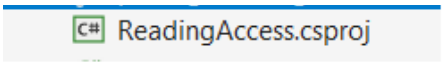


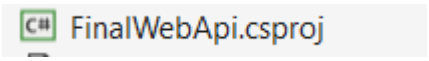
Final Fact table for CO2:



5.2.3 FinalWebAPI (Web-Service)

The web-service is made in C#. The FinalWebAPI it's made out of an API and an adaptor between Microsoft SQL Server Management and the web service.





The API has a controller(ValuesController) and a model(Readings)

Part of the controller:

```
using System.Web.Http;


namespace FinalWebApi.Controllers
{
    public class ValuesController : ApiController
    {

        List<Readings> readings = new List<Readings>();

        public String result_co2 = "";
        public String result_humidity = "";
        public String result_temperature = "";


        public ValuesController()
        {
            ForProjectEntities entities = new ForProjectEntities();



            foreach (AllCO2Facts f in entities.AllCO2Facts.ToList())
            {
                result_co2 = result_co2 + f.ToString();
            }

            foreach (AllHumidityFact f in entities.AllHumidityFacts.ToList())
            {
                result_humidity = result_humidity + f.ToString();
            }


            foreach (AllTemperatureFact f in entities.AllTemperatureFacts.ToList())
            {
                result_temperature = result_temperature + f.ToString();
            }



            int counter = 0;
            int x = 0;
```

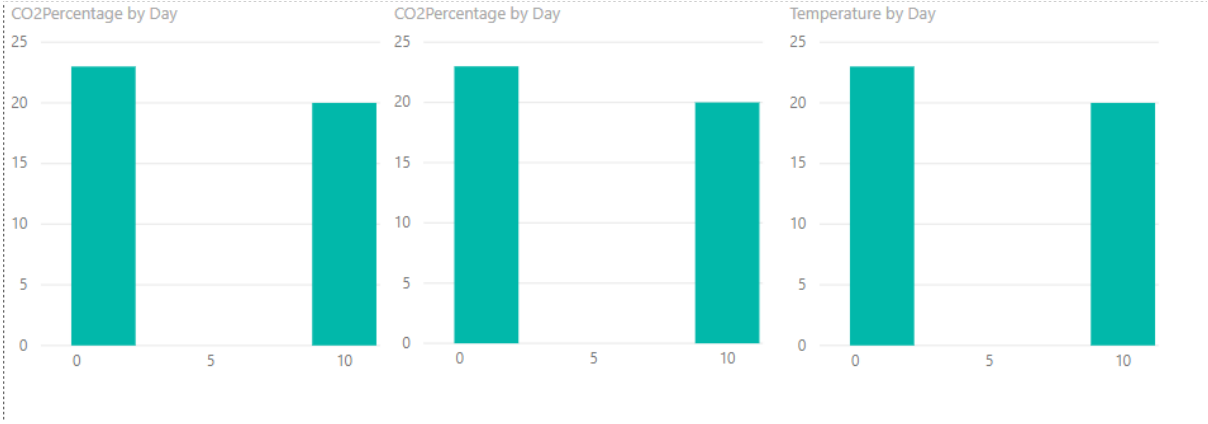
Part of Model:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Web;

namespace FinalWebApi.Models
{

    public class Readings
    {

        private float co2;
        private float humidity;
        private float temperature;

        public void setCo2(float co2)
        {
            this.co2 = co2;
        }

        public float getCo2()
        {
            return co2;
        }

        public void setHumidity(float humidity)
        {
            this.humidity = humidity;
        }

        public float getHumidity()
        {
            return humidity;
        }

        public void setTemperature(float temperature)
        {
            this.temperature = temperature;
        }

        public float getTemperature()
        {
            return temperature;
        }


    }
}
```

```
    // GET api/values
    public String Get()
    {

        String message = "";
        int i = 0;
        foreach (Readings f in readings)
        {
            message = message + " ObjectID: " + i + " / " + " CO2 Percentage: " + f.getCo2() + " / " + " Humidity Percentage: " + f.getHumidity() + " / " + " Temperature: " + f.getTemperature() + "||||";
            i++;
        }
        return message;

    }
```

Running the the project will display a list with all the data from Temperature,CO2 and Humidity.

5.2.4 Power BI (image)



5.3 Android Implementation (A. V. and R. D. B.)

In this chapter of the report the implementation for the Android app will be explained and examples will be illustrated. This chapter will start with presenting the Firebase database since this was a very useful tool for creating and authenticating users that will use the given software.

5.3.1 Firebase implementation (A. V. and R. D. B.)

When talking about implementing a login, creating your own authentication system can sometimes lack security and also require a unnecessary amount of time.

Firebase provides a bunch of built-in services that help and improves the development of web and mobile applications. Among the service offered by Firebase we have Authentication. Firebase Authentication offers an easy and straightforward way to implement a system that offers real-time updates and secure encryption for user data, that separates user's sensitive data from application data. From the multiple ways of implementing the login, such as getting accounts from certain social media platforms, the classical combination of an email and a password is maybe the standard way to-go and the choice to use in this case. The setup is done by adding an application to an existing google account.

The main activity opens the app in the login screen where existing users can log.

The logic behind the login activity and its connection to Firebase can be observed in the figure below.

Figure 5.3.1.1 Firebase example LoginActivity

```
public class LoginActivity extends AppCompatActivity {

    private Button login;
    private TextView email;
    private TextView password;
    private LoginViewModel loginViewModel;
    private ProgressDialog progressDialog;


    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_log_in);

        login = findViewById(R.id.registerTechnician);
        email = findViewById(R.id.userId);
        password = findViewById(R.id.passwordId);

        progressDialog = new ProgressDialog( context: this);

        loginViewModel = ViewModelProviders.of( activity: this).get(LoginViewModel.class);
        loginViewModel.init();

    }

    public void userLogin(View view) {


        // checks to see if the input field is empty
        if (loginViewModel.checkEmptyTextField(email)) {
            Toast.makeText( context: this,  text: "Please enter a user name", Toast.LENGTH_SHORT).show();
            //stops the function from executing further
            return;
        }
        // checks to see if the input field is empty
        if (loginViewModel.checkEmptyTextField(password)) {
            Toast.makeText( context: this,  text: "Please enter a password", Toast.LENGTH_SHORT).show();
            return;
        }
        // set's a message upon verifying credentials
        progressDialog.setMessage("Verifying credentials...");
        progressDialog.show();


        // uses fire base sign in method verification
        loginViewModel.getmFireBaseModel().getmFIreBaseAuth()
                .signInWithEmailAndPassword(loginViewModel.geStringFromTextView(email), loginViewModel.geStringFromTextView(password))
                .addOnCompleteListener( activity: this, (task) -> {
                // if authentication is completed successfully than it will move to the next page
                if (task.isSuccessful()) {
                    Intent Login = new Intent( packageContext: LoginActivity.this, SelectRoomActivity.class);
                    startActivity(Login);
                    //check if the account belongs to the admin
                } else if (loginViewModel.checkIfAdministrator(email, password)) {
                    Intent intent = new Intent( packageContext: LoginActivity.this, AdminSelectRoomActivity.class);
                    startActivity(intent);
                    progressDialog.dismiss();


                } else {
                    Toast.makeText( context: LoginActivity.this,  text: "Invalid user name or password", Toast.LENGTH_SHORT).show();
                    progressDialog.dismiss();

                }
                progressDialog.dismiss();
        });
    }


}
```

The first step is to set the layout for this activity followed by the setting of the button and the input fields. The method for setting the button is created and attached to the specific button through the

XML file. When the login button is pressed, the data submitted in the specific from the input fields is compared to the one in the Firebase Authentication. If the input matches with an account from the database, depending on the account type the user is directed to the appropriate activity. Otherwise an error message will be displayed. Furthermore, Firebase offers functionality for registering new account, which in this case refers to to higher ranked user creating a new account.

Figure 5.3.1.2 Firebase example CreateUserActivity

```java
package com.example.SEP_XYZ.views;

import ...

public class CreateTechnicianActivity extends AppCompatActivity {

    private TextView email;
    private TextView password;
    private TextView reenterPassword;

    private Button create;

    private CreateTechnicianViewModel createTechnicianViewModel;

    private ProgressDialog progressDialog;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main_create_users);

        email = findViewById(R.id.userId);
        password = findViewById(R.id.passwordId);
        reenterPassword = findViewById(R.id.passwordReenter);


        create = findViewById(R.id.registerTechnician);

        createTechnicianViewModel = ViewModelProviders.of( activity: this).get(CreateTechnicianViewModel.class);
        createTechnicianViewModel.init();

        progressDialog = new ProgressDialog( context: this);

        create.setOnClickListener((v) -> { registerUser(v); });
    }

    public void registerUser(View view) {

        //check empty field
        if (createTechnicianViewModel.checkEmptyTextField(email)) {
            Toast.makeText( context: this,  text: "Please enter a user name", Toast.LENGTH_SHORT).show();
            return;
        }
        //check empty field

        if (createTechnicianViewModel.checkEmptyTextField(password)) {
            Toast.makeText( context: this,  text: "Please enter a password", Toast.LENGTH_SHORT).show();
            return;
        }
        //check empty field

        if (createTechnicianViewModel.checkEmptyTextField(reenterPassword)) {
            Toast.makeText( context: this,  text: "Please re-enter your password", Toast.LENGTH_SHORT).show();
            return;
        }
        //check password length
        if (createTechnicianViewModel.checkLenght(password.toString())) {
            Toast.makeText( context: this,  text: "The password must be at least 6 characters long", Toast.LENGTH_SHORT).show();
            return;
        }
        //check matching passwords
        if (createTechnicianViewModel.geStringFromTextView(password)
                .equals(createTechnicianViewModel.geStringFromTextView(reenterPassword))) {

            progressDialog.setMessage("Verifying credentials...");
            progressDialog.show();


            // this creates a user account with two parameters of email and password on the fire base
            createTechnicianViewModel.getmFireBaseModel() FireBaseModel
                    .getmFIreBaseAuth() FirebaseAuth
                    .createUserWithEmailAndPassword(createTechnicianViewModel.geStringFromTextView(email)
                            , createTechnicianViewModel.geStringFromTextView(password)) Task<AuthResult>
                    .addOnCompleteListener( activity: this, (task) -> {
                    if (task.isSuccessful()) {
                        //if account is created also go to specified intent
                        Toast.makeText( context: CreateTechnicianActivity.this,  text: "Account has been registered", Toast.LENGTH_SHORT)
                                .show();
                        Intent createUsers = new Intent( packageContext: CreateTechnicianActivity.this, AdminSelectRoomActivity.class);
                        startActivity(createUsers);

                    } else {
                        Toast.makeText( context: CreateTechnicianActivity.this,  text: "Unable to create user account", Toast.LENGTH_SHORT)
                                .show();
                        progressDialog.dismiss();
                    }
                });
        } else {
            Toast.makeText( context: this,  text: "Passwords don't match", Toast.LENGTH_SHORT).show();
            return;
        }
    }
}
```

In the above picture, the logic behind the registration process is presented. With the connection to Firebase established, the set layout, the press of the “create” button sends the user credential are sent to Firebase and the specified activity starts. If one of the inputs does not respect the standards, an error message will be displayed guiding to the mistake.

5.3.2 UI implementation (A. V. and R. D. B.)

The user interface was implemented using XML, keeping in mind that that the content of the layouts is placed in the exact desired manner. Consistency was a target for the user interface

design. This was made by using the same layouts for a big majority of the items such as: buttons, text views etc.

For the purpose of cleaning and optimizing code, the string and files color are used, in order to organize text all around the application.

```
<string-array name="roomNrs">
    <item>01</item>
    <item>02</item>
    <item>03</item>
    <item>04</item>
    <item>05</item>
    <item>06</item>
    <item>07</item>
</string-array>

<string name="app_name">SEP4xyz</string>
<string name="email">E-mail Address</string>
<string name="password">Password</string>
```

```
<LinearLayout
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:orientation="horizontal">

    <ImageView
        android:id="@+id/imageView"
        android:layout_width="wrap_content"
        android:layout_height="match_parent"
        android:layout_weight="1"
        app:srcCompat="@drawable/person" />

    <EditText
        android:id="@+id/userId"
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:layout_weight="1"
        android:ems="10"
        android:hint="E-mail Address"
        android:inputType="textEmailAddress" />
</LinearLayout>
```

```
 <color name="darkBlue">#1D7597</color>
 <color name="paleYellow">#FFDC84</color>
 <color name="palerYellow">#FFE5A5</color>
 <color name="startLightBlue">#A1DDF4</color>
```

5.3.3 Android application architecture (A. V. and R. D. B.)

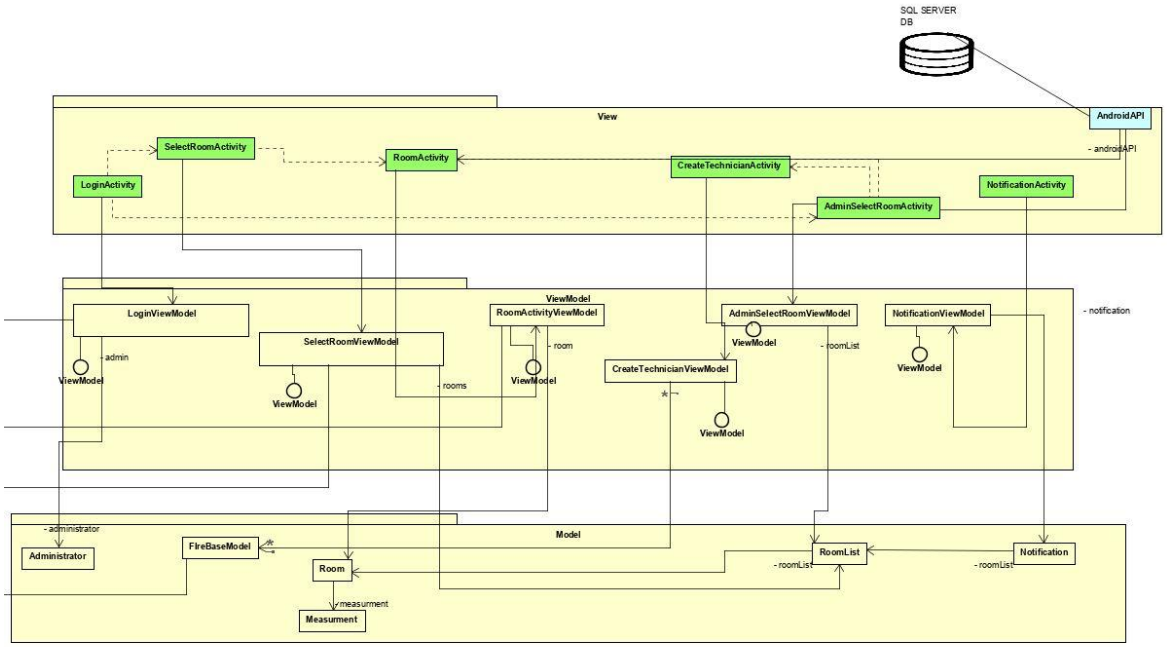
The main design pattern used to develop the Android app, was **MVVM**. This pattern allowed a better structure for the code that had to be built. This architecture splits the code into smaller parts each having their own part to play.

In the **Model** package resides the actual objects that will contain the basic attributes for a class and the needed behaviors.

The **ViewModel** package is the link between the model and the **view.** Its sole purpose is to transform model information into values that can be transformed in the view package.

Lastly, the **View** package will be used for user interaction since it displays visual elements and the controls in form of button handlers.

Figure 5.3.1 MVVM design pattern



In **Figure 5.1** the **MVVM** model has been applied. Classes have been created in the **Model** make an interaction with the **ViewModel** package that contain most of the logic which will be called by classes in the **View** package.

Basically, classes with corresponding attributes have been created in the model which where instantiated as object in the view model where the information is transformed so that it can be displayed on the view which contains all the user interaction tools.

6 Testing

6.1 Android Testing (A. V. and R. D. B.)

Regarding testing for the Android app, the chosen method was **Black Box** testing. This method primarily focuses on test cases for the user interaction. Different scenarios where created to test if the set rules are functioning properly for the given app.

This subchapter will continue in illustrating the test cases that where implemented for this part of the report.

Figure 6.1.1 User Login Test Case

Pre-condition: *Make sure that the user account exists*

Step	Action	Reaction	Result
1	Verify if a user can login entering a valid username and password	System checks to see if the information entered is of a valid type	System displays a confirmation message. Access is granted
2	Verify if a user can login entering a valid username and invalid password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
3	Verify if a user can login entering an invalid username and valid password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
4	Verify if a user can login entering an invalid username and invalid password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
5	Verify if a user can login entering a password not matching the required length	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
6	Verify if a user can login entering a username and not entering a password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
7	Verify if a user can login not entering a username but enters a password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
8	Verify if a user can login by entering no information in the two fields	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
9	User has internet access	System verifies if information is sent by the user	System displays a confirmation message. Access is granted
10	User has no internet access	System verifies if information is sent by the user	System displays an error message. Access denied.

Figure 6.1.2 Create Users Test Case

Pre-condition: *Make sure that the administrator account can create user accounts*

Step	Action	Reaction	Result
1	Verify if a user can be created by entering a valid username and password	System checks to see if the information entered is of a valid type	System displays a confirmation message. Account is created
2	Verify if a user can be created by entering a valid username and an invalid password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
3	Verify if a user can be created by entering an invalid username and a valid password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
4	Verify if a user can be created by entering an invalid username and an invalid password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
5	Verify if a user can be created by entering a password not matching the required length	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
6	Verify if a user can be created by entering a username and not entering a password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
7	Verify if a user can be created by not entering a username but enters a password	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
8	Verify if a user can be created by entering no information in the username field and password field	System checks to see if the information entered is of a valid type	System displays an error message. Access denied.
9	Administrator has internet access	System verifies if information is sent by the administrator	System displays a confirmation message. Access is granted
10	User has no internet access	System verifies if information is sent by the administrator	System displays an error message. Access denied.

Figure 6.1.3 View Data Test Case

Pre-condition: *Data must be stored an accessible for the give users*

Step	Action	Reaction	Result
1	User must be logged in	System checks to see if the information entered is of a valid type	System displays a confirmation message. Access is granted.
2	User must be connected to the internet	System checks user credentials	System validates user credentials. Access is granted.
3	Establish a secured connection between the data source and the mobile app	System establishes a connection	System displays a confirmation message. Access is granted.
4	Connection between data source and the mobile app is not established	System fails to establish a connection	System displays an error message. Access is denied.
5	User selects which type of data he/she wants to view	System finds the data and returns it to the app	Data is displayed for the user.
6	User selects which type of data he/she wants to view	System cannot find the requested data	System displays an error message. Data is not found
7	User selects which type of data he/she wants to view	System finds the data but cannot display it	System displays an error message.
8	User is be able to click and choose the selected data	System checks to see if the function is implemented	System displays the data
9	User is not able to click and choose the selected data		

Figure 6.1.4 Remove User Test Case

Pre-Condition: *User account must be created and should be accessible .*

Step	Action	Reaction	Result
1	User account is available	System checks to see if the account is available	System displays a confirmation message. Access is granted.
2	User account is not available	System checks to see if the account is available	System displays an error message. Access is denied.

3	Administrator can log in	System checks credentials	System displays a confirmation message. Access is granted.
4	Administrator cannot log in	System fails to establish a connection	System displays an error message. Access is denied.
5	Administrator can select the user account	System executes the specified task and removes account	System displays a confirmation message.
6	Administrator cannot select the user account		
7	Administrator can select the user account	System fails to remote user account	
8	Administrator cannot find the user account		

Figure 6.1.5 Edit User Test Case

Pre-Condition: *User account must be created and should be accessible .*

Step	Action	Reaction	Result
1	User account is available	System checks to see if the account is available	System displays a confirmation message. Access is granted.
2	User account is not available	System checks to see if the account is available	System displays an error message. Access is denied.
3	Administrator can log in	System checks credentials	System displays a confirmation message. Access is granted.

4	Administrator cannot log in	System fails to establish a connection	System displays an error message. Access is denied.
5	Administrator can select the user account	System executes the specified task and edits account	System displays a confirmation message.
6	Administrator cannot select the user account		
7	Administrator can select the user account	System fails to save changes for the user account	System displays an error message.
8	Administrator cannot find the user account		

7 Conclusions

Reflecting on the requirements for the business case established as team work in the analyzing phase, together with the project requirements, it can be concluded that 60-70% of it has been completed.

In final phase the project is able to measure habitat conditions, prepare and upload the data on the LoRiot server from where the Java bridge was able to receive and decrypt the data.

The transmission to a MongoDB database has been successfully done so that the data to be sent further to an SQL Server where a DataWarehouse should have handled it.

The Data Team was able to make a Web Api that turned out a string with data from final facts tables.

Not having available data from the SQL server in due time and being less members than considered in the start, the Android team was able to manage presenting fake data to users who

could have access to the data. Creating and managing users accounts in Firebase by an administrator has also been achieved.

From the decided business case point of view, the system does not fit the requirements, not being a mean for an end Android user to monitor and interact with real data from a closed environment. Also a technician actor not being able to take decisions and interfere with the system, taking actions in accordance with real data not been achieved. Also, the hardware system is not able to accept interactions and configurations in according to environment state, the thresholds first considered been neglected on the real system.

8 References

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9 Appendices

9.1 Appendix 1 Project Description

Github Link: https://github.com/Adojan/SEP4

Youtube Link: https://www.youtube.com/watch?v=735kbi43a9g&feature=youtu.be