SMART METER

Software Engineering

CO2307

(Group Project)

Department of Computer Engineering

Group No   : <06>

Group Members : <18ENG112>

<18ENG080>

<18ENG033>

<18ENG031>

<18ENG037>

Acknowledgement

Smart Meter is a project developed for Ceylon Electricity Board and National Water Supply and Drenaige Board to increase the efficiency of the service provided to their customers. Both the services providers and the customers, all citizens who uses national electricity and national water supply service, will be beneficiaries of the project.

Abstract

There are some reasons for developing this kind of application. Some of main things are mention in below. The electricity and water billing system are a new system that is design to replace the manual billing system and this is speedup the calculations of bills. This system creates awareness on consumption and a way to save and manage power and water by each individual consumer. The power and water consumed by user is monitored by Arduino with NodeMCU separately. That information is saved to database. Database is connected to desktop application and web application. According to that information the bill is automatically generated and users can identify their usage at a particular time. Operations Admin and each user login to applications. Admin can add or remove users. He also modifies the personal information of the customer. He also checks the list of connection in a particular feeder. He can update the unit cost of electricity and water. He also can update the tax rates.it also specify the list of customer that are not pay bill in a month.

In the modern world time is very limited because of that we have to manage our time in very perfect way. Physically bill paying is very time-wasting thing and it want lot of man power, as a solution for that also we can use this product. It will much helpful for modern world for saving lot of things.

This system will very helpful for modern world. Because there are lot of power need modern world. When using low electricity that is important for save the environment. When consume less power can reduce the number of toxic fumes released by power plants, conserve the earth's natural resources and protect ecosystem from destruction. This will contribute to the healthier and happier world.

Table of Contents

Chapter 1 –Introduction

With the development of the technology, many fields of the world have been changed and upgraded. When comparing with Sri Lanka, though Sri Lanka have developed with some fields, the bill reading system of water and electricity still have not changed. The system follows the manual system yet. So, we decided to change the bill reading system from manual to automatically. So, the main purpose of this system is to read the water bill and the current bill by the user himself without any complex calculations. From this system the usage of current and water can be reduced. As well as, from this smart meter system both user and the system provider are updated with the current usage and the overall usage. From this system, it is decided to perform both bill reading and bill paying system from only one system. So, this software can be known as two in one software.

The system consists with both hardware part and a software part. The software part consists with a web application and a desktop application. From the hardware part, the used units of the device are calculated. The result which is given from the hardware part is taken from the software part and from the software the output or the usage units and the bill is shown to the user. So, both hardware part and the software part are interacted with each other well.

1.1 Aims of the project

The aim of this project is to develop a system for monitoring and managing the electricity and water usage in Real-time and to develop a system for addressing a desktop application and a mobile application to read the units of the used current, bill and pay the bill via smart phone.

1.2 Goal of the project

For saving electricity & water and get those services easier.

1.3 Main objective of the project

- ➢ Build two smart meters which can measure electricity and water usage
- ➢ Develop two desktop applications for administrate the system
- ➢ Develop a web application for customers
- ➢ Make a secure and easy way of reading /paying the bill

> ➢ Build up a trusted connection with the service provider and the user

1.4 Scope of the project

With the development of the world people always find easy ways to do their day to day work. Though in the bill paying and bill reading system have not been updated yet, people have to face for some problems. The problems are shown in below.

> ➢ With the current system lots of man power is wasted for manual meter reading.
> ➢ Customers are not able to view their current usage easily.
> ➢ If the usage passes a certain limit additional charges are applied on the bill.
> ➢ People are not aware of peak and off-peak times of electricity usage.
> ➢ There's no single platform for customers to manage and pay both their electricity and water bills.

Since these are very common issues among all the customers in Sri Lanka as well as all around the world this project can have an impact on all the people who own a smartphone or a desktop computer and a payment card, which is quite a larger percentage. The smart meter system has three main sub systems. They are,

> ➢ Registering, login and authentication system
> ➢ The card payment verification system
> ➢ Security system

Above three subsystems are interconnected together to create the smart meter system. In the registering, the account numbers regarding to the CEB and water bill of the customer is taken first. After verifying the account, the details of the customer are taken. After the verification succeed the account is created successfully. After creating the account unique user name and a password is provided to the customer. In the future login, customer can log with the account with entering user name and the password. In the account, the account details of electricity bill and the water bill is shown separately. So, the system has two separate logins to log with the account. They are electricity side and the water side. As well as, the current usage, overall usage and the calculated bill is shown in the account properly. These all operations can be handled from both web application and the desktop application.

1.5 Assumptions

> ➢ If there are customers who have not pay bills on time system will show this information in a pop-up screen. Then the relevant admin will send the fine payment request to the member through and email or by post.

> ➤ Daily/Weekly/Monthly/Minutely Usage costs are shown in dashboard and high consumption in each category will be informed to the customer by pop-up window, message or email.

> ➤ All the electric appliances can be operated through our system and can be monitored.

1.6 Important outcomes

> ➤ Users can save the current and water by referring their account.

> ➤ Users can pay their bills very easier by online.

> ➤ Water board and electricity board don't want to interact with users in physically. They can do all billing things online.

> ➤ When using low electricity that is important for save the environment also. When consume less power can reduce the number of toxic fumes released by power plants, conserve the earth's natural resources and protect ecosystem from destruction. This will contribute to the healthier and happier world.

Chapter 2 – Problem Specification

- In the current system, the usage of both current and water are read from manual. So, with this current system lots of manpower is wasted.

- Customers can not be able to check or view their usage easily and directly. Because they have to do some calculations to get the result.

- Because of the ignorance of the usage, sometimes the user limit is passed without knowing. So, the additional charges are added to the bill.

- People have the lack of knowledge about the peak and off-peak times of electricity usage.

- There is no single platform for customers to manage read and pay both the electricity and water bills.

Chapter 3 - Design Methodology

The Smart Meter application is for Electricity, Water Board Administrators and Customers who willing to getting update about their Real-time electricity and water usage. The customers can create their own smart Meter account and utilize the service. According to the project, the administrator can access the all users records through both web application and desktop application. The administrator can get details about usage of all users. The main usage of the desktop application is to

generate automatic report at the end of week or month. So, through the desktop application we analyst the peek time of electricity and water usage of a day.

Users can manage their electricity and water usage within necessary limits and pay bills themselves.

All the information of customer, such as Realtime water and electricity usage, customer details is stored in a database that is accessible by the administrators should be given permission to access them and create bills according to them. Users Realtime usage is measures and recorded by hardware component that easily plug to switches and wirelessly connect with desktop application and web application.

3.1 Architecture Design

Presentation Layer

(UI Desktop Application)

Data Layer

Data Model

Business service

mySQL

Data Access

Database

Back end

Authentication Layer

Control Layer

Data access Layer

Front End

Web Application
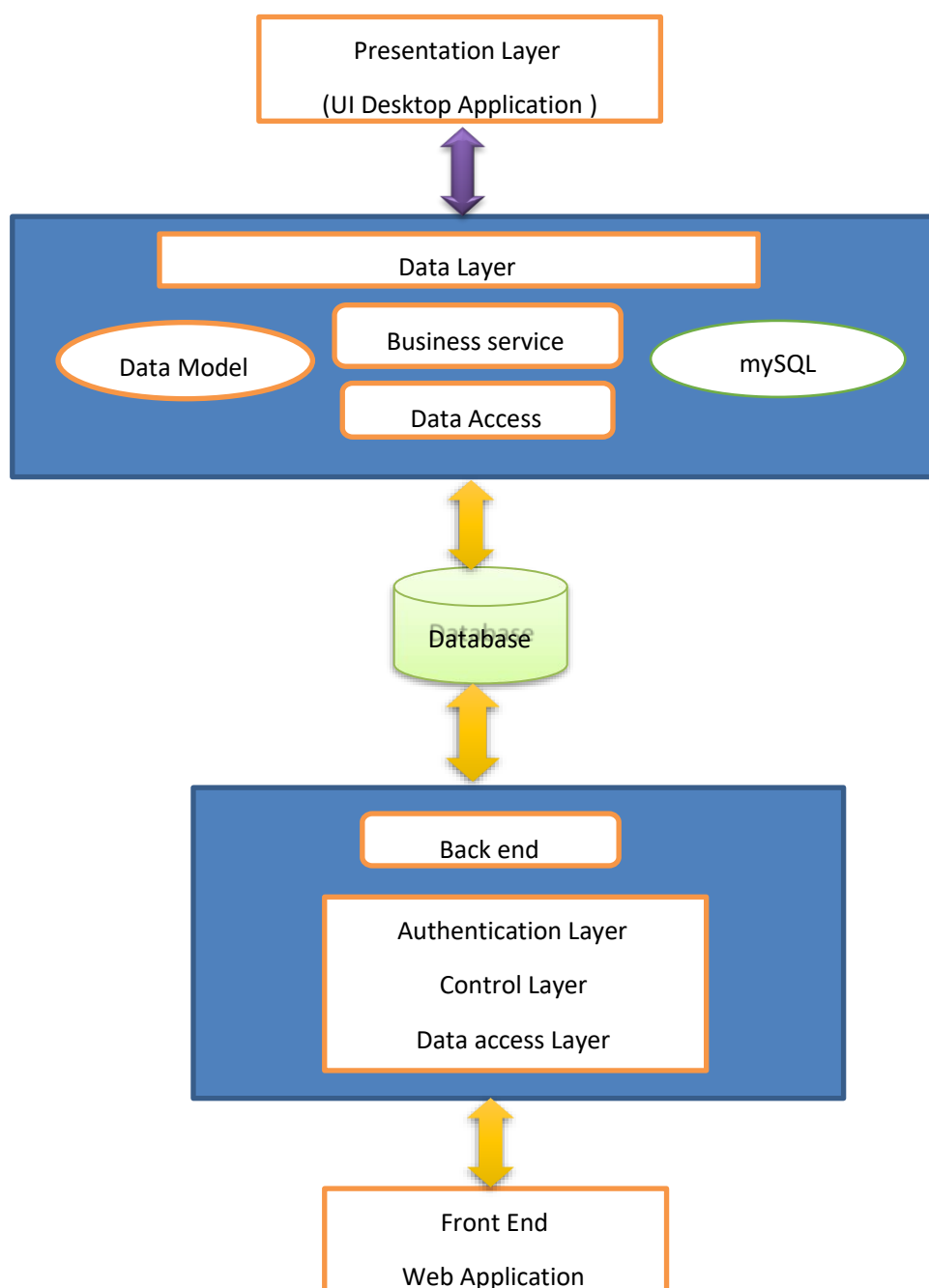
Figure 3.1.1-Architectural Diagram

3.2 Level 0 Data Flow Diagram
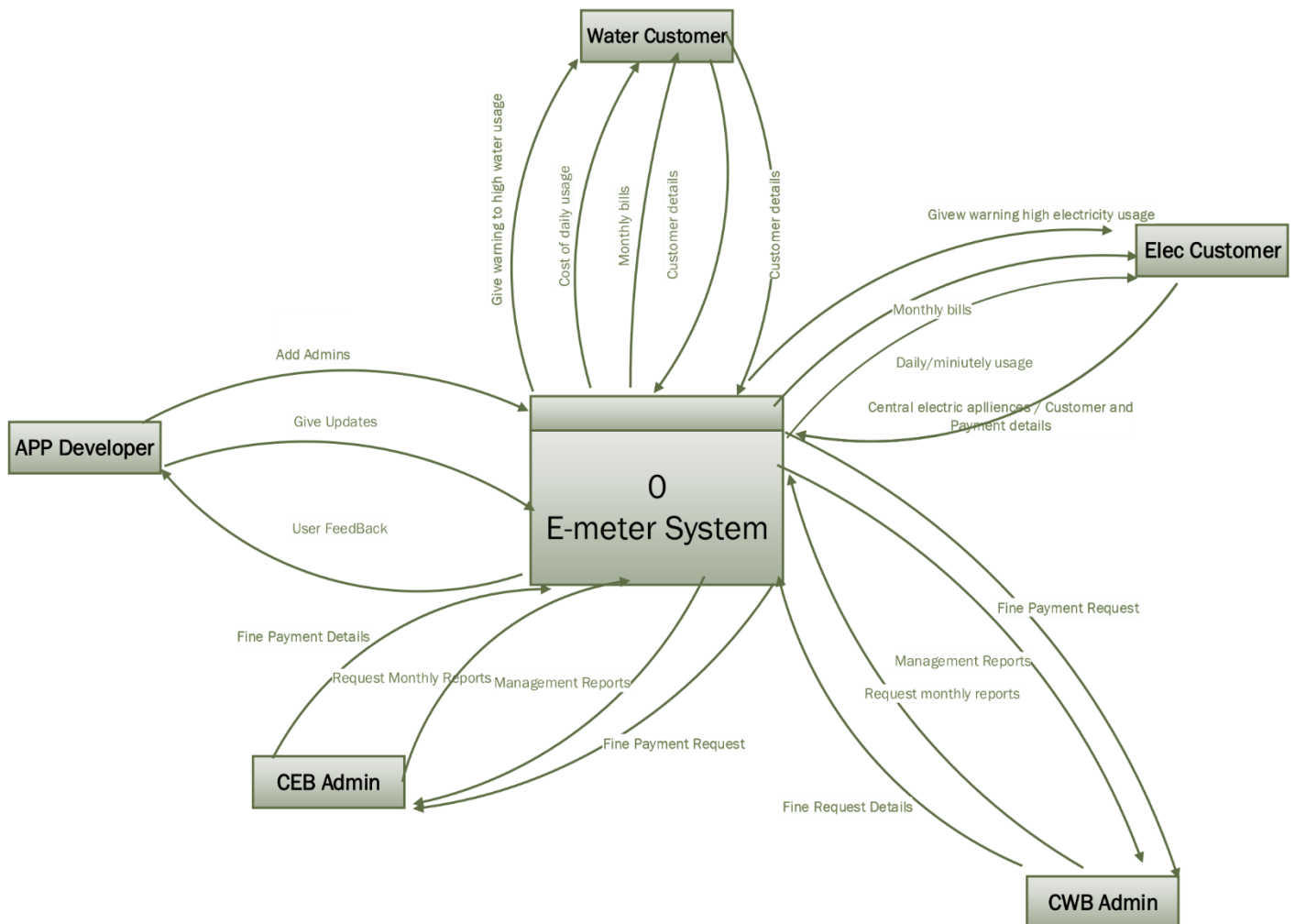
Figure 3.2.1-Dataflow Diagram Level 0

Assumptions/Comments

- If the user is new to the system, He /She should register to the system by giving customer details according to the registration forms. For security issues system use OTP number to verify the customer.
- All the customer details are saved in database according to its category.
- If there are customers who have not pay bills on time system will show this information in a pop-up screen. Then the relevant admin will send the fine payment request to the member through and email or by post.
- Daily/Weekly/Monthly/Minutely Usage costs are shown in dashboard and high consumption in each category will be informed to the customer by pop-up window, message or email.

- All the electric appliances can be operated through our system and can be monitored.

3.3 Level 1 Data Flow Diagram
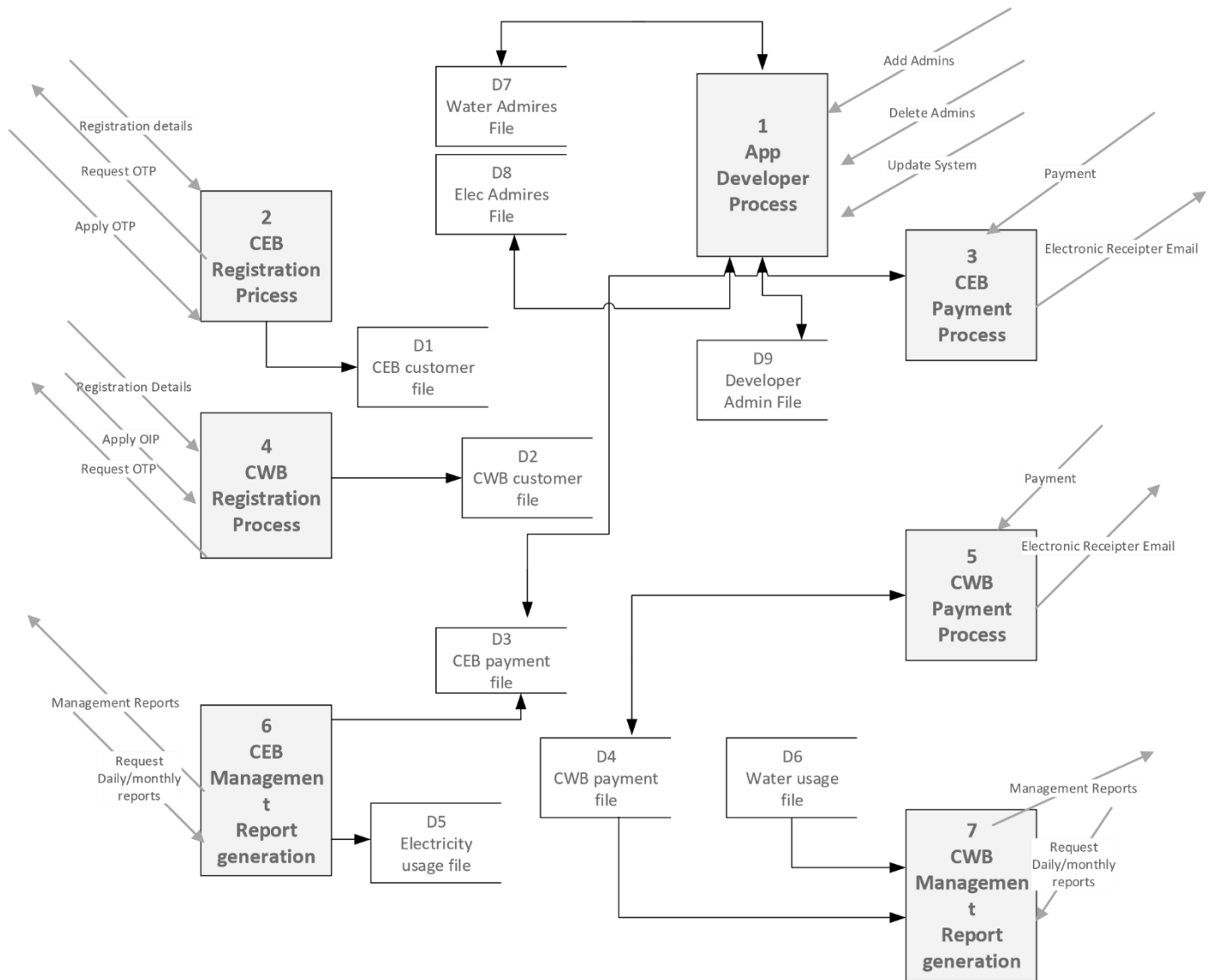
Figure 3.3.1-Data Flow Diagram Level 1

3.4 Use case diagram
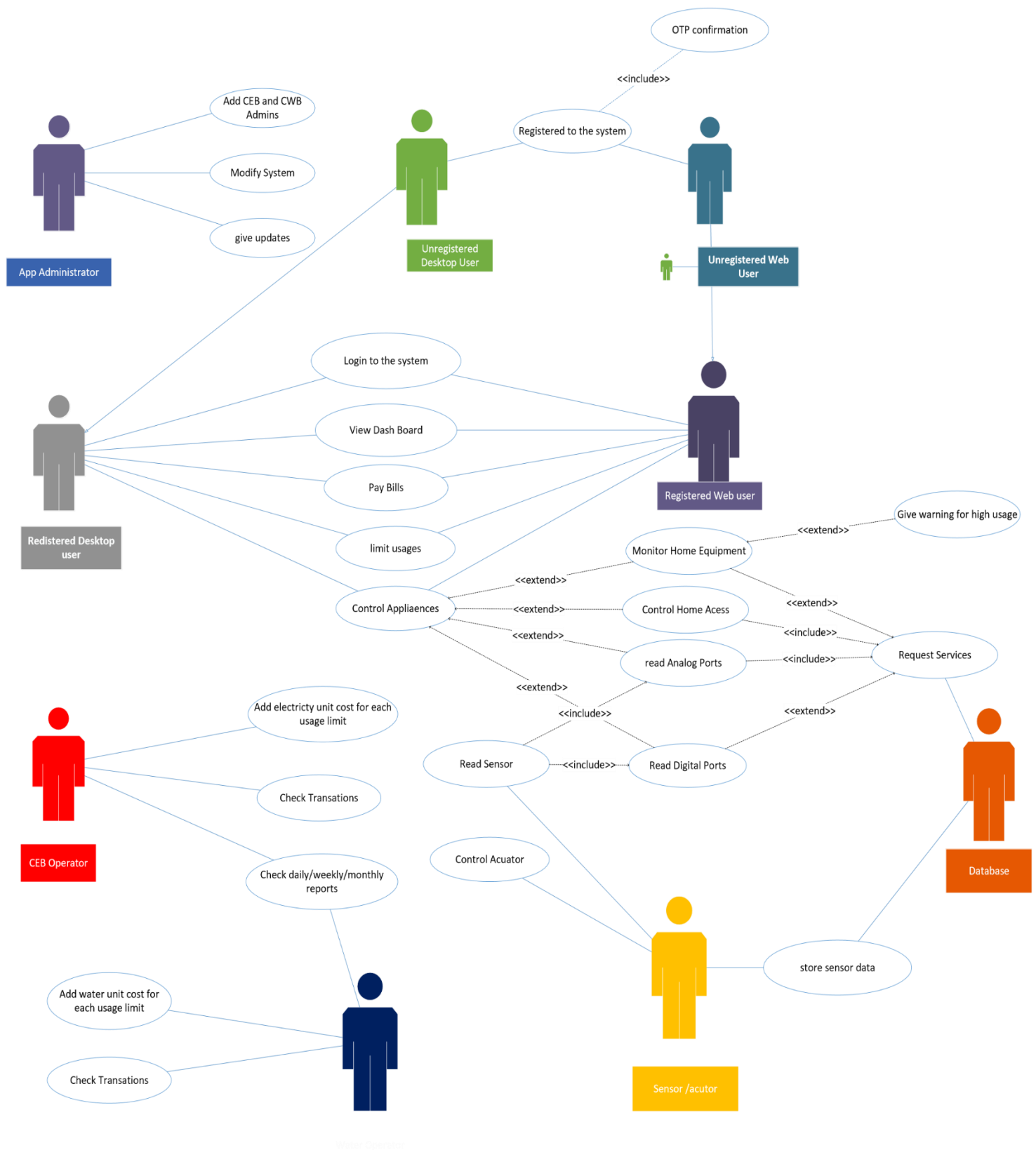
Figure 3.4.1-Use Case Diagram

3.5 _Sequence Diagram_

- ## Login process
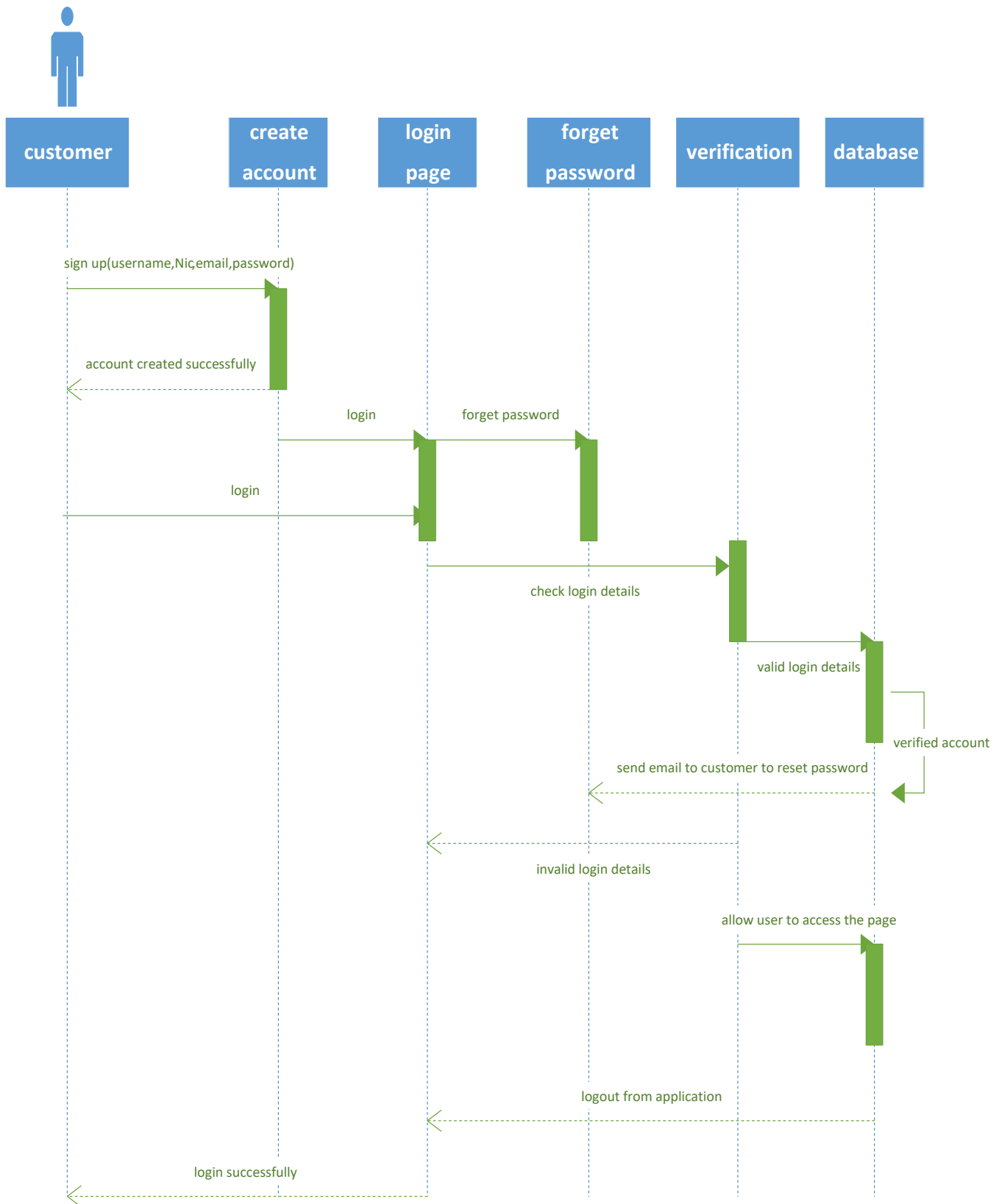
Figure 3.5.1-Sequence Diagram

- **Bill Payment Process**
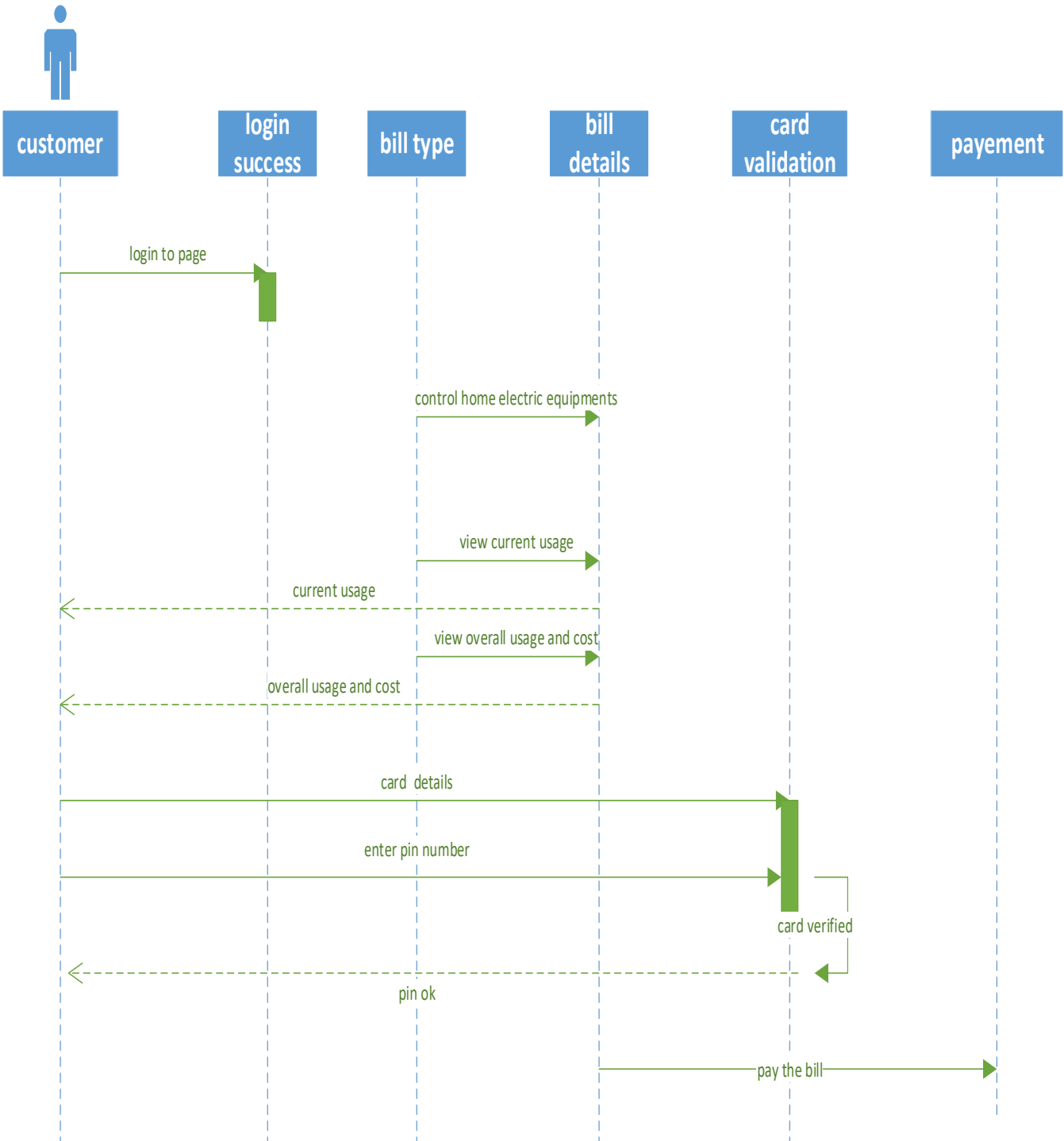
Figure *3.5.2* -Bill Payment Process

3.6 Activity Diagram (For User)
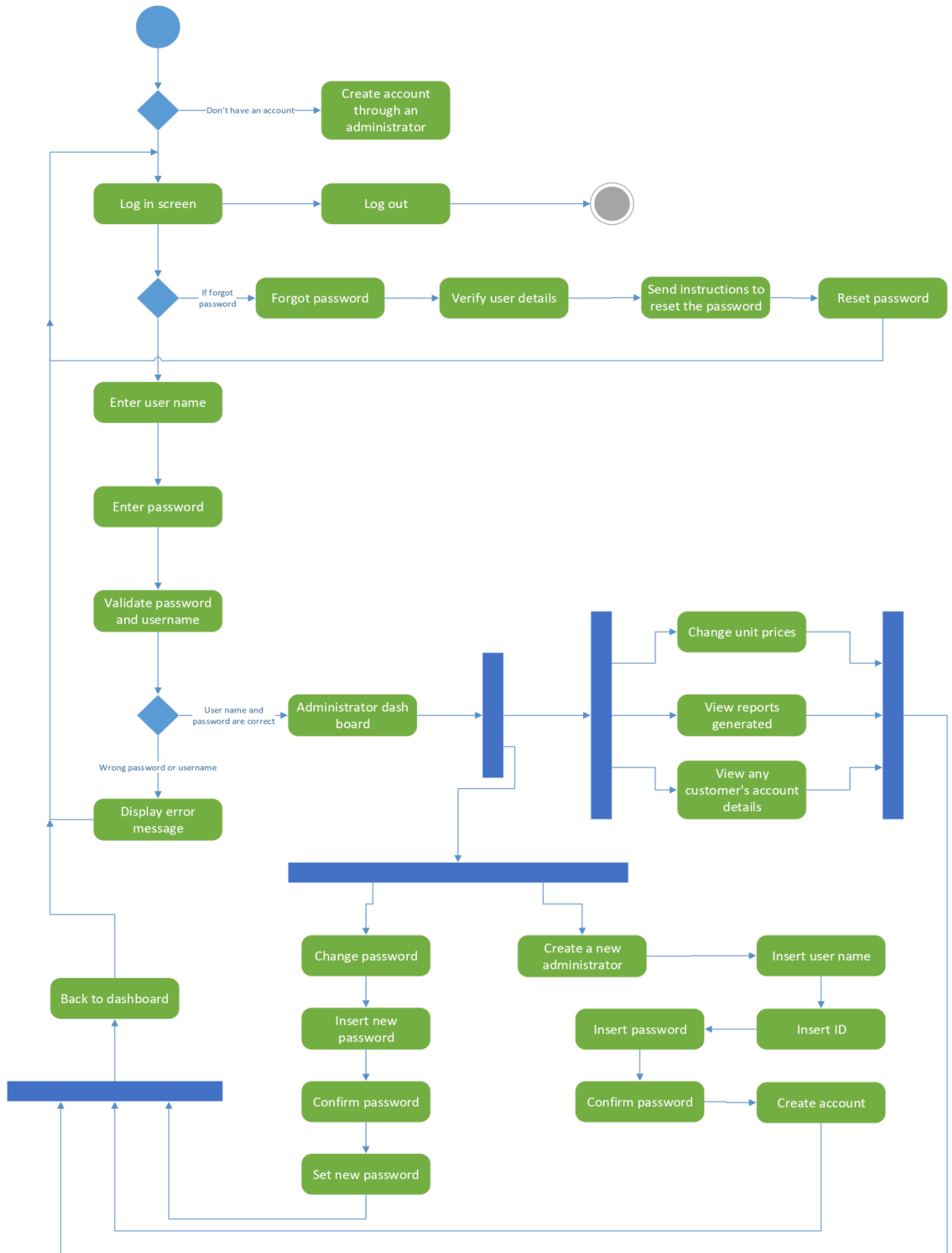
Figure 3.6.1-Activity Diagram for Users

Activity Diagram (For Administrator)
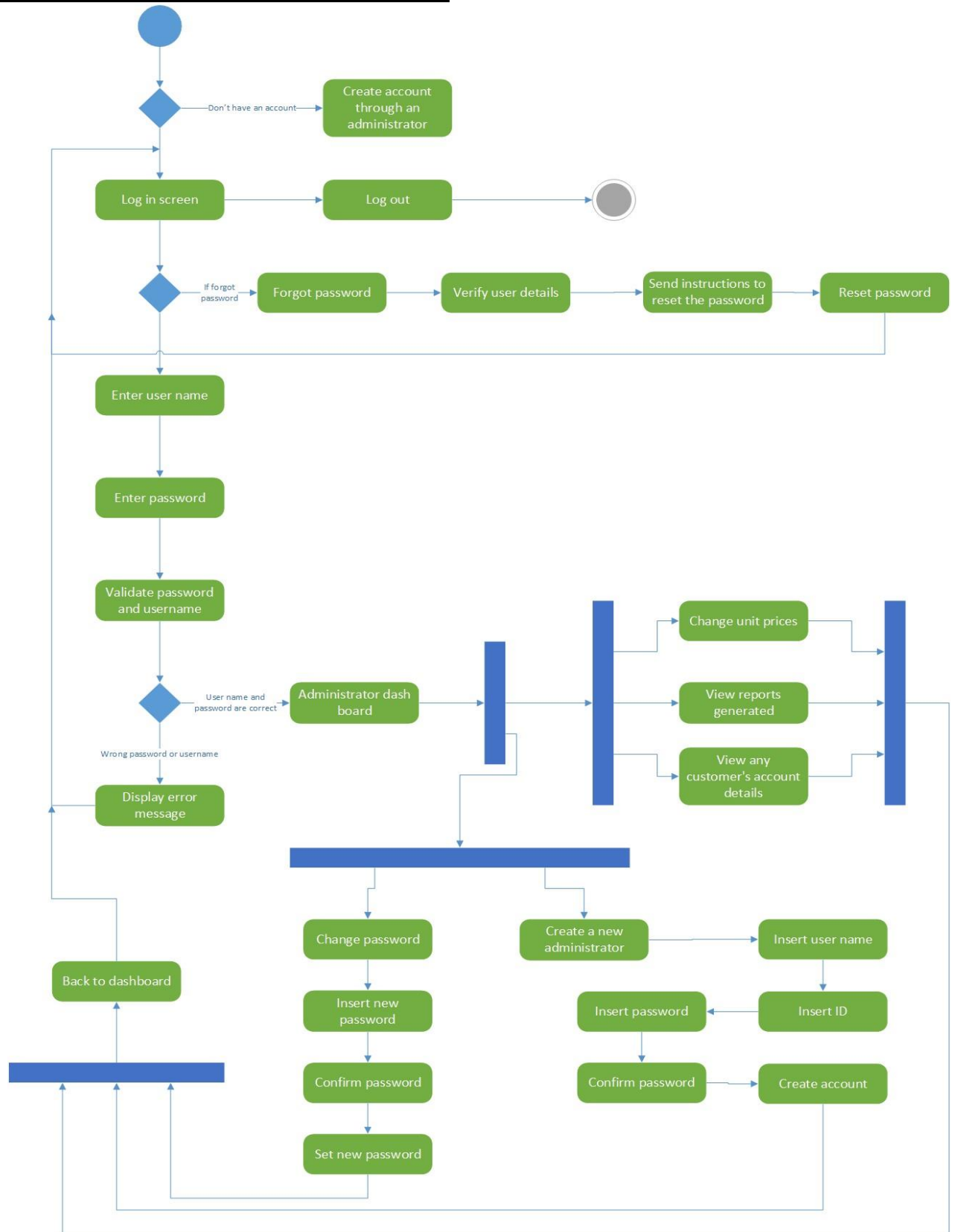
Figure 3.3.2-Activity Diagram (For Administrator)

3.7 Class Diagram
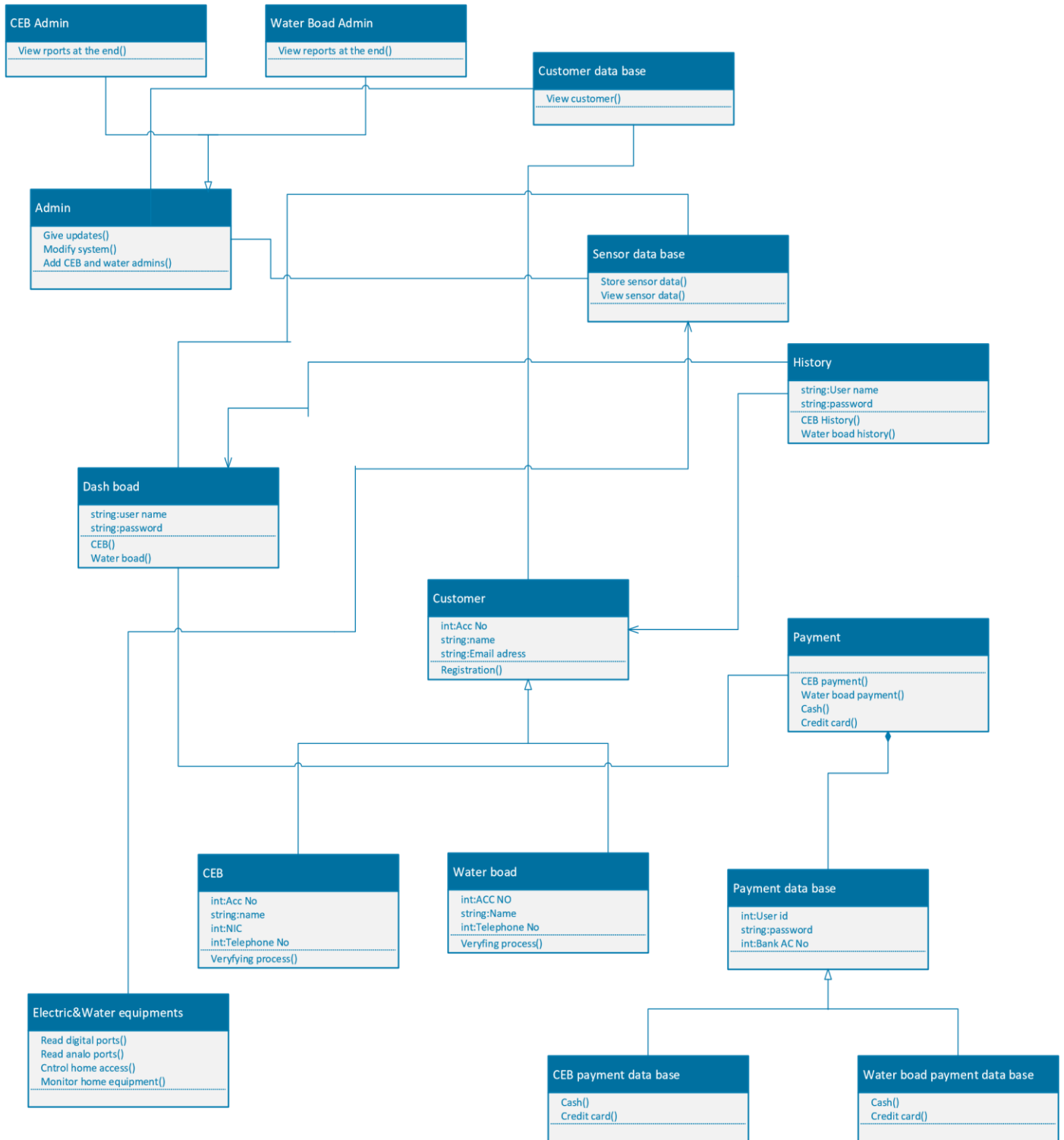
Figure 3.7.1-Class Diagram

3.8 <u>DEVICE WORKFLOW DIAGRAM</u>
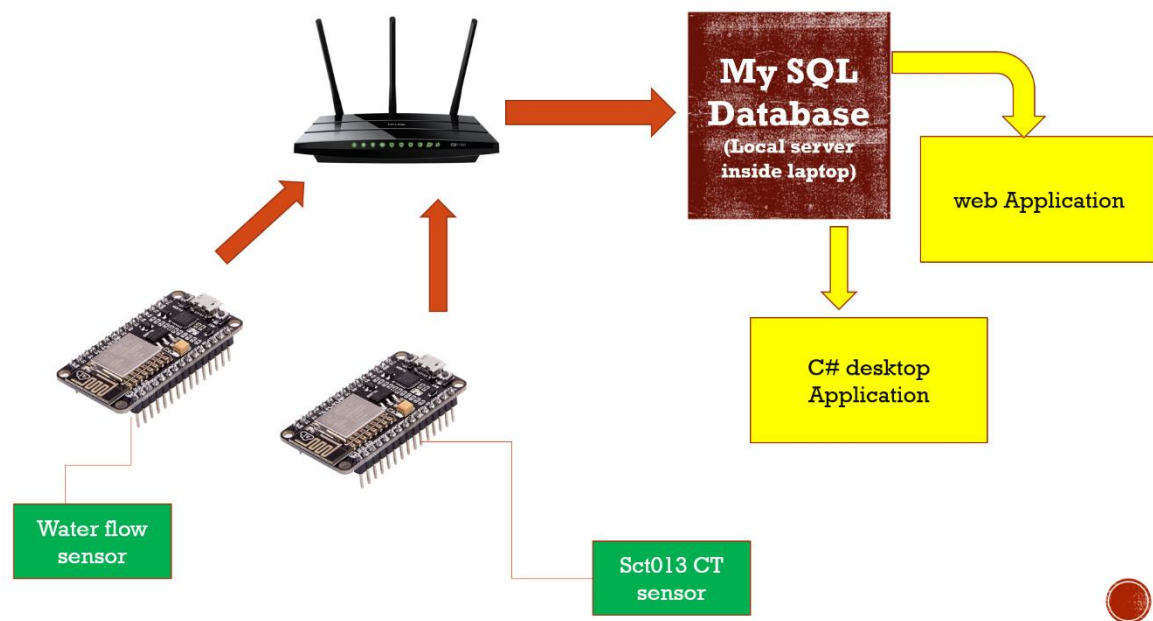
Figure 3.8.1-how device send data to database

Chapter 4 – Implementation

This system is consisting with both web application and desktop application.to develop the both application we used new modern programming languages.

4.1 Web application

To develop the front end of the web application we have use java scripts, hypertext markup language and cascade style sheets.fo the back end we use PHP programming language. On the other hand, we have use MySQL queries to do database activities.

Here the web page has three different parts.it has only on login to enter to the system. Both CWB and CEB admins and customers are facilitate to enter to the system by same login. But they were given different password type. Basically, there are three different password types in our web application.
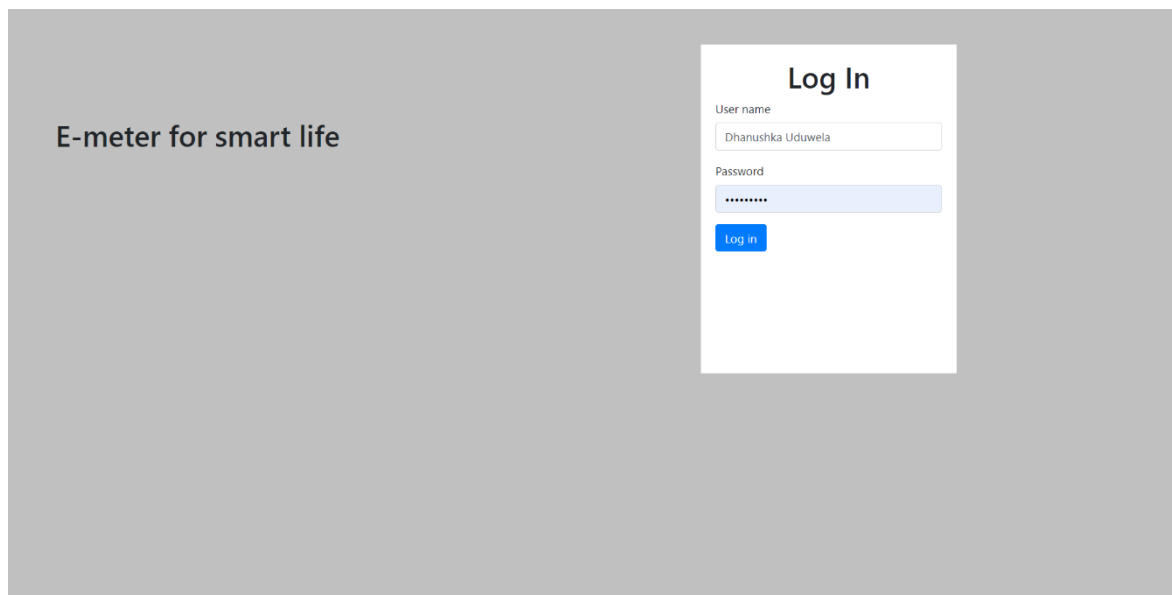
Figure 4.1.1-LOGIN PAGE
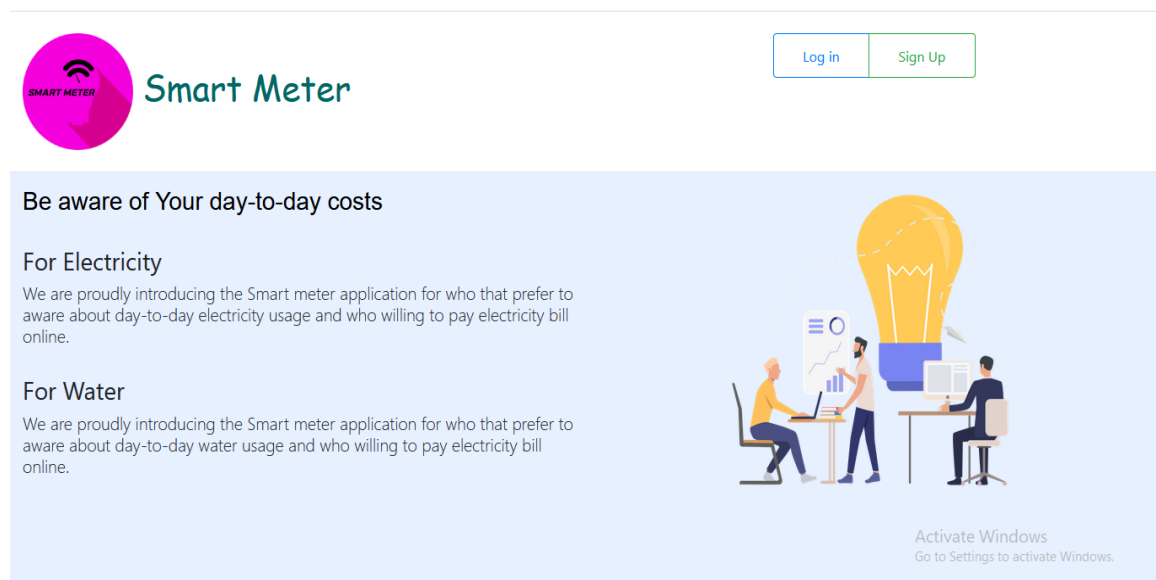
Figure 4.1.2-HOME PAGE
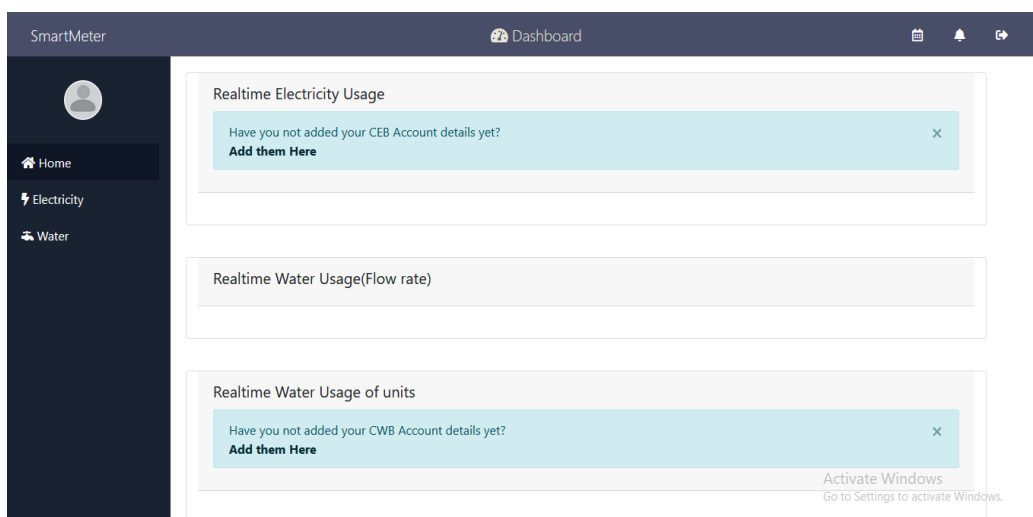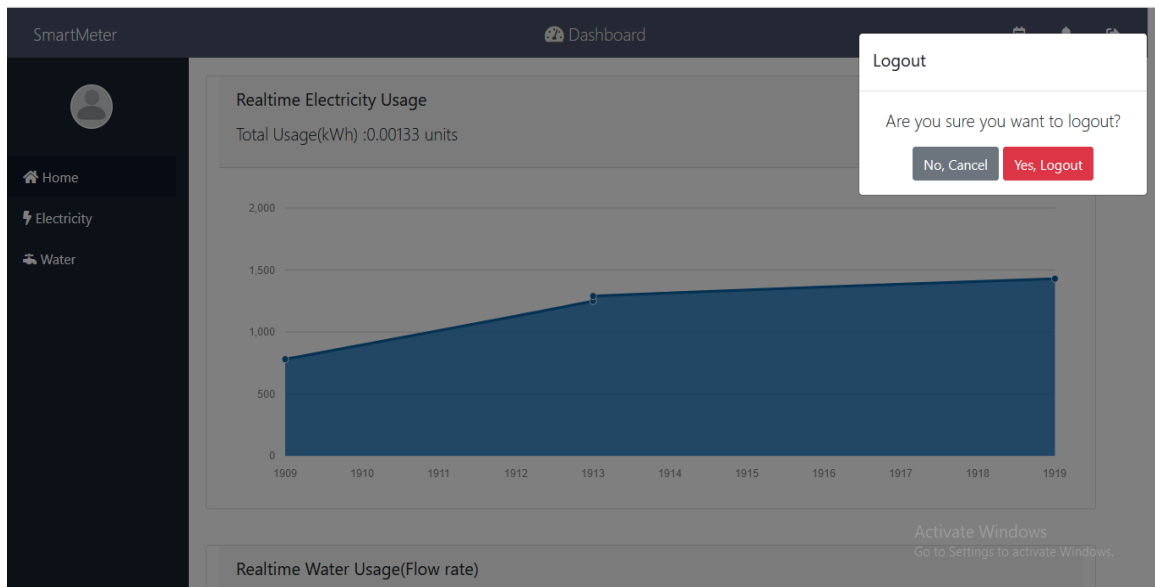

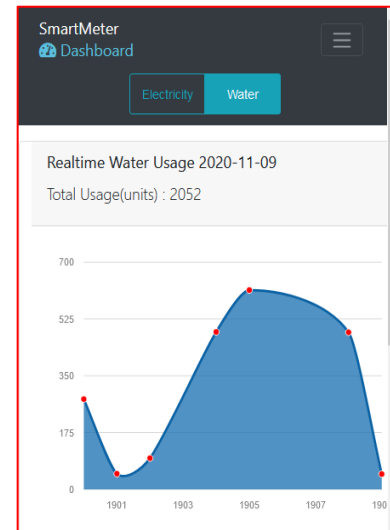**Figure 4.1.3-USER DASHBOARD**

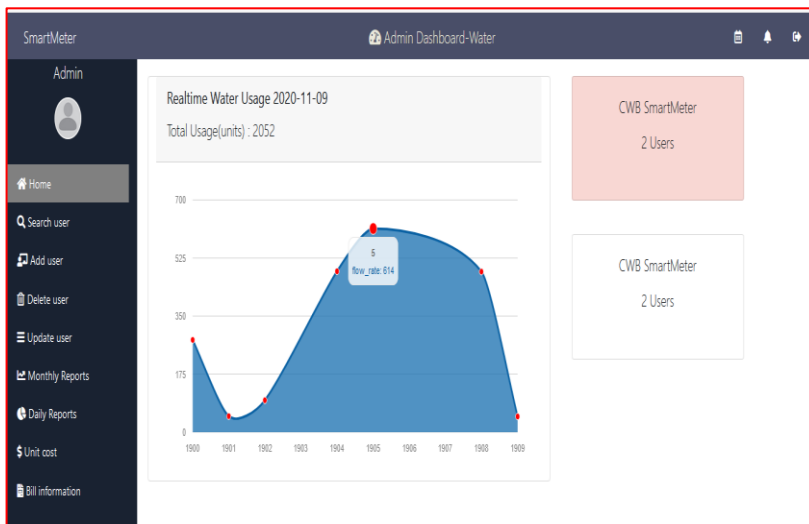**Figure 4.1.4-LOGOUT PANNEL**

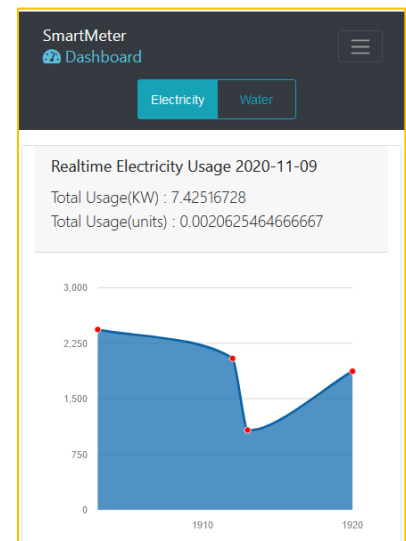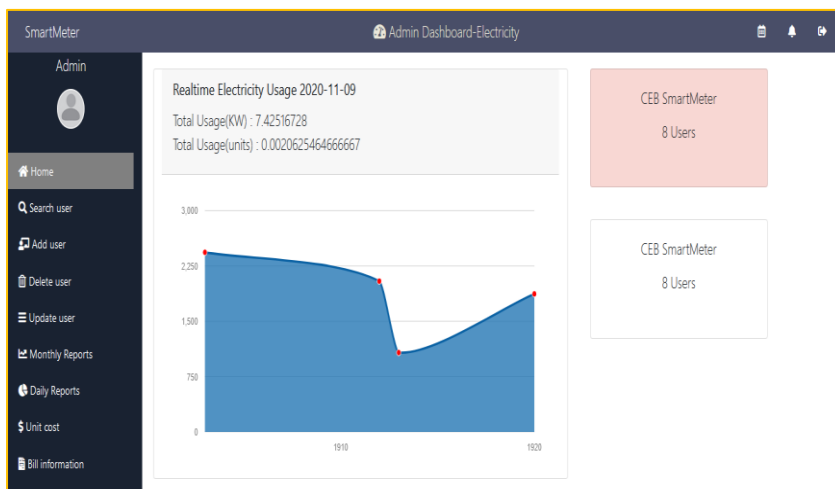**Figure 4.1.5-CWB ADMIN DASHBOARD**

Figure 4.1.6-CEB ADMIN DASHBOARD

4.2 Desktop application

to develop front end of the desktop application C# programming language is used. In the back-end development MySQL queries were used for database activities.
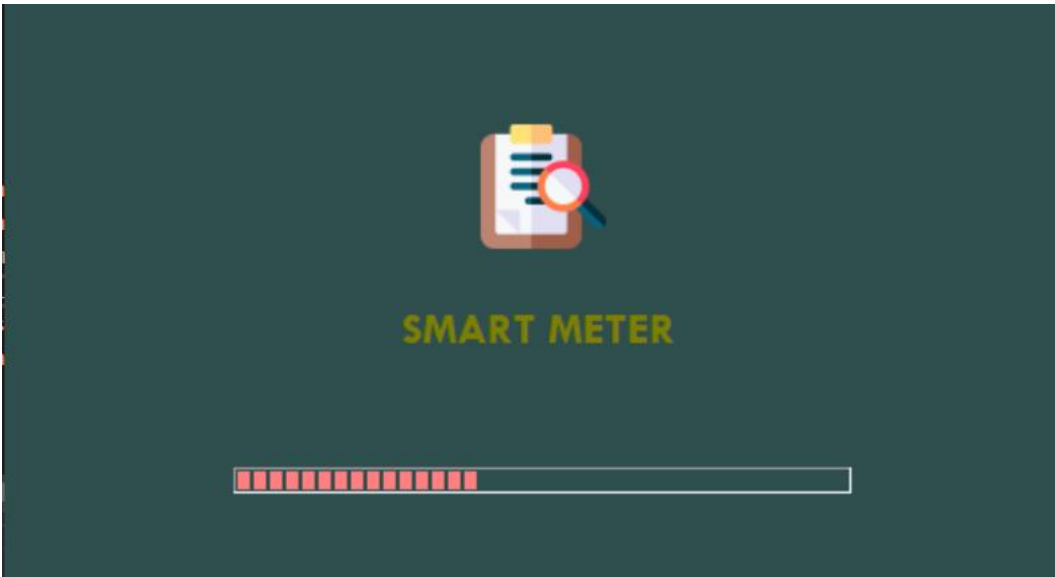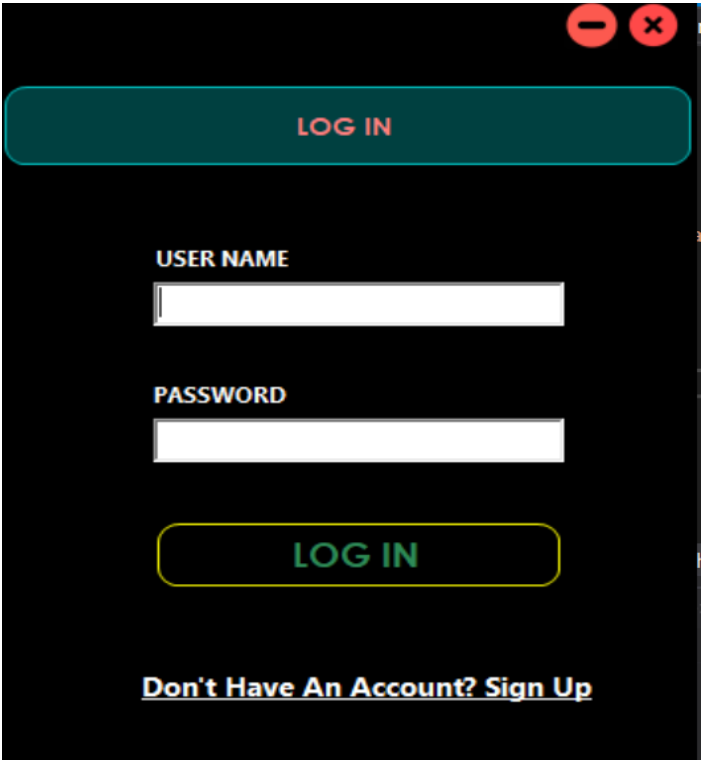

Figure 4.2.1-SPLASH SCREEN

Figure 4.2.2-LOGIN PAGE

Figure 4.2.3-CREATE ACCOUNT
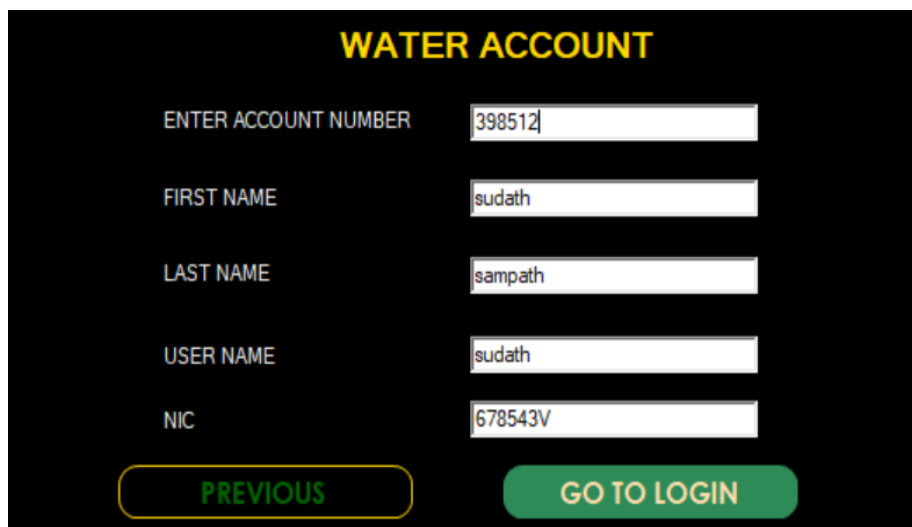
Figure 4.2.4-VERIFY CEB ACCOUNT

Figure 4.2.5-VERIFY WATERBOARD ACCOUNT
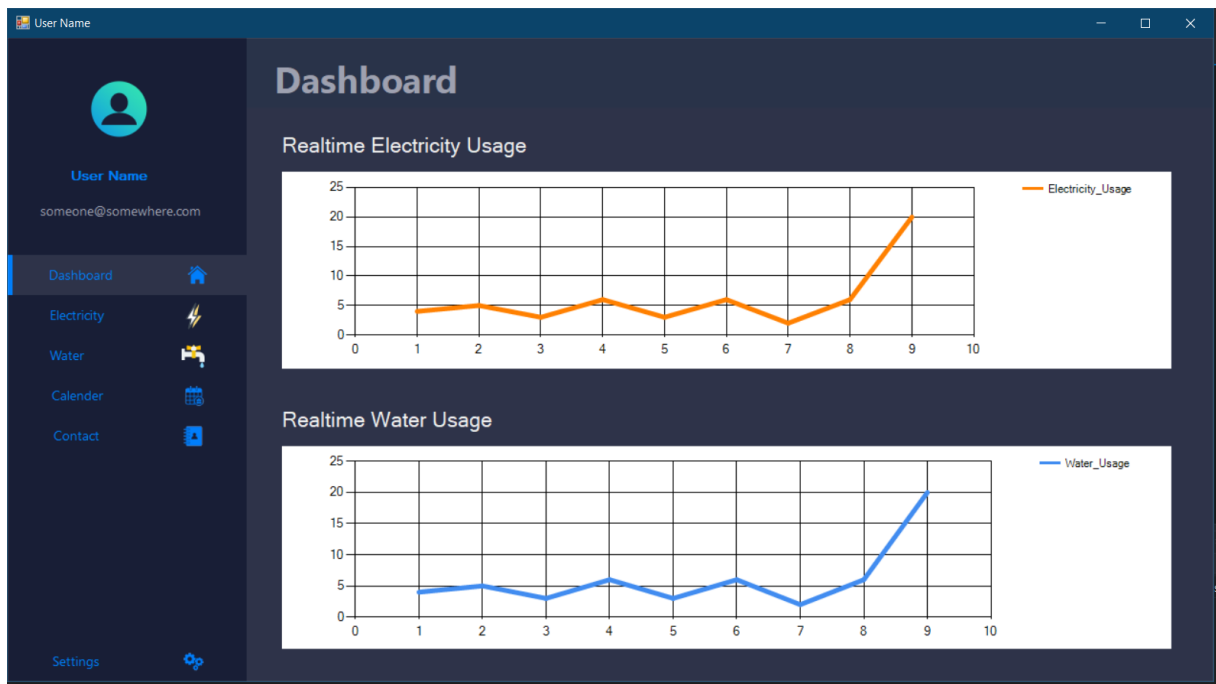
Figure 4.2.6-User dashboard
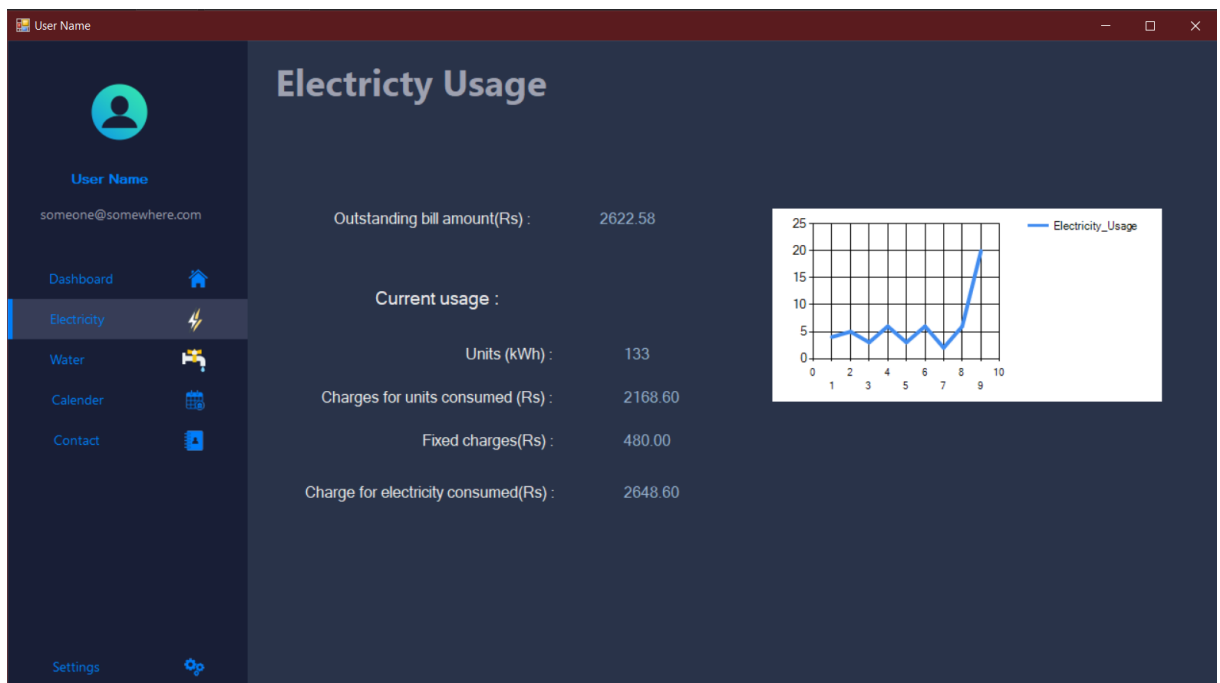
Figure 4.2.7-User electricity Usage display panel

Figure 4.2.8-Common view of Admin panels for both CWB and CEB administrators

Figure 4.2.9-Admin management panel

4.3 Databases

Using xampp MySQL option a server was created and kept all database on it. both web applications and desktop application and devices were connected to one database.

4.4 Devices

We used node two node mcu boards, one water flow sensor, one CT sensor. But at the moment we were not able to measure current using CT sensor. Arduino programming language is used to develop our devices.
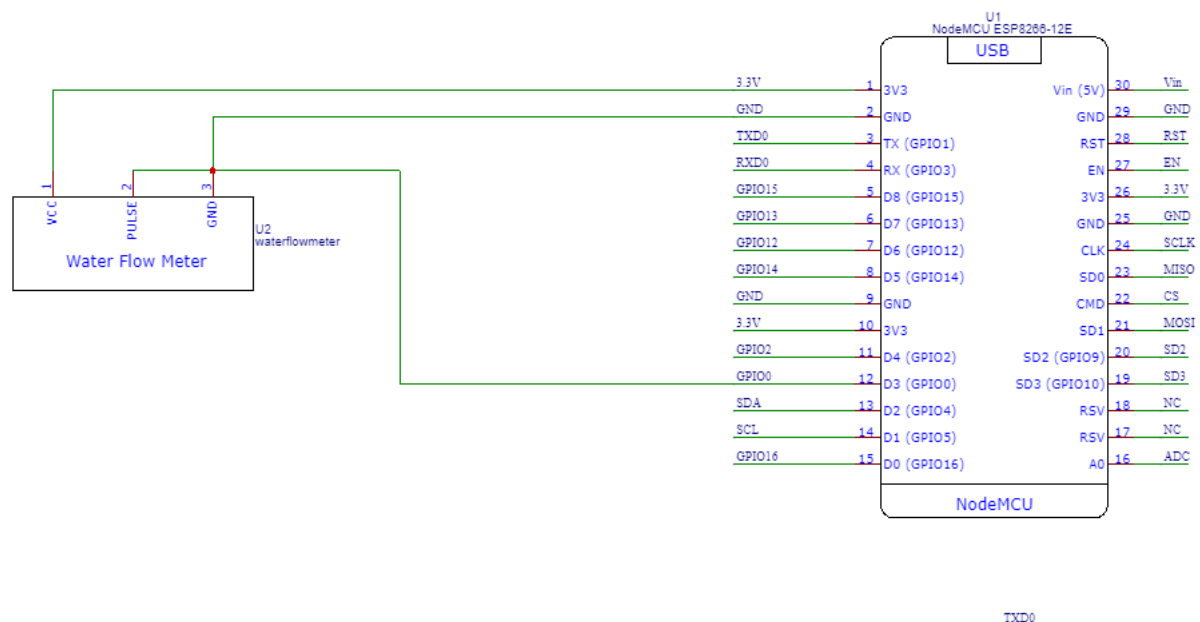
Figure 4.4.1-Circuit diagram for the water flow and volume measuring part
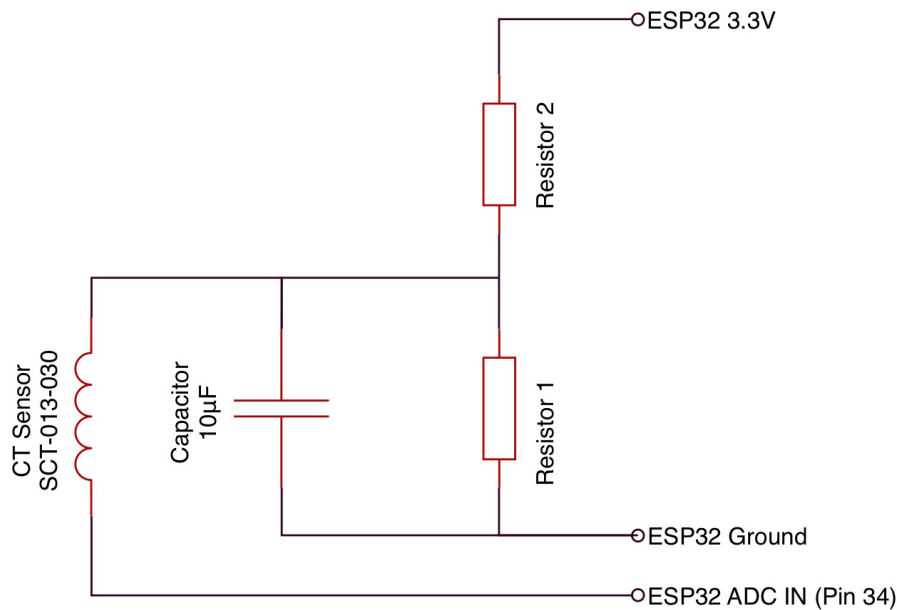
Figure 4.4.2-**Circuit diagram for the current and voltage measuring part**

4.5 Problem occurred in implementation

Difficulties of login and signup (web application) and how to overcome those difficulties

If user don't have an account using signup, user can create an account. When user creating an account, user has to give his username, email and password for signup. After creating an account using username and password user can directly go into the dashboard. After logout in the dashboard user can view again main login and signup page.

Main difficulty I faced when I creating this was when user logout in the system and press the back button again previous login users' dashboard displayed. That is very big problem for this system. Because any use after logout in the system only way to login to the system should using users' username and password again. It is very important for security purposes also.

 For overcome this issue I used below coding parts

1. I input below coding part for logout

    session_destroy();

2. I input below coding part for dashboard.php

```
<?php if(!isset($_SESSION['username'])): header("location: logout.php");?>

    <?php else: ?>

    <?php endif ?>
```

If use second dashboard.php coding part only previous users details not displayed but still we can go into the dashboard by pressing back button in the main login and signup page. That is not again a good thing that's why first logout.php coding part is important.

Using above mention solutions, I could overcome that issue.

Difficulties in connecting several node mcu through a wireless device

When we trying to send several data to database at same time the my sql server was crashed.

Because at that time we didn't know we can only pass one data for a selected time. Therefore, at the same time to nodemcus cannot send data to the database. For that we decided to send data by allocating time periods for node mcus.as example if one node mcu send data to the data base. The other node mcu is not trying to send data to the database. After the first node mcu done its job the the second node mcu is sending data to the data base. To do this we use delay () command in Arduino. Another problem is we can only connect 10 NODEMCU devices to home router. If we want to connect more devices with routers, we should go for Commercialize routers like CISCO router. Then we can connect lots of devices.

Chapter 5 –Results and Evaluation

Through this project we were able to measure water usage and calculate the price of the total usage. On the other hand, real-time graphs were generated to give a clear idea about the water usage for the customer. To test our system, we measure water flow usage for a certain time period of time and then compare with the old system. There is certain amount of difference

between our system and old water usage measuring system. Main reason for that is the sensors we used are not calibrate well. Therefore, there are lots of errors. For that we should calibrate the water flow sensor inside a laboratory and we should the calibration factor. But in this situation, we were not able to do that.

To calculate water flowrate, we used below equations inside the Arduino code. On the other hand, we use calibration factor as 4.5. But that value is not the most suitable one.
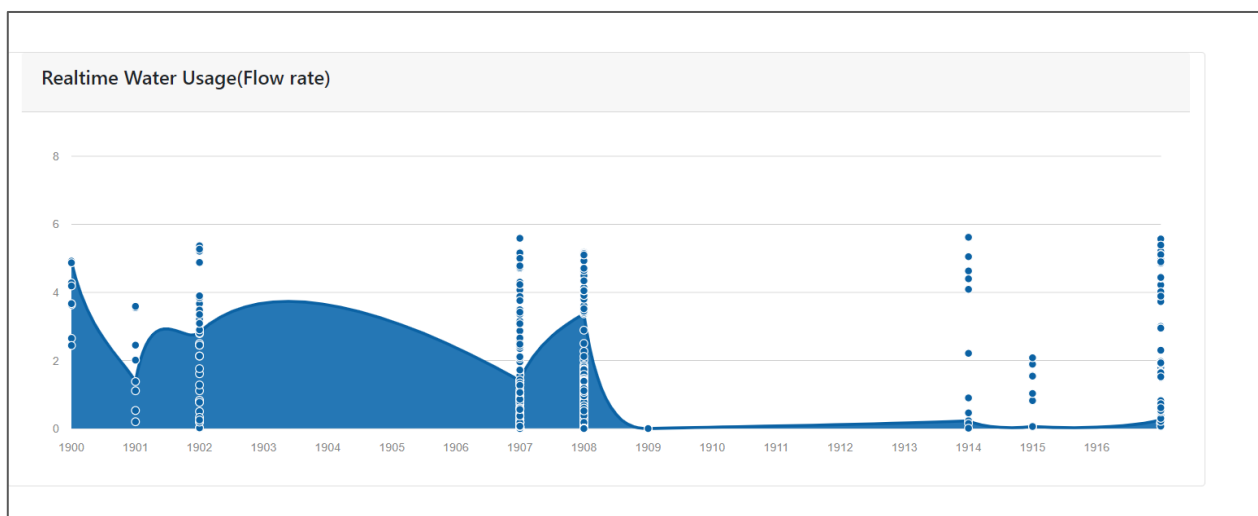
flowRate = ((1000.0 / (millis()- previousMillis)) * pulse1Sec) / calibrationFactor;

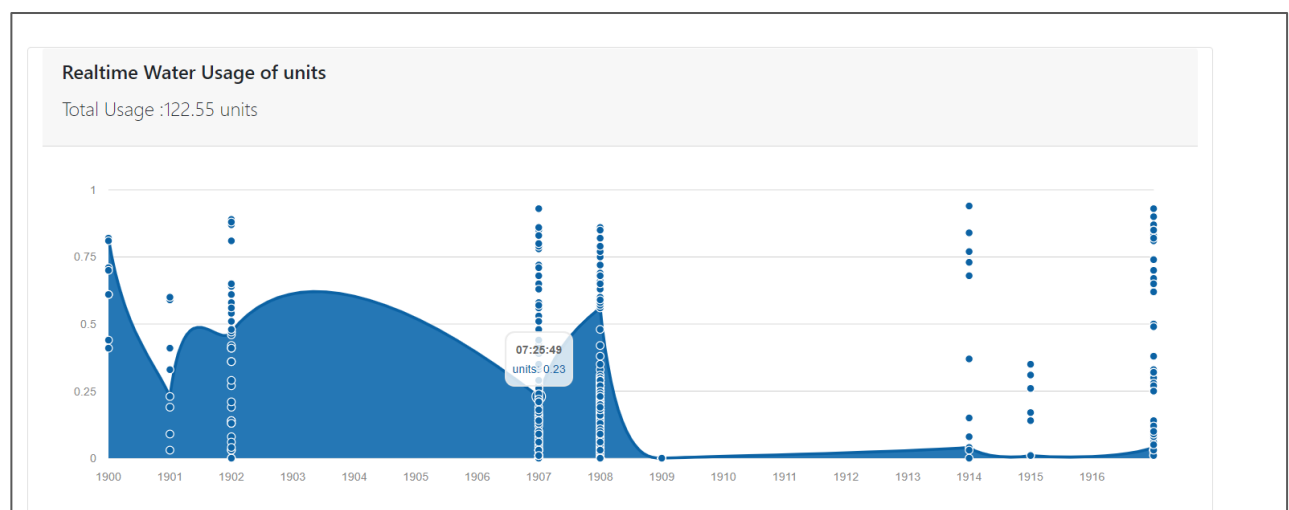
***Figure 5.1*-plotting the water flowrate**

***Figure 5.2*-total water usage in units and how water units vary with time**

For the Electricity part also, we should parallel run both old meter system and our smart meter system. then we should compare both values and check whether the smart meter reading are nearly same to the old meter reading. if values are not nearly same, we should calibrate our sensors till the corrects values are showing in the smart meter. For this the smart meter should test certain amount of long period. Sometime the time period would be one moth or higher.

Chapter 6 - Discussion

Project Smart Meter is a real time electricity and water usage monitoring system. Aim of the project was to reduce the loss of man power during the current manual meter reading system. This is a discussion about the development of the project Smart Meter including its strengths, weaknesses, challenges faced during the implementation and also about the future developments.

➢ **Strengths and Weaknesses**

Our main objective of the project was to introduce a substitution for the current manual meter reading process. So, we developed two Smart Meters which can be placed in series with our home electricity circuit and water line to measure the usage dynamically. These smart meters update two databases which are unique for the customer. So, by using these Smart Meters, CEB and CWB will be able to stop manual meter reading process which consumes more time, man power and money.

Our next target was to develop two applications for customers and for administrators which are CEB and CWB. So, we developed these applications in both web and desktop platforms. We developed four applications which are,

- ✓ Customer application - web and desktop (Windows)
- ✓ Administrator applications - web and desktop (Windows)

Using the customer application users can register with their water and electricity accounts and view their real time usage and real time cost for the month up to the moment. Administrator application is capable of managing both customers including updating details, deleting users and creating new users.

Users can make their own account their selves as the user interfaces are created in a more user-friendly manner. All the users need to insert their username and password to log in to their accounts. Therefore, the privacy and the security are maintained throughout the system.

There are few weaknesses of the system as well. Current sensor used in the electricity smart meter is not calibrated due to the unavailability of lab equipment's during the project development. Therefore, the implementation of the electricity Smart meter is not hundred percent accurate.

At the beginning, we planned to add some more features to the customer application to give warnings when they are reaching some milestones of their usage. And also suggest power plan to reduce the cost. But due to the limitation of time we were unable to add these features in our system.

➢ **Challenges faced during the implementation**

Majority of the work of the project development process was done during the quarantine period due to the COVID-19 crisis. Therefore, faced difficulties when gathering members for the team discussions using online methods. And also, we could not purchase some hardware components due to the same reason.

We were unable to use lab equipment's to calibrate our current sensor during the period.

We developed different parts of the project separately by each member. So, it became a challenge to connect the whole system to gather at the final stage.

➢ **Further developments**

- ✓ The system can be developed introducing online payment system, which can be used for customers to pay both their water and electricity bills.
- ✓ A power plan can be introduced as a new option to the system which can be used as a guidance for users to reduce their bill.
- ✓ Smart meter can be developed to control and view the current usage of each part of the home.

Chapter 7 – Conclusion

Today's bill reading system is done by manually. And also, there is no single platform for customers to manage and pay both their electricity and water bills. So, we decided to create a system to read and pay the bill by customer itself. this system consists with a hardware part and a software part. When considering about software part, both user and the service provider are updated with the current usage and the overall usage. Users can manage both their electricity and water usage within necessary limits.

There are two separate interfaces to access to electricity and water fields. And also, from both desktop and web applications can be used to access to the users' accounts. When considering about the hardware part, it can easily plug to switches and wirelessly connect with desktop application and web application. Real time graphs are generating to show the usage of both electricity and water usage.

Developing a desktop application along with a web application is not much as we planned at the beginning. As it consumed lot of time and that time could be used to develop the web application with better features what we could not be achieved due to the time limitation.

But as a conclusion, we could achieve our main objective which is to develop a Smart Meter along with a real time usage monitoring system.

Chapter 8 References

1. Sensor, Y., 2020. *YF-S201 Hall Effect Water Flow Meter / Sensor |*. [online] Hobbytronics.co.uk. Available at: <https://www.hobbytronics.co.uk/yf-s201-water-flow-meter> [Accessed 8 November 2020].

2. www.banggood.com. 2020. *5V 30A ACS712 Ranging Current Sensor Module Board Module Board From Electronic Components & Supplies On Banggood.Com*. [online] Available at: <https://www.banggood.com/5V-30A-ACS712-Ranging-Current-Sensor-Module-Board-p-86583.html?utm_source=google&utm_medium=cpc_ods&utm_campaign=bay-eu2-sds-cont-category-rm&utm_content=bay&ad_id=288123913175&gclid=CjwKCAjwtNf6BRAwEiwAkt6UQjPQ-eKLOkn6WAJuLB5qI2R6sw_t6CknjxCItSObfGHmJkJvYpyN3BoCMAUQAvD_BwE&cur_warehouse=CN> [Accessed 8 November 2020].

3. Visual-paradigm.com. 2020. *What Is Data Flow Diagram?*. [online] Available at: <https://www.visual-paradigm.com/guide/data-flow-diagram/what-is-data-flow-diagram/> [Accessed 8 November 2020].

4. Medium. 2020. *Data Flow Diagram Comprehensive Guide With Examples*. [online] Available at: <https://medium.com/@warren2lynch/data-flow-diagram-comprehensive-guide-with-examples-d9858387f25e> [Accessed 8 September 2020].

5. Tutorialspoint.com. 2020. *UML - Use Case Diagrams - Tutorialspoint*. [online] Available at: <https://www.tutorialspoint.com/uml/uml_use_case_diagram.htm> [Accessed 8 November 2020].

6. Tutorialspoint.com. 2020. *C# - Loops - Tutorialspoint*. [online] Available at: <https://www.tutorialspoint.com/csharp/csharp_loops.htm> [Accessed 12 November 2020].

7. https://creately.com/blog/diagrams/sequence-diagram-tutorial/

8. Tutorialspoint.com. 2020. *UML - Activity Diagrams - Tutorialspoint*. [online] Available at: <https://www.tutorialspoint.com/uml/uml_activity_diagram.htm> [Accessed 8 November 2020].

9. Visual-paradigm.com. 2020. *UML Class Diagram Tutorial*. [online] Available at: <https://www.visual-paradigm.com/guide/uml-unified-modeling-language/uml-class-diagram-tutorial/> [Accessed 8 November 2020].

10. Erg.abdn.ac.uk. 2020. *Communications Protocols*. [online] Available at: <https://erg.abdn.ac.uk/users/gorry/course/intro-pages/protocols.html> [Accessed 8 November 2020].