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Abstract

This paper shows the technique of using LabView to design a smart home control system. The designed system will have the function of controlling the lights, doors, curtains, TV, and air conditioner remotely. Hardware requirement for developing the system is also provided. This paper also demonstrates the system design using flowchart and the protocol design using TCP/IP in this project.

1.0 Introduction

1.1 Smart Homes

Nowadays, we stand at the portals of a new age. The architectural designer must constantly adapt and innovate to ensure success in a growing market. Apart from tracing national origins of building designs, designer has an opportunity to introduce the high-tech home systems that able to connect with the internet to perform remote controlling and management of other home applications. As the economy is in the upswing, the demand for high-tech systems has increased and it becomes a bright spot in the architectural market.

A smart home system, also called home automation, provides home security, comfortable and convenient environment. It not only helps to save time and cost but also helps to produce energy-efficient operations. Example of home automation such as smart light which can change its colour according to room temperature, smart door which can detect when occupants get close to the door, smart curtain which can open and close according to the day/night time automatically, and others.



Figure 1 Smart Home Applications (Vigderman and Turner, 2021)

Besides, users can check each home application's status even when they are not at home. They can remotely switch off the home applications when they already left home and forgot to turn off the home applications. On hot days, users also can turn on the air conditioner remotely before they arrive in their residential areas. With a click of the finger, they can easily do what they wish to the home applications remotely.

Home automation requires software and hardware support together. LabView has been chosen as a programming environment to build the Smart Home Control System in this project. LabView is a system engineering software that provides system visualization, such as the connection of hardware components, the flow of signals, and others. It enables the integration of analysis and IP and supports thousands of devices.

1.2 Internet of Things (IoT)

The Internet of Things (IoT) is the act of physical devices and systems connected to the Internet for sending or receiving data. Day after day, IOT shows its great potential to impact the human lifestyle and make their life easier. The concept of IoT will be shown as the following diagram:

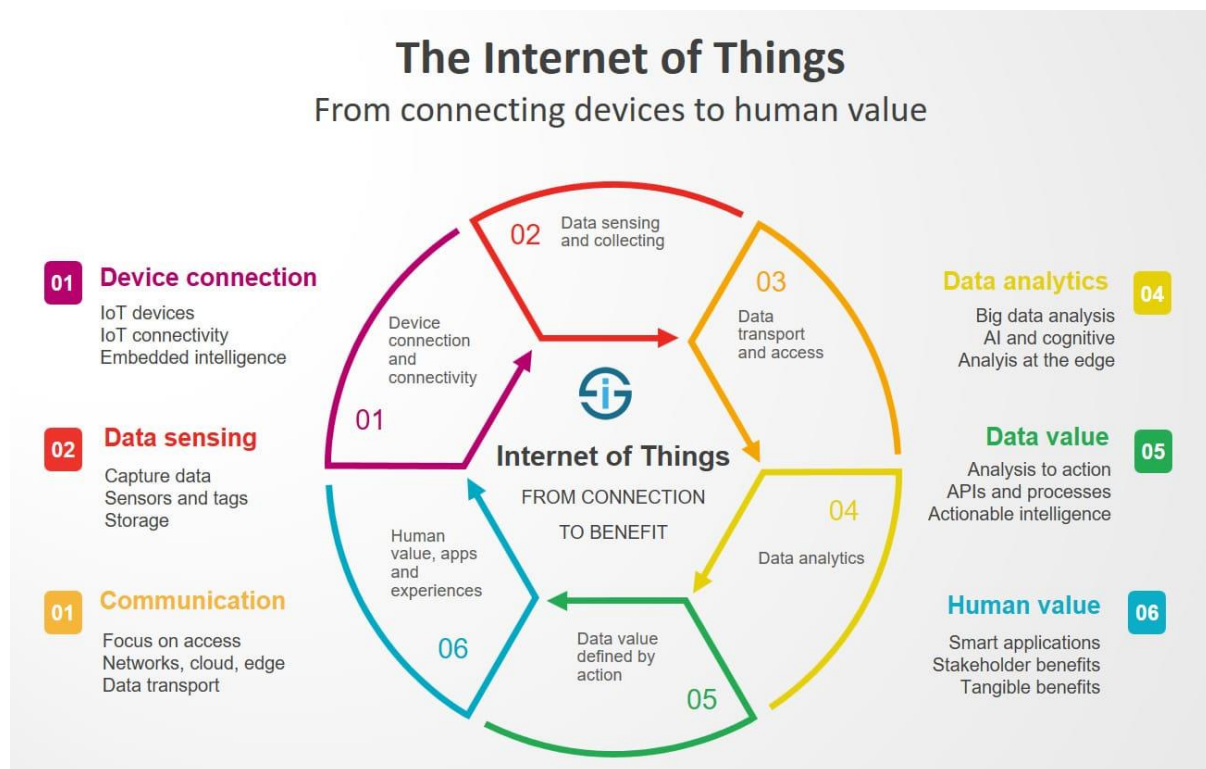





Figure 2 Internet of Things Definitions (What is IoT? The Internet of Things - definitions and facts, 2021)

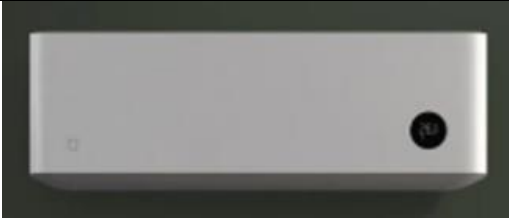

To implement the IoT in a device, the connection between the physical devices and the Internet must be stable for data transmission among the devices. IoT enables the collection of all the data and stored in the cloud storage for data analysis by communicating with the devices. The implementation of artificial intelligence can help perform extensive data analysis to know the users' habits to improve their living standards.


IoT has a giant network of connections, including people, physical devices, and the main servers. IoT has been applied in many industries and continues to happen in manufacturing settings. For example, it can control the traffic light, monitor the air pollution, track the parcel status, and optimize workflow operations.

Hence, the IoT concept was used in this project to produce a smart home control system. The primary purpose of implementing the IoT is to monitor home applications to increase their efficiency and effectiveness.

2.0 Hardware Requirements

Hardware	Image	Description
Sengled Smart Wi-Fi LED Multicolor		<p>Brand: Sengled</p> <p>Wattage: 9.8 watts</p> <p>Light Source Wattage: 75 Watts</p> <p>It has multiple colours that allow change according to the environment. Besides, it is also an energy-saving product.</p>
Xiaomi Mijia Smart Door Lock		<p>Brand: Xiaomi</p> <p>Size: 365.6×75.6×24.5mm</p> <p>Connection: Bluetooth 5.0</p> <p>Battery: 8 AA Batteries or Micro-USB port</p> <p>It can store up to 50 fingerprints, 50 codes, and 25 NFC devices.</p>
Samsung TU8000 4K UHD Smart TV		<p>Brand: Samsung</p> <p>Size: 50 "</p> <p>Processor: Crystal Processor 4K</p> <p>Design: 3-side Boundless Design</p> <p>Connector: 3 HDMI & 2 USB</p> <p>It has high picture quality and can provide up to 4K</p>

		<p>resolution. It can connect to Wi-Fi without any plug-in USD. The built-in application includes browser, Netflix, Spotify, and others.</p>
<p>Xiaomi Mijia Smart Air Conditioner</p>		<p>Brand: Xiaomi Category: Wall-mounted Number of horses: 1.5 Size: 879x293x212mm Energy efficiency rating: 3</p> <p>It enables to set the opening and closing temperature. The temperature displayed on the air conditioner is LED display.</p>
<p>Aqara Curtain Controller (Zigbee)</p>		<p>Brand: Aqara Dimensions: 70x50x346mm Weight: 1.5kg Voltage: 100-240V Wireless Protocol: Zigbee</p> <p>It enables to control the curtain using smartphone through Wi-Fi.</p>

<p>Enbrighten In-Wall Z-Wave Smart Outlet</p>		<p>Brand: Enbrighten Material: Plastic Size: 1.75x2.1x4.2 inches Switch Style: Receptable It allows the remote control via smartphone or voice command using Alexa or Google Assistant.</p>
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3.0 System Design

3.1 Flowchart

3.1.1 Client Flowchart

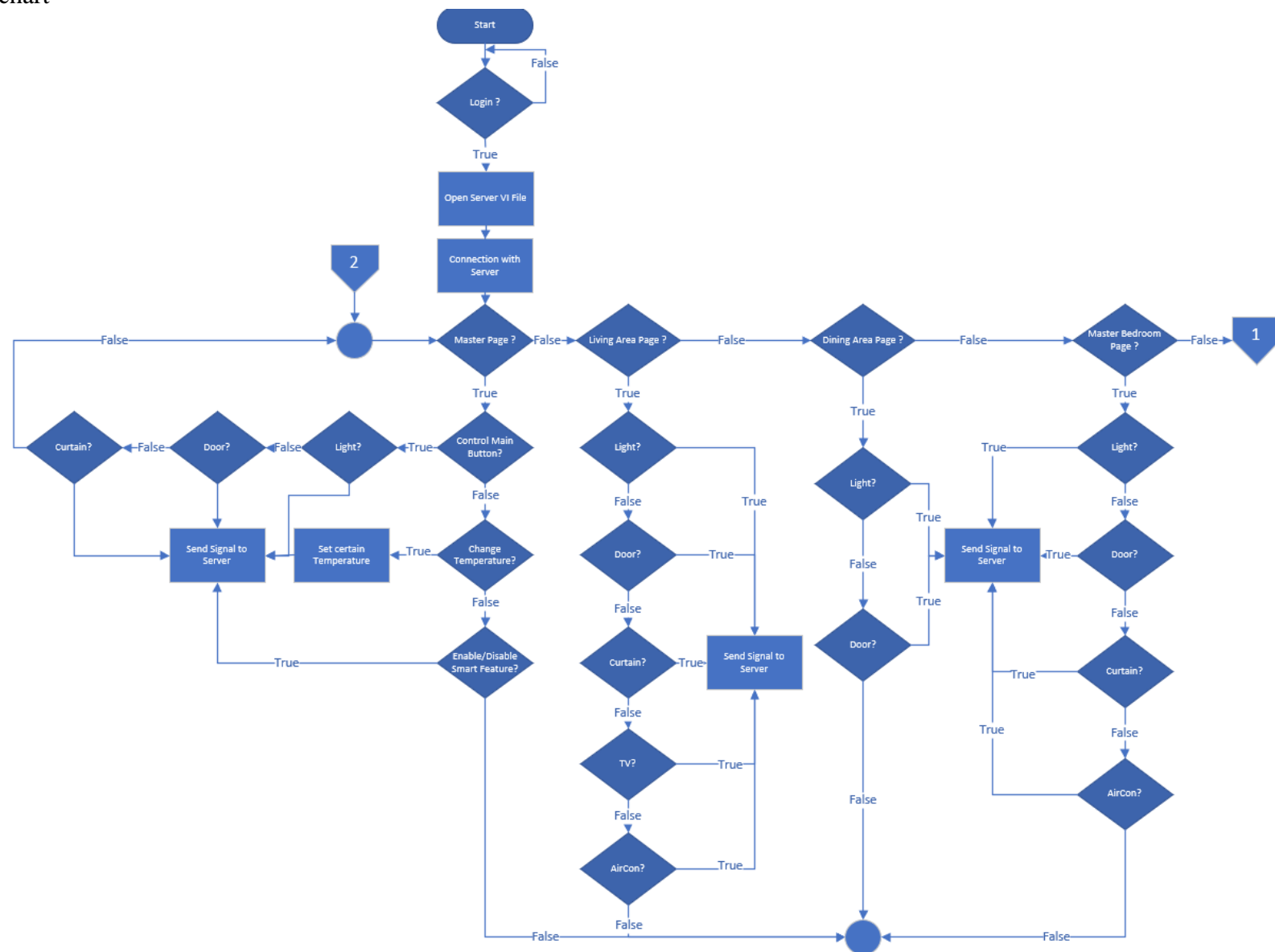


Figure 3 Client Flowchart Page 1

Figure 3 and figure 4 show the process from accepting user input to sending the signal to the server on the client-side. After successful login to the client-side, the client will first open the server vi file and start the connection. Next, users can choose specific pages for specific functions such as turn on/off the light, change the room temperature, open/close the door. Finally, after receiving the user requirement, the client will send the signal to the server to request the function of a specific feature.

3.1.2 Server Flowchart

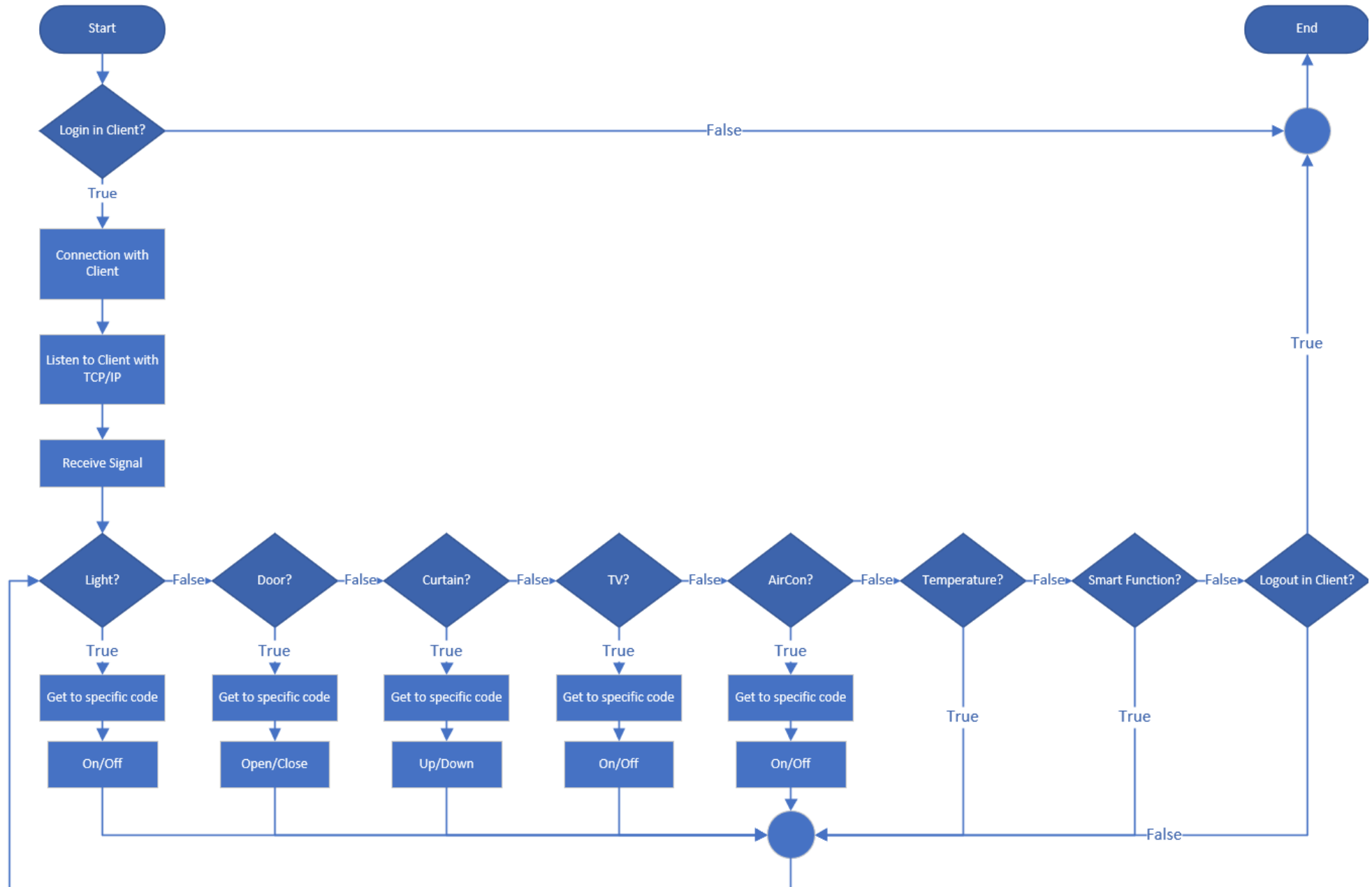


Figure 5 Server Flowchart

Figure 5 shows the process of turning on/off the specific home applications on the server-side, such as lights, doors, curtains, tv, and air conditioner. After opening the server vi file, it will connect with the client-side and wait for the signal. If users choose to open/close the specific home application, it will go to a specific code and perform the instructions. If users wish to change the temperature or turn on the smart feature, the server will control the home applications according to the environments.

3.2 Use Case Diagram

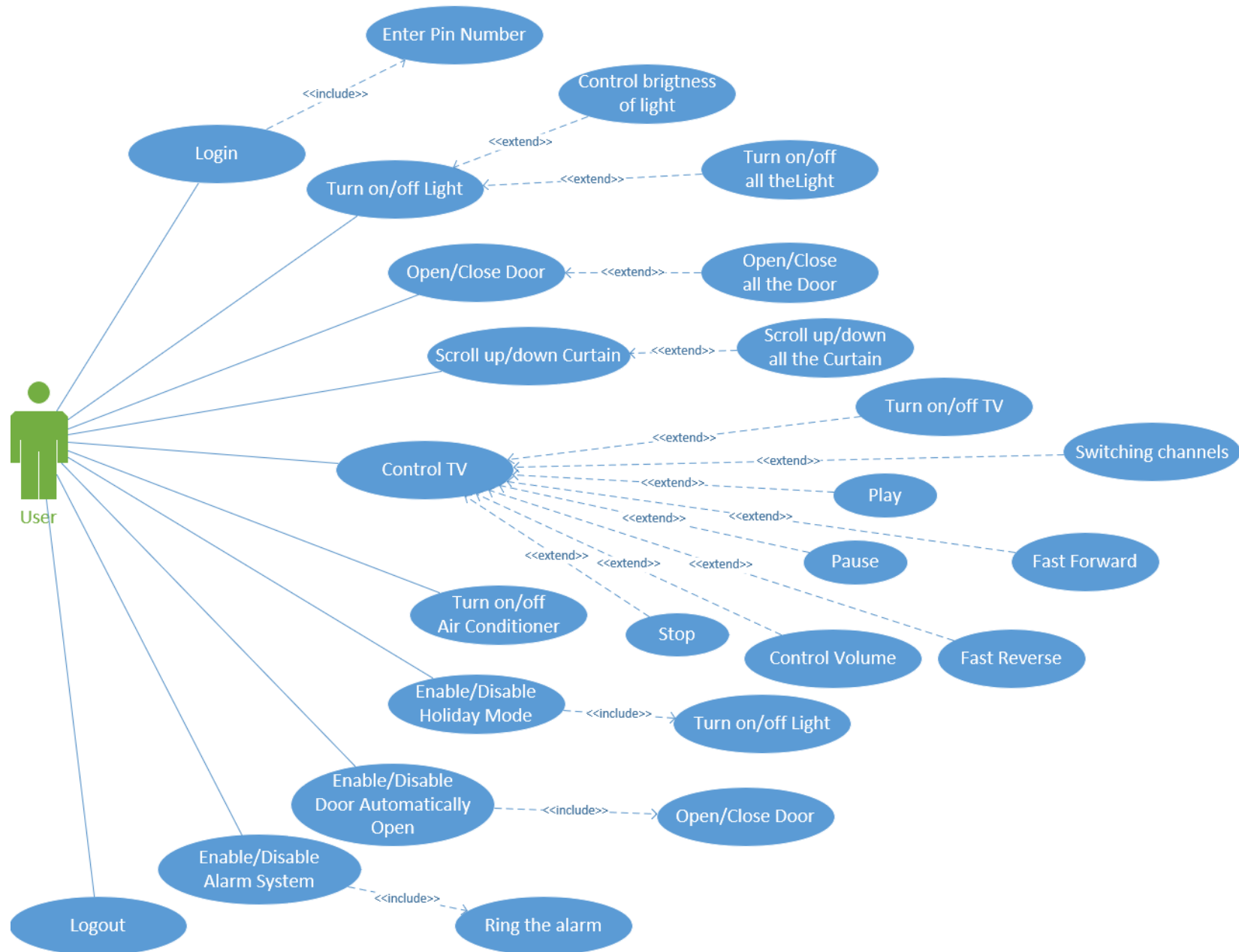


Figure 6 Use Case Diagram

4.0 Protocol Design

In this project, the Transmission Control Protocol/Internet Protocol (TCP/IP) provides the connection between client and server-side. TCP/IP relationship allows the client to communicate with the server.

When a message is sent over TCP, the connection will be established, and a three-way handshake will be made. One of the advantages of using TCP is the three-way handshake which helps to ensure a reliable connection before the real data communication process begins. It will exchange the synchronization and acknowledgment packets between the client and server. After the secure and reliable connection is established, the real data can be transmitted trustingly.

Compared to UDP, TCP is more reliable, and the lost data packets will be retransmitted. Although UDP is faster than TCP, TCP will provide an extensive error checking for the packets and the data acknowledgment. Besides, TCP will rearrange the data and provide ordered delivery from client to server (Matt Cook, 2017).

4.1 Client Protocol Design

In client side, LabView provides three main types of TCP terminals for establishing the connection:

1. TCP Open Connection

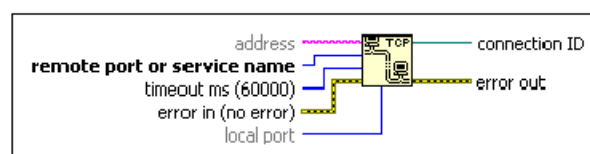


Figure 7 TCP Open Connection

TCP open connection function will open a connection with the given address and connect to certain remote port or service name in the server.

2. TCP Writer

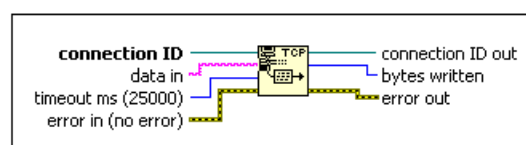


Figure 8 TCP Writer

This terminal will allow users to pass the data in the client to the server side. The connection ID will be given by the TCP Open Connection and the “connection ID out” must be linked to the TCP Close Connection.

3. TCP Close Connection

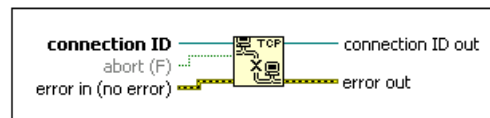


Figure 9 TCP Close Connection

After passed the data, TCP will need to close the network connection.

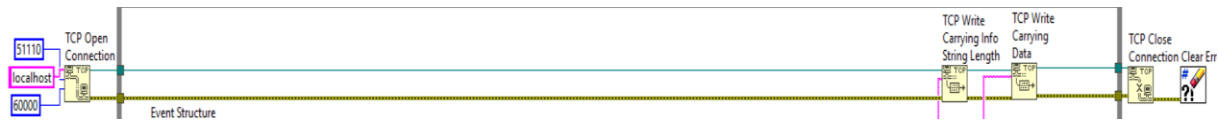


Figure 10 Example of TCP Client Protocol

In this example, the client will establish the connection with the remote port “51110” on the server-side. The connection has 60000 seconds time out. The server side must have the “51110” port number. After the connection is successfully established, the client will first send the data length to the server for handling purposes on the client-side. Then, the actual data will be sent. The sent data must be in string format as it can contain a character or numeric data. Hence, “Type Cast” will be used to convert the data into a string type. After successfully deliver the data, “TCP Close Connection” will close this running network connection. The “Clear Error” will be responsible for cleaning the error if any connection error occurs.

4.2 Server Protocol Design

In server side, the three main type of TCP terminal are shown as the following:

1. TCP Listen

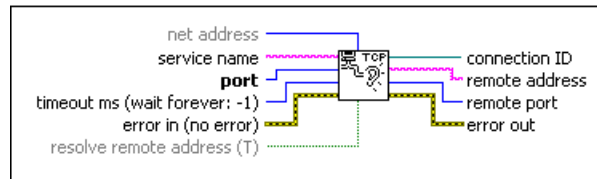


Figure 11 TCP Listen

After connected with server side, the TCP Listen will be ready to receive the signal anytime from the client side. However, it is only used to listen the coming signal, the data will be read in TCP Read stage.

2. TCP Read

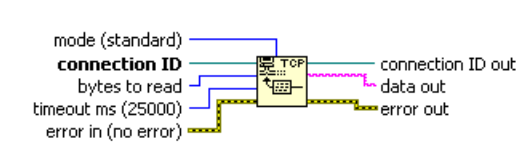


Figure 12 TCP Read

After received signal, TCP Read will read the number of bytes and transform the signal into string data type.

3. TCP Close Connection

TCP Close Connection in server side is same as the close connection in client side. Its purpose is to close the existing connection.

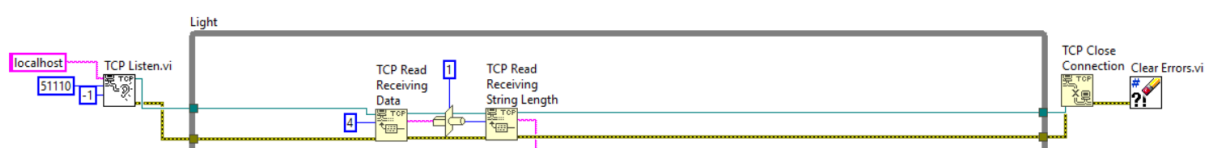


Figure 13 Example of TCP Server Protocol

The timeout “-1” in the TCP Listen means the server will wait for the signal forever and always be ready to receive the signal. After received the signal from the same port number “51110” on the client-side, TCP Read function will be instructed to read only four incoming bytes and return the results to the following functions to perform further actions. There are two TCP Read on the server-side, one is used to receive the actual data, and the other is used to receive the string length. After the data successfully transform, the TCP Close Connection will close the existing connection, and the TCP Listen will wait for another signal.

5.0 Extra Features

To improve the quality of the proposed Smart Home Control System, few extra features are included in this project and will be shown as the following:

1. Air Conditioner

The designed air conditioner is designed in living area, master bedroom, bedroom 2, and bedroom 3. The air conditioner will be automatically turned on when the temperature goes up to 30 degrees. It will also be automatically turned off when the temperature goes down to 10 degrees.

2. Fire Alarm System

When the room temperature goes up to 50 degrees, the message “There is a fire!” will be shown and the all the doors and curtains will be opened to let the occupants have the chance to escape. The sound “bi” also will be made to alert the occupants.

3. Curtain

The curtain will automatically scroll down at 7pm and automatically scroll up at 7am. It is based on the time of the clock on client-side.

4. Logout Option

Users are able to logout from the Smart Home Control System to avoid their child improperly use the system.

6.0 System Review

6.1 Limitations

Although the Smart Home Control System can perform many automation features, some limitations still restrict users from having a better experience using the system.

The limitations include:

1. The system will not be functional when the electricity fails.
2. When users add in other home applications, the system cannot control the new applications without reprogramming the system.
3. The system is only designed for one type of user and did not provide child mode. It may cause any damage to the system if a child uses it improperly.
4. The system has just only a password and did not provide the feature of password modification. If a stranger has the login password, he can just enter the system without any permission.

6.2 Future Enhancement

The designed Smart Home Control System has a vast space for enhancement in the future. By implementing the enhancement, it can avoid the current limitations and let the system have a better performance.

Some suggested future enhancement will be shown as follows:

1. The system should be able to add/modify/delete passwords to avoid any invasion of unknown users.
2. The system can design according to the user category. Child mode can be added. The child can only perform few features, such as switching on/off the light, opening/closing doors and curtains. It is suggested to avoid any improper use of other features.
3. The system can be designed with a more attractive user interface to exemplifies the ideal of “beauty and practically.”
4. Air conditioner system can be enhanced by turning on/off automatically according to the existence of the users. If users only available in the master bedroom, when the temperature goes up to 30 Degrees Celsius, only the air conditioner in the master bedroom has to be turned on instead of all the air conditioners.
5. More sensors can be added to the system, such as a smoke sensor which will trigger the alarm when there is an unnormal drift of smoke in the house.
6. More security features can be added to the system, such as CCTV features which will only start recording when there is a movement in the house.

7.0 Appendixes

7.1 User Manual

First of all, users must log in to the client-side before performing any Smart Home Control System feature. Only the Login page is shown in the Tab Control, and the other pages are not allowed to enter.



Figure 14 Login Page

The entered pin number will be shown in encrypted password style (*), and it only allows four inputs. “C” is used to clean the entered pin number, and the “E” is used to validate the password after confirmed the input.

If users enter a wrong pin number, the LED light will change to red colour, and the “Incorrect Password” message will be shown as the following diagram:

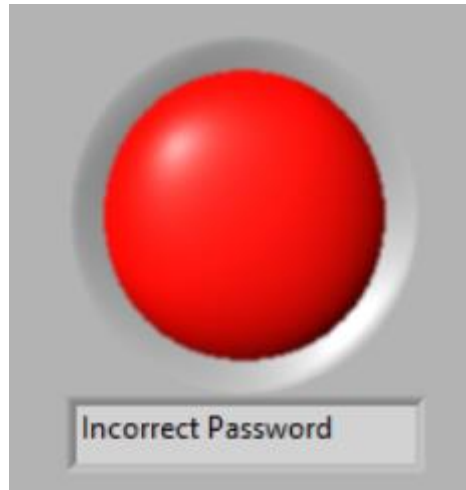


Figure 15 Change after entered incorrect input

After entering the correct pin number, the LED light will change to green, and the “Correct Password” message will be shown. Besides, another message will be popped out before entering the system.

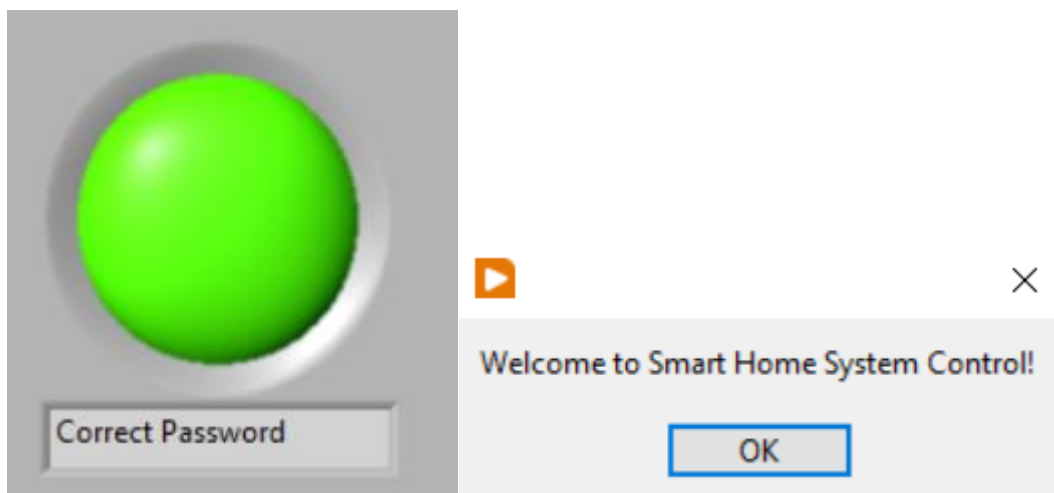


Figure 16 Change after entered correct input

Apart from that, the server-side will be automatically opened and shown to the users after successful login in the client-side. The original server-side before any change will be shown as the following diagram:

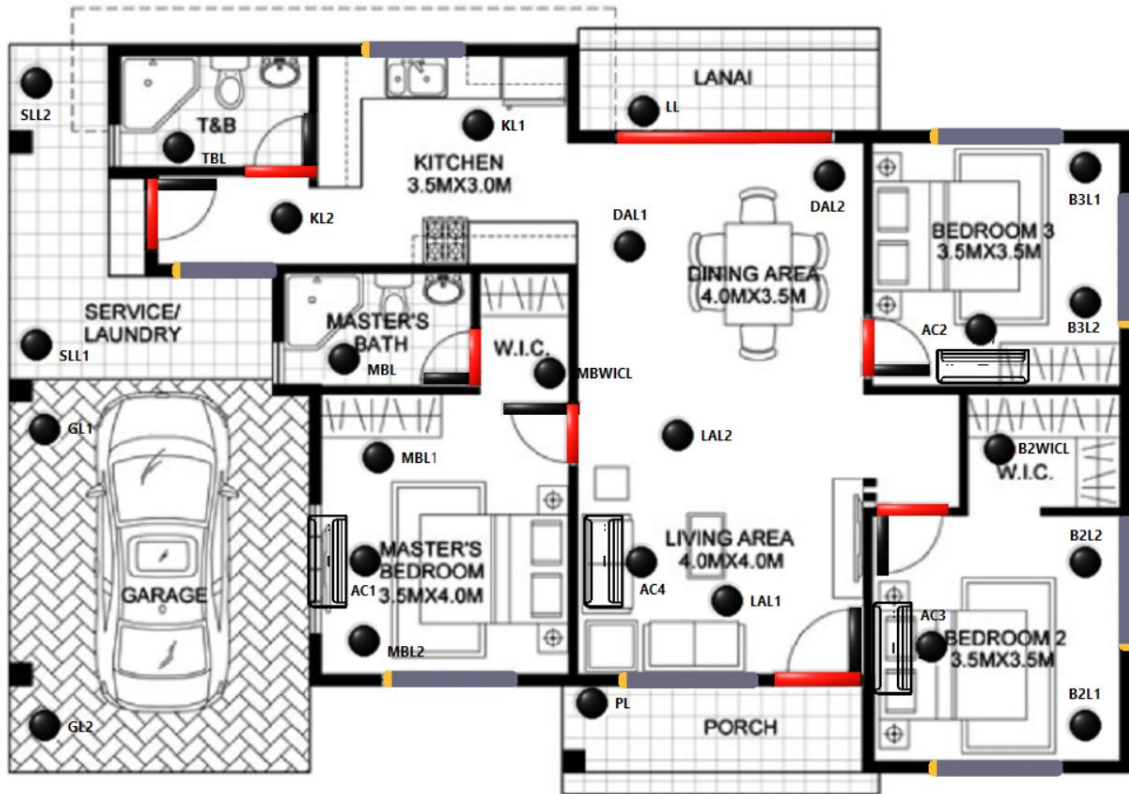


Figure 17 Default Smart Home Control System Server

The default settings in this system will turn off all the lights, close all the doors, curtains, and air conditioner in the house. The diagram below shows the server-side with turning on all the switches.



Figure 18 Smart Home Control System Server with all the turned on switch

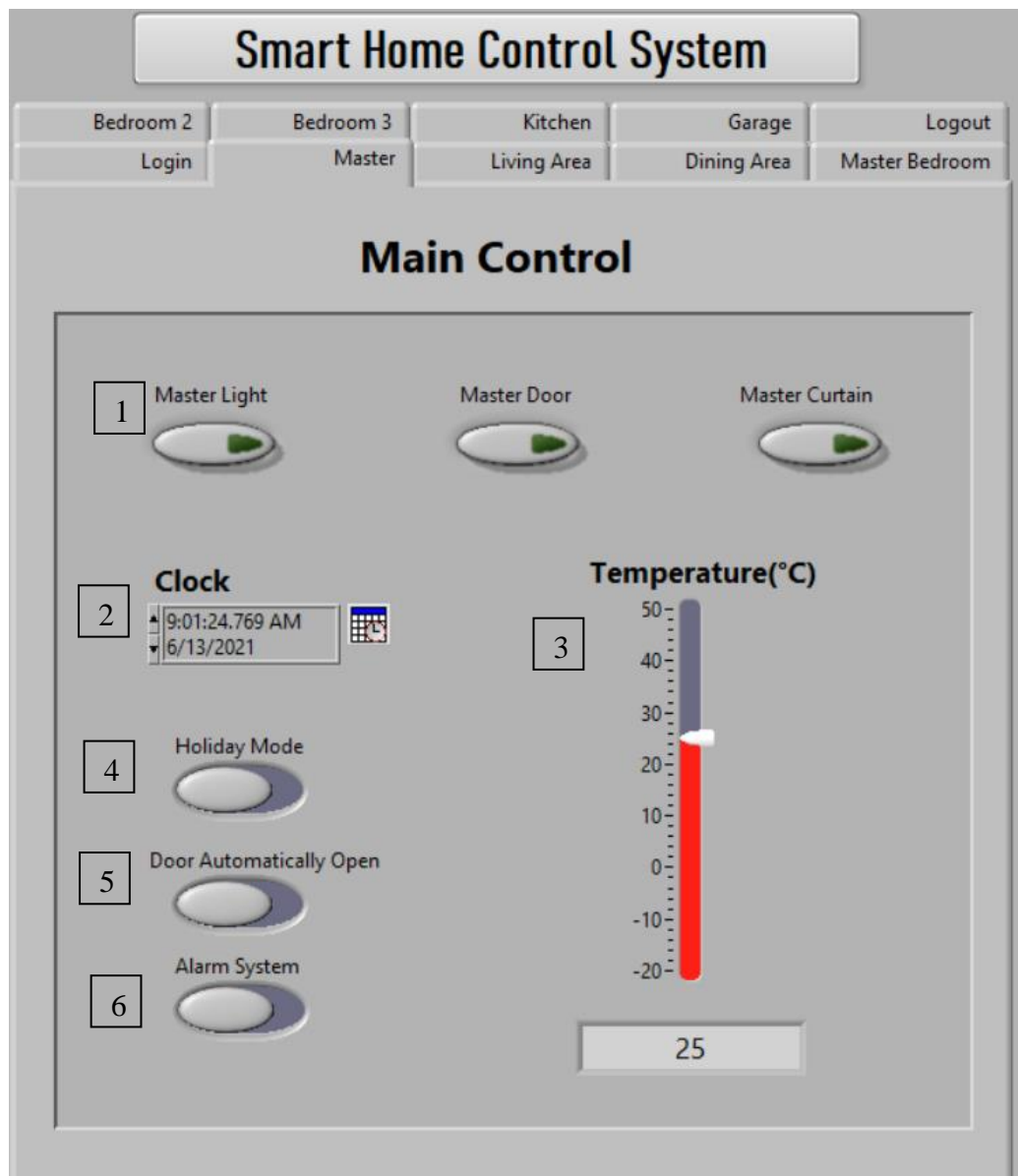


Figure 19 Master Page

Figure 19 shows the central control and the automation settings in this system. 1 is the master control for light, door, and curtain. After turned on one of the buttons, such as Master Light, all the lights on the server-side will be turned on. Besides, the specific light buttons in other pages will be turned off and cannot perform further action until the main button is turned off.

2 shows the current time in the system according to default real-time in users' computers. After 7pm, the curtain will automatically scroll down, and after 7am, the curtain will automatically scroll up itself. Besides, the volume of TV will be set to 50 after 7pm to avoid the noise.

3 is the current room temperature. The accurate temperature will be shown below the thermometer. Users can control the room temperature by themselves. If the temperature goes up to 30 degrees, all the light will turn in red and the air conditioner will be opened automatically. If the temperature goes down to 10 degrees, all the light will turn in green and the air conditioner will be close automatically.

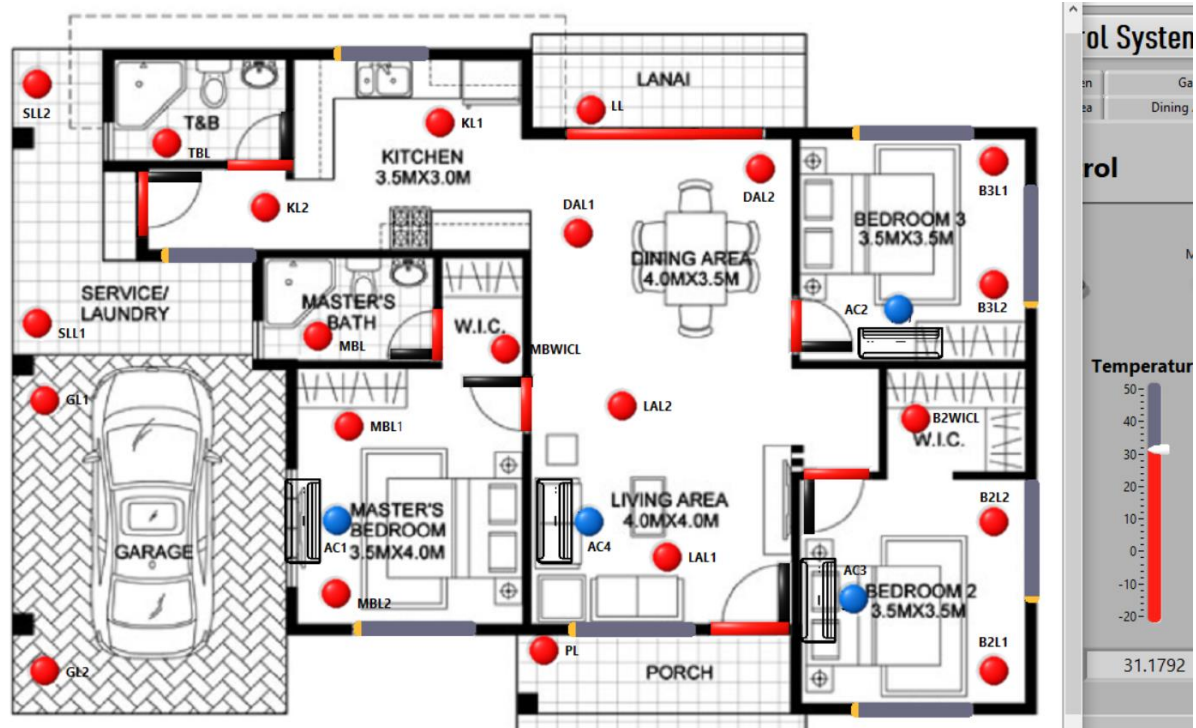


Figure 20 Server-Side when Temperature over 30°C

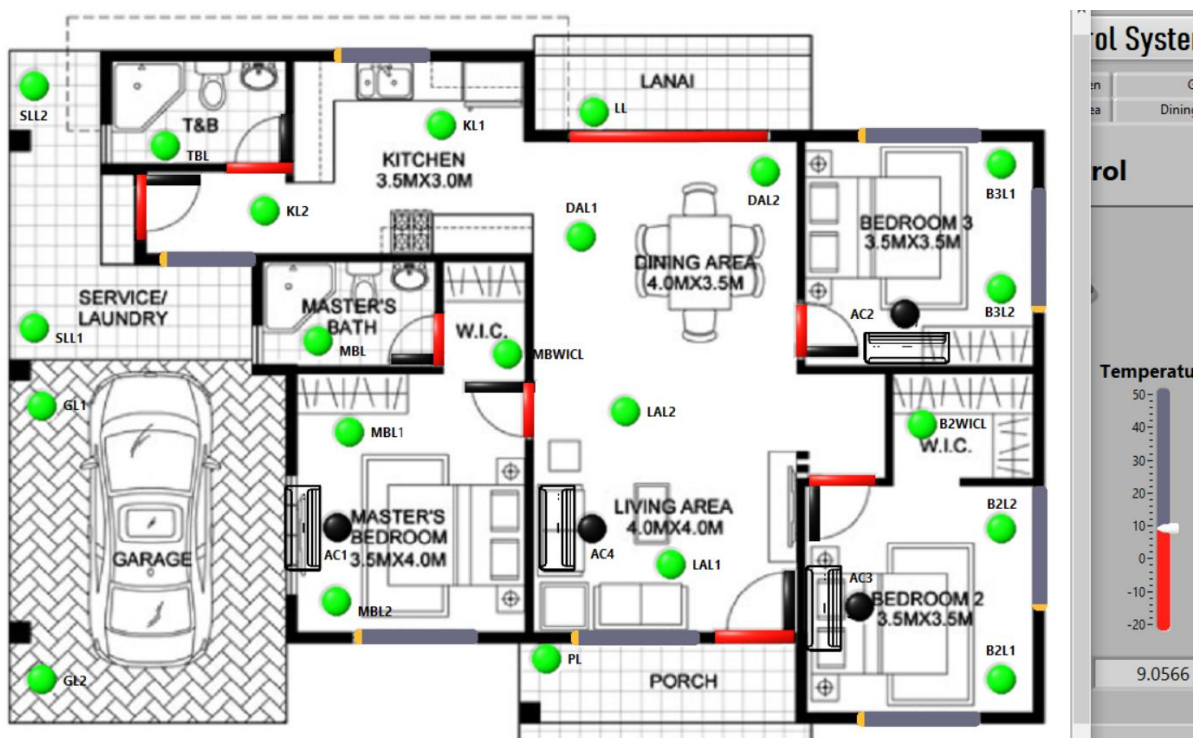


Figure 21 Server-Side when Temperature below 10°C

4,5, and 6 is the automation setting in this system. 4 allows the light to change from one room to another automatically when users are out for a holiday. 5 allows the doors to open themselves when someone gets close to the door. After opened the door, it will also automatically close when the person away from the door. 6 is the alarm system. When the button is turned on, three doors which are the door between porch and living area, dining area and lanai, and kitchen and service/laundry, will be closed and not allowed to open. When someone tries to break-in, the sound “bi” will be made to alert the house owners.

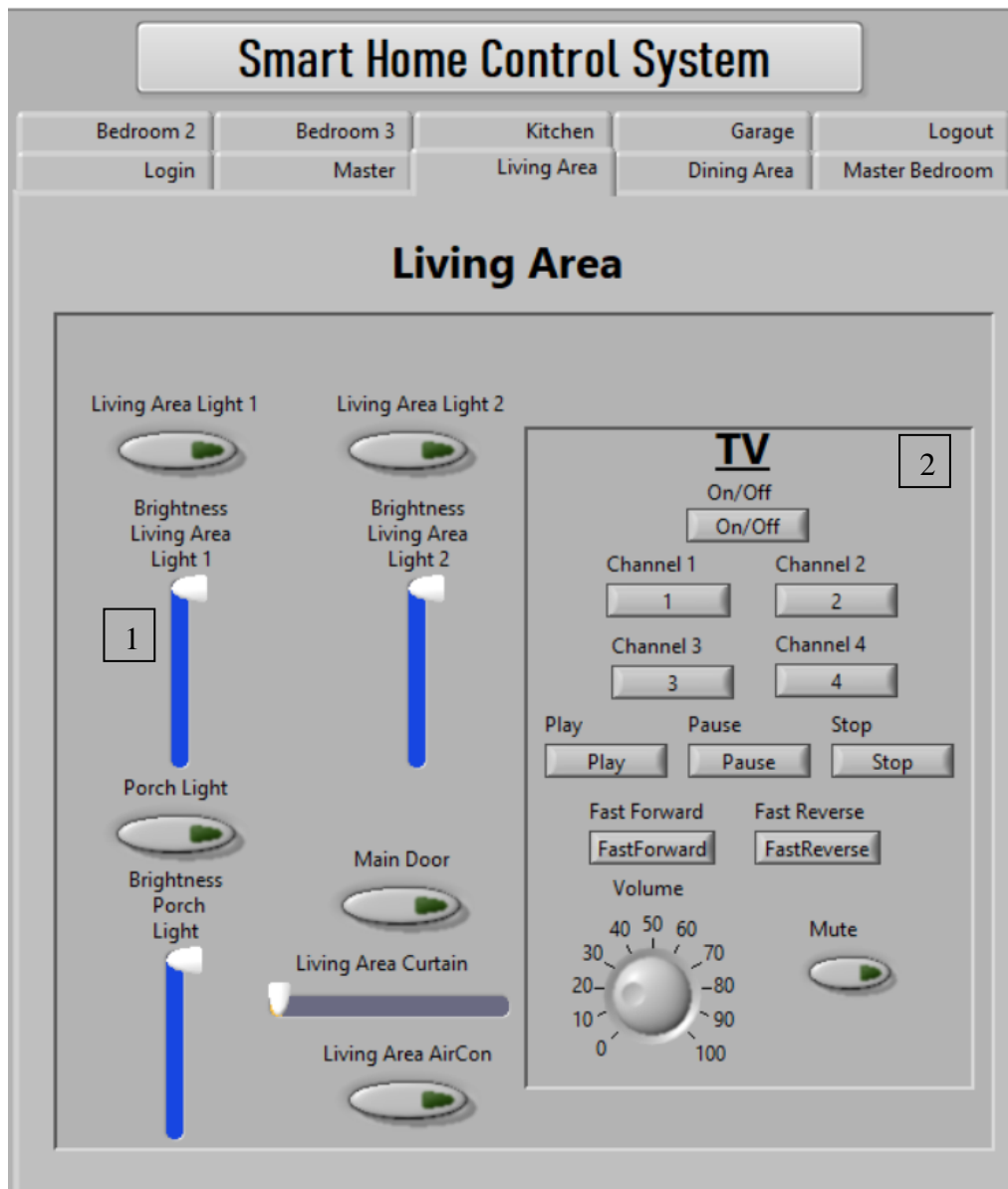


Figure 22 Living Area Page

In the living area, users are able to control the light, door, curtain, and TV in the living room. Besides, users can also control the brightness of the light in the 1. After login to the system, the LED light brightness will start at 255. Users can scroll up/down to change the brightness of the light. 2 shows the controller of the television. By default, the TV will not be shown on the server-side. However, users can turn on/off and perform television features, such as changing the channel, fast-forwarding/reversing the channel, and changing the volume.

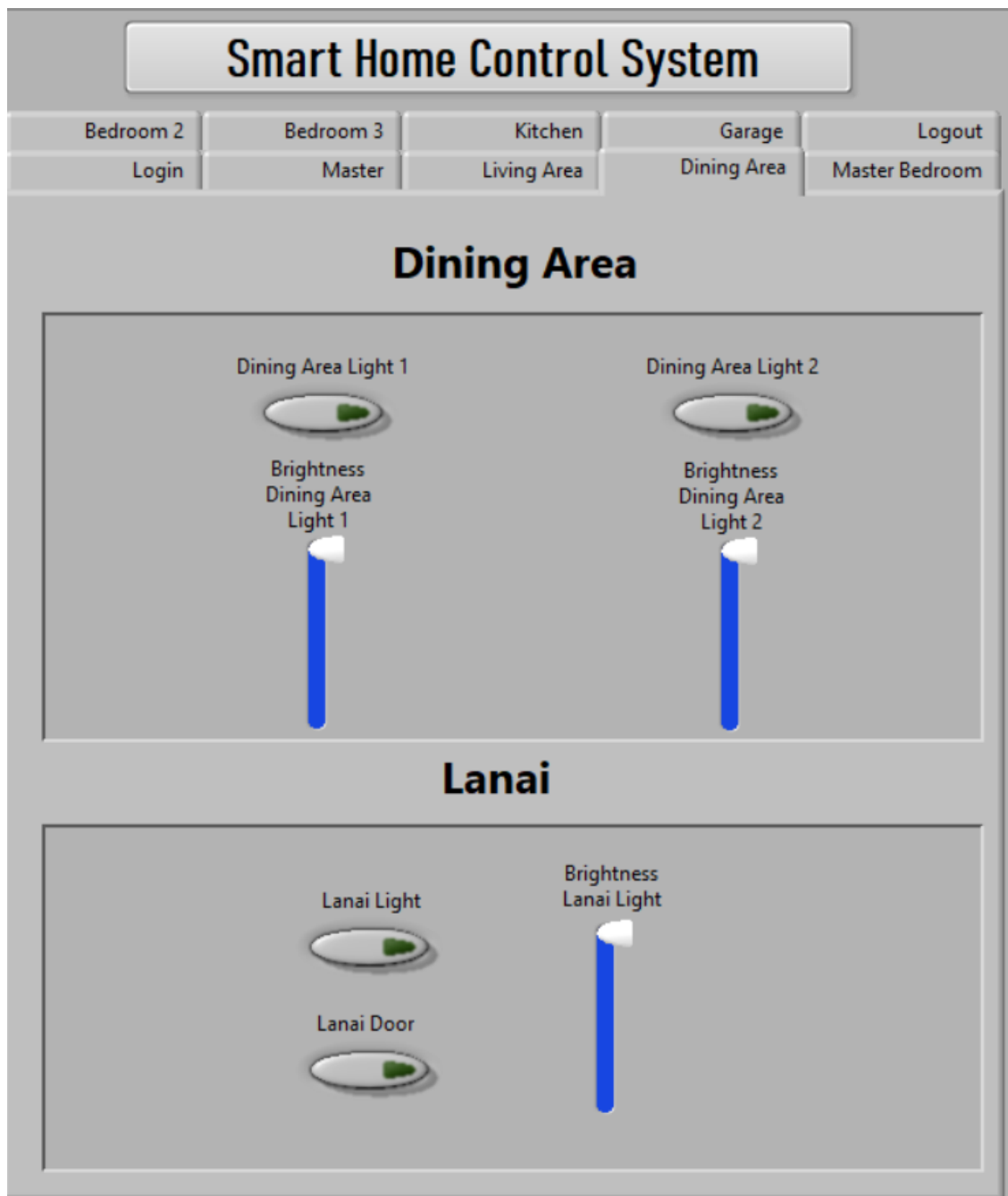


Figure 23 Dining Area Page

In dining area page, it is divided into two parts, one is for the dining area, and the other one is for the lanai area.

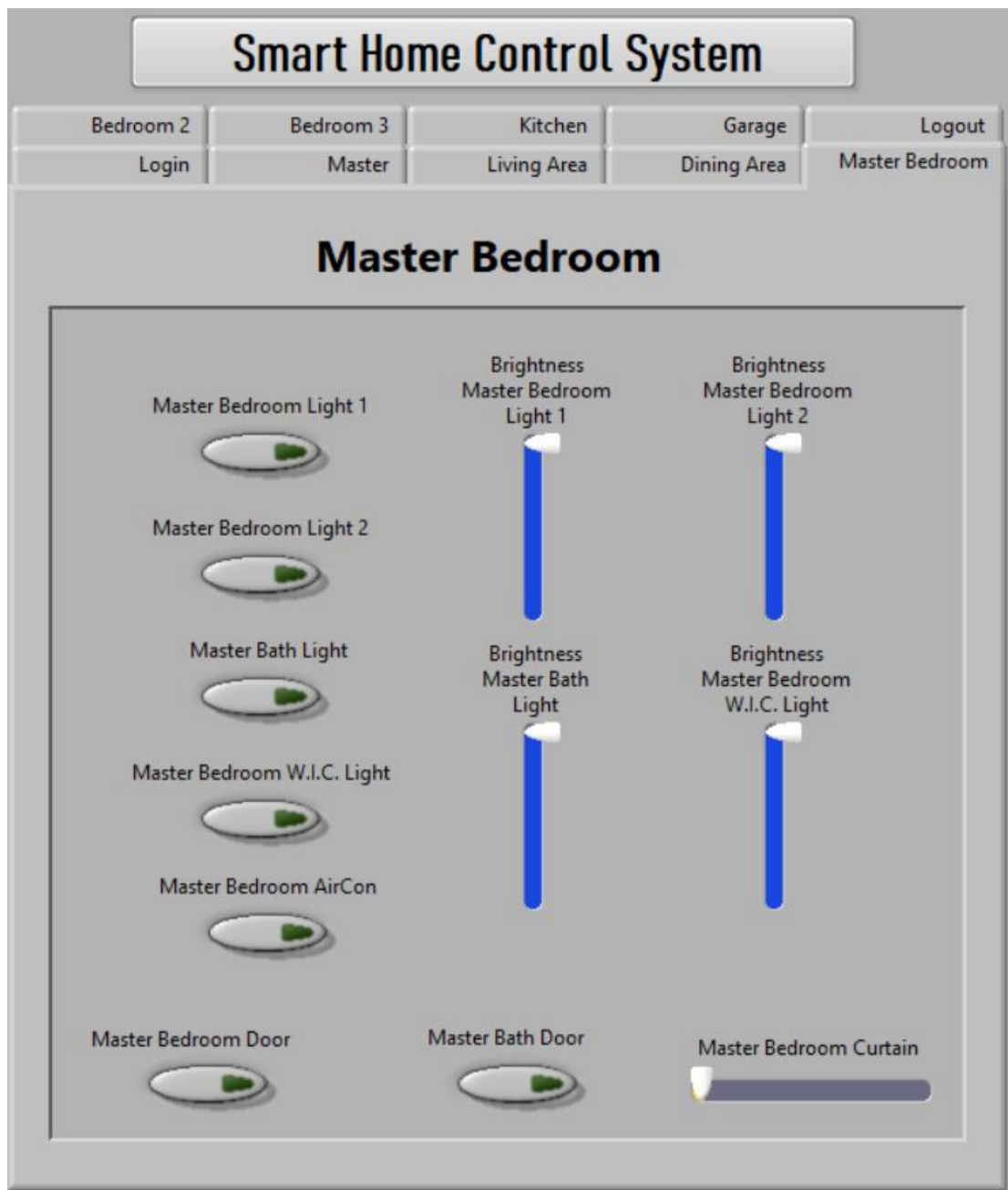


Figure 24 Master Bedroom Page

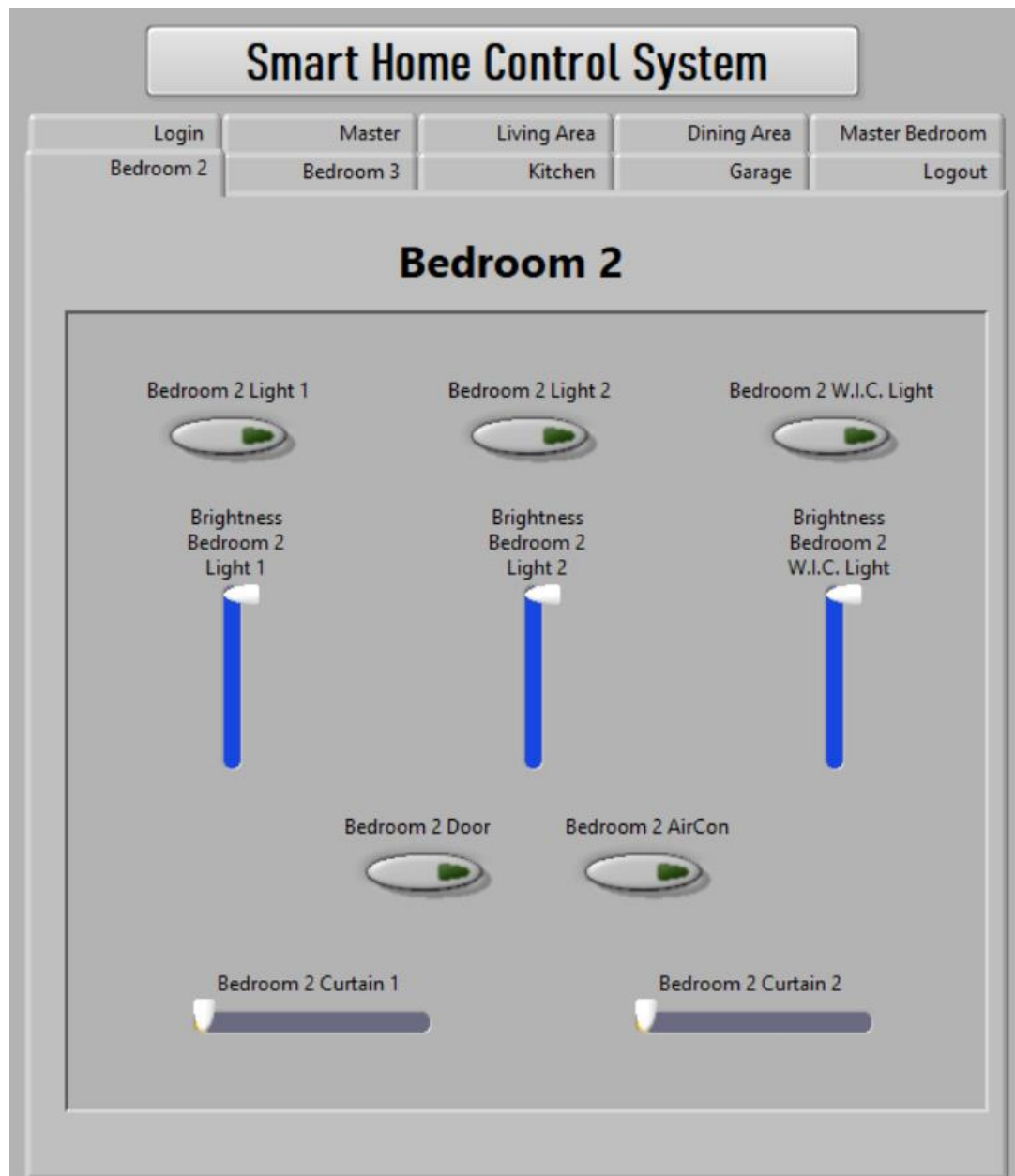


Figure 25 Bedroom 2 Page

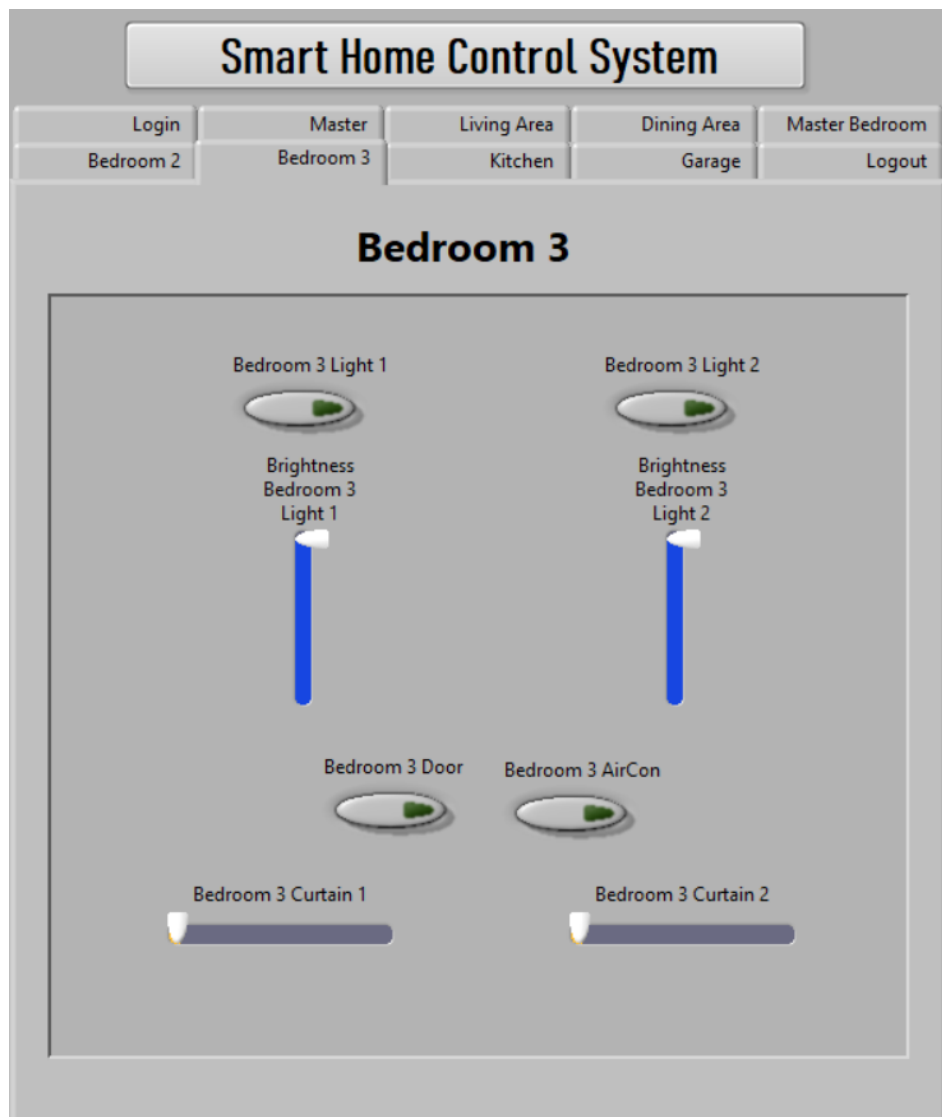


Figure 26 Bedroom 3 Page

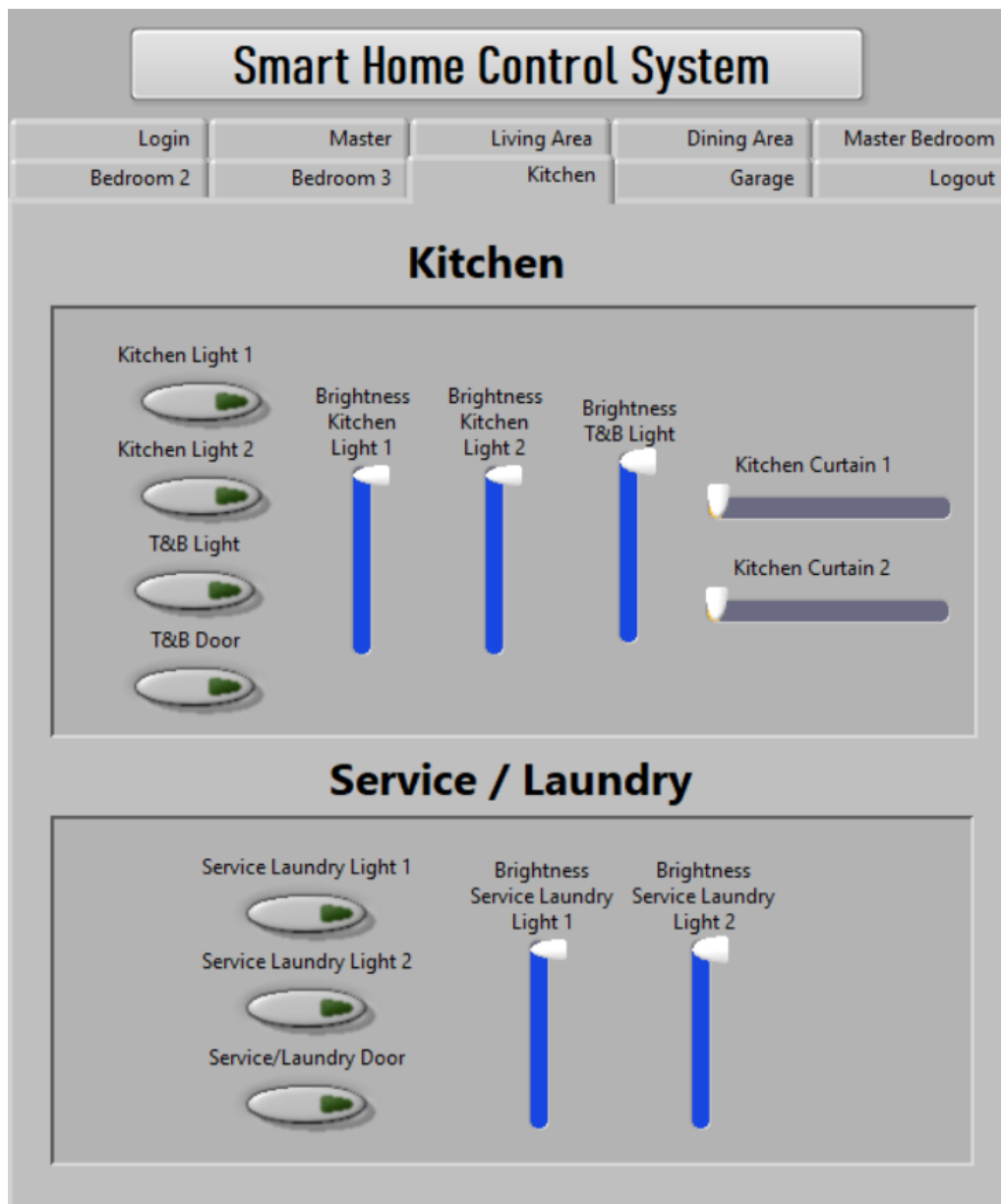


Figure 27 Kitchen Page

In kitchen page, it is divided into two parts, one is for the switch controls in kitchen and the other is for the switch controls in service/laundry area.

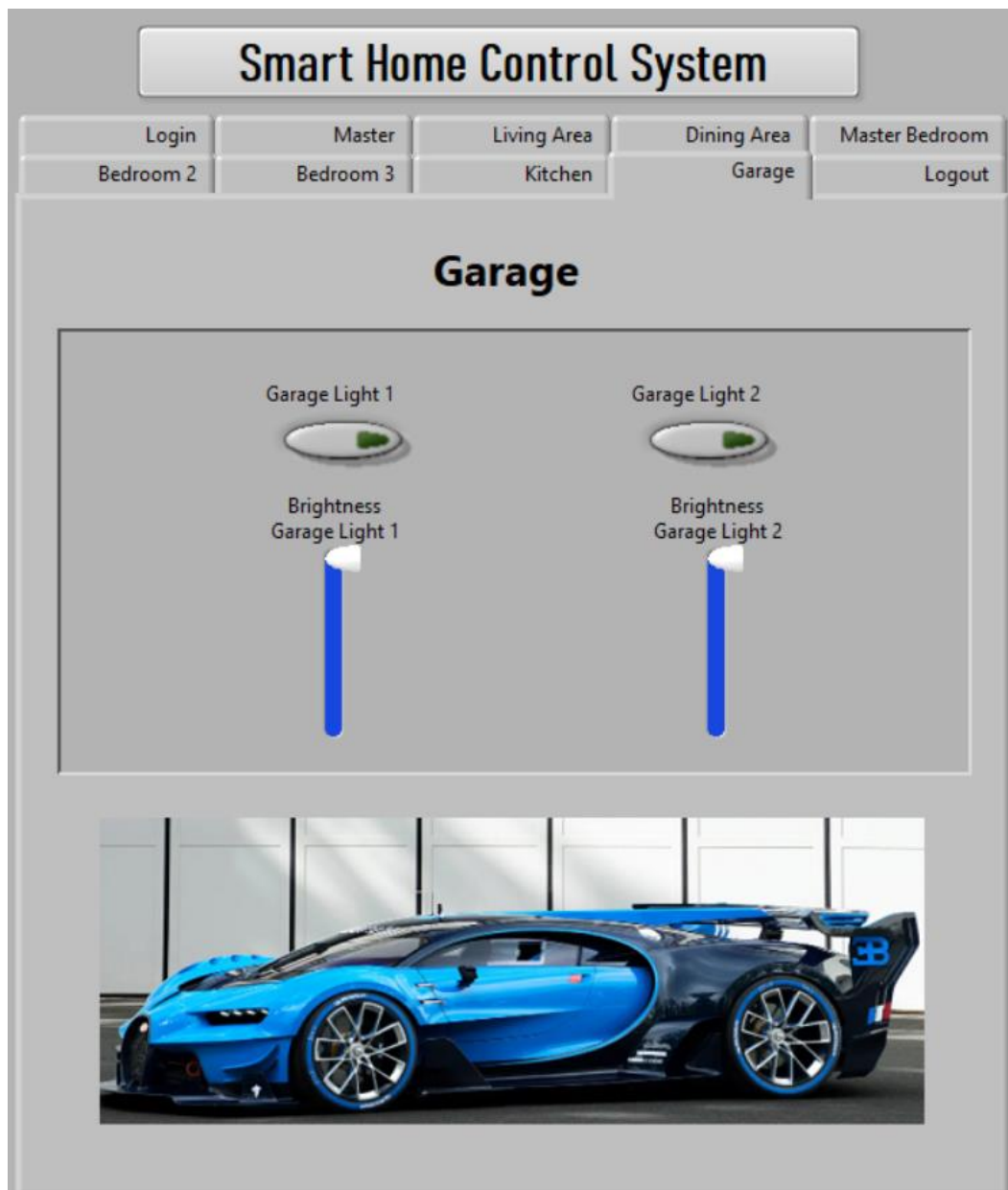


Figure 28 Garage Page

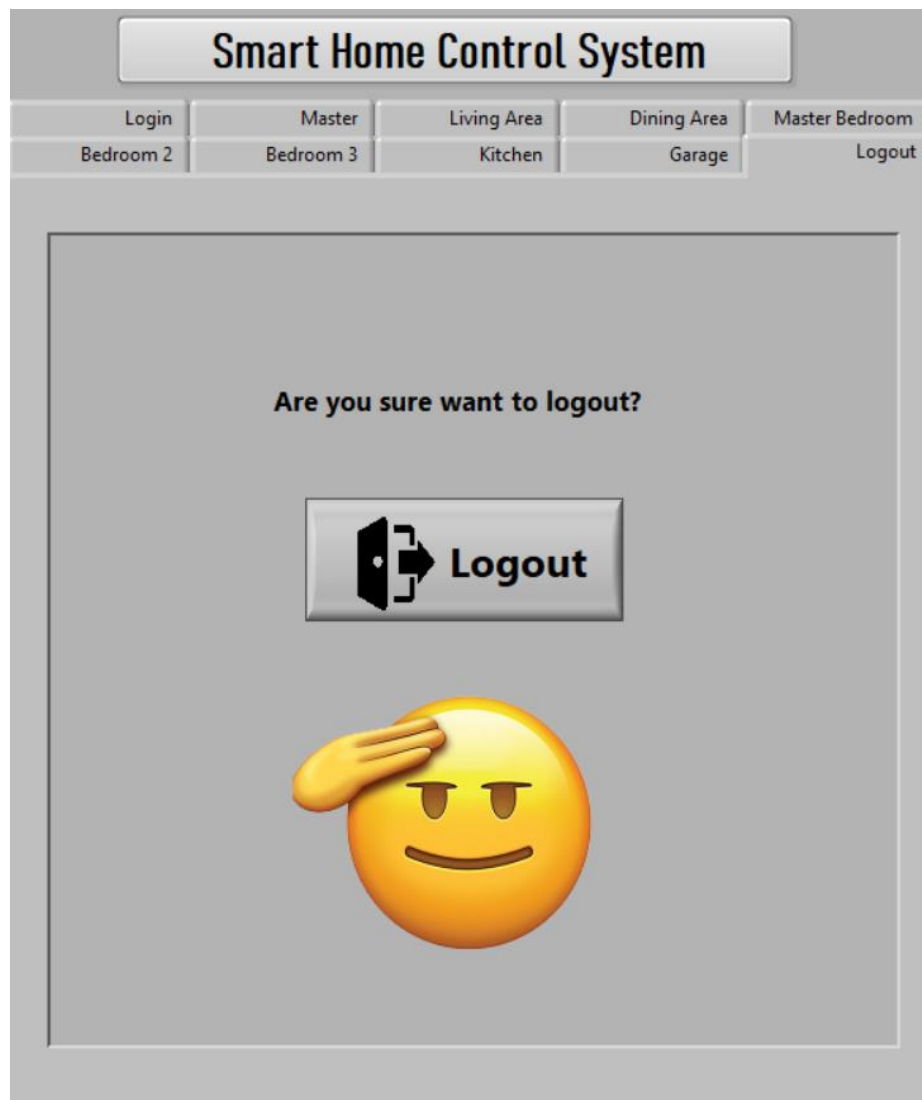


Figure 29 Logout Page

The logout button will close the server vi file and disable all the tabs in the tab control except the login page. After successfully logout from the system, the “Successfully Logout Out!” message will be shown as the following diagram:

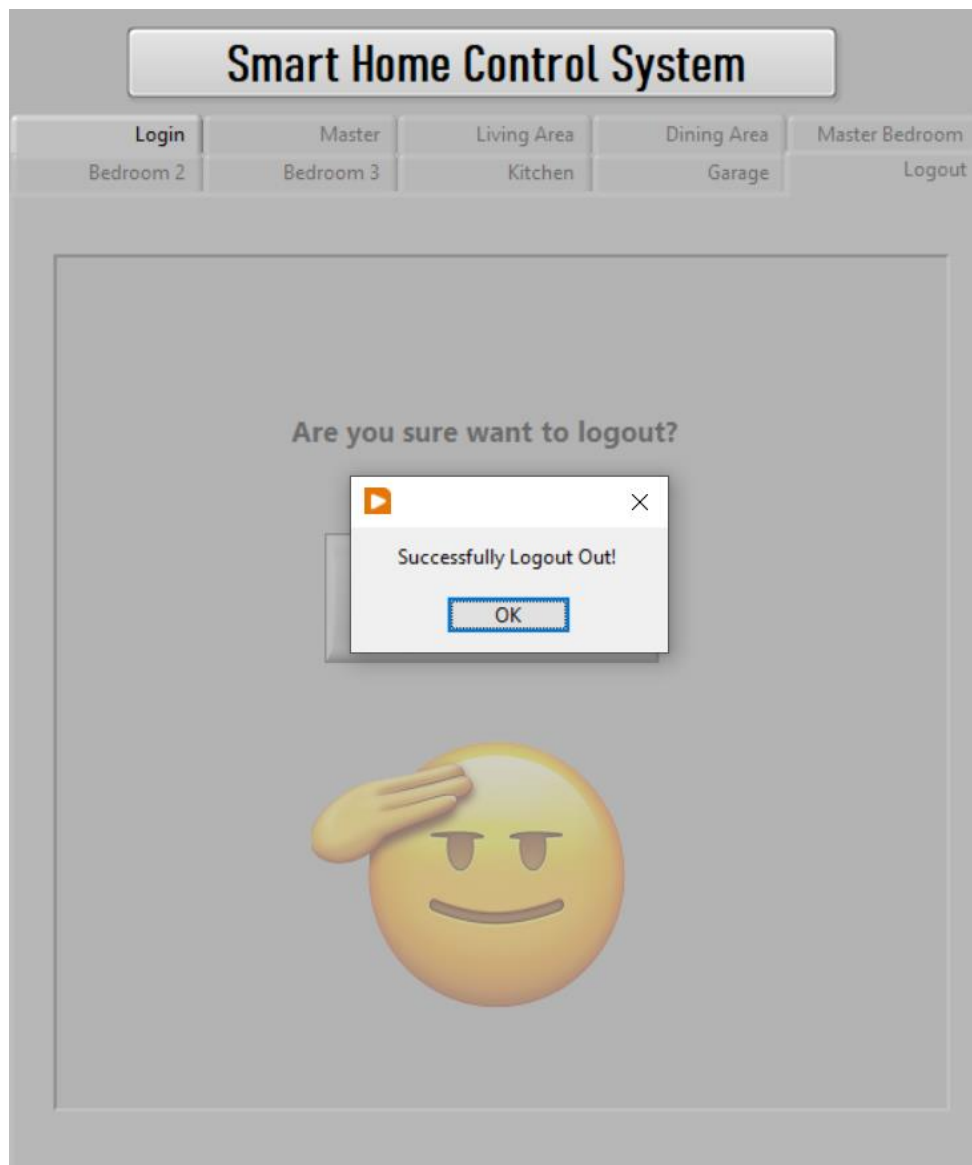


Figure 30 Shown Message after Logout

8.0 Conclusion

In a nutshell, the designed prototype system can be implemented in the real-world instead of the written word in the report. With the appropriate hardware and installation, the system can fully function. By using this Smart Home Control System, there will be a significant improvement in people living standards. It will provide a comfortable and secured residential environment. To reduce the limitation of the system mentioned in Section 5.1, future enhancement must be done to improve the user experience and enhance the system's attractiveness.

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