Emulating Internet of Things for Smart Home Application

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ABSTRACT

This proposal presents the development of an IoT simulation framework aimed at advancing smart home applications. Traditional smart home development often requires physical hardware, which can be costly and time-consuming. To address these challenges, the proposed of this project is focusing on emulating Internet of Things (IoT) devices in a virtual environment, allowing the developers to test and refine a smart home system without the need for physical deployment.

The simulation will encompass key smart home features such as lightning control, air conditioning control, curtain control, humidity regulation, and security management. By enabling real-time interaction between virtual devices, the framework will replicate the behavior of an actual smart home, offering insight into device communication, performance, and potential issues. The simulation will also allow the user to remote monitoring and control, mimicking real-world IoT applications.

The project scope includes the development of the simulation using Node-Red, MQTT application and Twitter, with a focus on creating an intuitive interface and seamless interaction between devices. By offering a flexible and scalable environment, this IoT simulation framework will contribute to the development and optimization of smart home technologies, reducing costs and improving system reliability. The goal of this project is to facilitate innovation in the smart home sector by providing developers with a robust and accessible toolset for IoT experimentation.

Area of Study: Internet of Things and Smart Home Simulation

Keyboards: Node-Red, MQTT, Twitter Integration, Home Automation and Device Emulation.

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LIST OF ABBREVIATIONS

IOT	Internet of Things
IEEE	Institute of Electrical and Electronics Engineers
PKI	Public Key Infrastructure
MCS	Mixed-Criticality Scheduling
MQTT	Message Queuing Telemetry Transport

CHAPTER 1

Introduction

In this chapter, I will present the background and the problem statement of this project and the motivation of the research and my contributions.

1.1 Project Introduction

The IoT refers to the network of physical objects embedded with sensors, software, and connectivity, enabling them to collect and exchange data [1]. IoT technology fosters communication between devices, leading to more efficient and automated systems across various industries. By integrating electronics into everyday objects, IoT is revolutionizing fields such as medicine, agriculture, smart cities, and smart homes. The interconnectedness of these devices provides unique identifiers and allow for data transfer over networks without requiring direct human interaction.

The IoT is a network of interconnected devices embedded in everyday objects and allows them to send and receive data. This connectivity transforms ordinary items into “smart” devices that can communicate and interact over the internet. Besides there are four key components of IoT. There are a Device of Sensor, Connectivity, Data Processing and Interface. Device of Sensor is the physical component that collects data from the environment. Sensors measure physical quantities such as temperature, humidity or motion, converting them into signals for further processing. Next is Connectivity, this component ensures that devices can communicate with each other and with central systems. It encompasses various technologies like WI-FI, Bluetooth, and Cellular Networks that enable data transmission. Continuing with Data Processing. Once data is collected, it needs to be processed to generate meaningful insights. This involves analyzing the data and making decisions based on the results, often performed by cloud servers or edge computing systems. The final one is the Interface. This is the platform through which users interact with the IoT system. It includes dashboards, mobile apps, or other user interfaces that present data and allow control over connected devices.

Also, now, there are over 9 billion physical objects connected to the internet, and this number is expected to increase to 20 billion soon. Not only that, the core components of IoT are included in the low-power embedded systems, which are designed for minimal energy consumption while maintaining high performance, and sensors, which play a crucial role by measuring and detecting various physical quantities and converting them into actionable data.

Smart home technology revolutionizes the way that we interact with our living spaces by connecting various devices, appliances, and systems into a unified network [2]. This interconnected system, often referred to as a "connected home," allows users to independently and remotely control elements such as lights, TVs, audio speakers, security cameras, locking systems, and thermostats, all from a smartphone or a mobile touch screen device. Advancements in technology have enabled smart home automation to offer high-tech functionality and luxury previously unattainable. These innovations enhance convenience, comfort, and efficiency, ultimately contributing to a more pleasant and resource-efficient lifestyle. While smartphones transformed personal communication in the 2000s, smart homes represent the next level of technological advancement for the 2010s and beyond.

Here is the question that is always being asked, do we really need a smart home? Here is the explanation, while the concept of a smart home might initially seem like a luxury or an unnecessary convenience, its benefits extend far beyond mere comfort and ease. Smart home technology is particularly transformative for elderly individuals, those with disabilities, and people with special needs who may struggle with everyday tasks. For these groups, home automation can be the key to maintaining independence and improving quality of life. Home automation systems offer practical solutions that enhance safety and accessibility. For example, automated sensors can monitor whether applications are left on taps are left running, which is crucial for individuals with conditions like dementia. Motion-activated lighting helps prevent falls by illuminating paths during the night, and simple computer controllers allow blind individuals to manage household chores more effectively. Beyond improving safety and convenience, smart home technology also contributes to energy efficiency. By incorporating energy

monitors and sensors, homes can reduce power consumption in unoccupied rooms, helping to lower energy bills.

1.2 Problem Statement and Motivation

1.2.1 Data Security and Latency

Data Security and Latency are big issues in smart home automation [3]. To enhance the security of data, use the IEEE standard protocol. To overcome the latency issues, the use of fog computing is a resolution. As smart home technology becomes increasingly prevalent, ensuring the security of IoT devices is crucial to protect against malicious attacks, misconfigurations, and accidental data exposure [4]. The expanding global regulations are driving the integration of robust security measures within smart home ecosystems. There are also a few key areas to focus on for security smart home IoT devices including identity and root of rust, firmware and software authenticity, data integrity, and communication security. Device identities, managed through certificates from trusted authorities, are crucial for maintaining data security, privacy and secure communication channels. Standards like Matter 1.0 emphasize the necessity of authenticated and encrypted communication to minimize security risks. The role of digital certificates and PKI is pivotal in smart home IoT security. The PKI facilitates secure connections between identified devices, allowing them to communicate safely from any location. With various options for certificate provisioning, deployment, and management PKI technology are well-suited to support the evolving security needs of smart home environments.

1.2.2 Mixed critically

The use of different systems and functions in smart home automation the different criticalities raise [3]. The IoT for smart home applications arises when a system must manage tasks or processes with varying levels of importance and urgency. In smart homes, this problem typically involves ensuring high-critical tasks. For example, tasks like safety and security-related functions guarantee sufficient resources and response time. For the lower-critical tasks like entertainment-related function are managed with lesser or best-effort guarantees. To overcome mixed-criticality, separate the low-criticalities functions and high criticality functions. Not only this method, we also can use Task Scheduling method to solve this problem. The Task Scheduling method has

been separated into two sides. One is implementing priority-based or deadline-based scheduling algorithms to ensure high-critical tasks are always executed on time. Next side is the MCS techniques. These techniques can be used, which dynamically adjust task priorities based on the current system state.

1.2.3 Fault Tolerance

There are hundreds of sensors interfaced with hardware and software in the smart home automation system [3]. Hence, it is difficult to find fault in the system when it occurs. To counter the faults that occurred in the system. We can use redundant controllers. Redundancy in IoT applications refers to the practical of including backup or duplicate components, systems, or processes to ensure the reliability and availability of interconnected systems [5]. The more critical the application is, the more redundancy controllers are in place. Redundancy helps to mitigate risks associated with hardware or software failures, communications breakdowns, and other issues that could arise in IoT environments. When implemented correctly, the redundant controller will mitigate single points of failure, enhance reliability and availability, protect against data loss and corruption and increase network and security resiliency.

1.2.4 Functional safety is not a priority of the system

Functional safety in IoT for smart homes refers to ensuring that systems operate reliably and safely, even in the presence of failures. In a smart home, functional safety is critical, as many connected devices control essential functions like security, energy management, and health monitoring. Any failure in these systems could lead to dangerous situations, making functional safety a priority in IoT system design. The Functional safety like fire systems or emergency systems should be a priority [3]. It should be working consistently. To overcome this challenge, we can build a separate IoT-based emergency system.

Motivation

The aim of this project is to present a brand-new IoT smart home system that will improve homes' comfort, security, and energy efficiency by giving the users dynamic feedback and real-time monitoring. The goal of this project is to build a smart home environment that uses data analysis and ongoing user feedback to adjust to the

requirements and preferences of the people who live there. Through the utilization of IoT devices and smart home technologies, this system will let the users monitor and manage multiple aspects of their house, including lightning, temperature, humidity, security and so on, all from one platform.

Additionally, by encouraging dynamic feedback from the people living there, this approach allows them to offer feedback on how well the smart home systems and gadgets are working. The home environment will be optimized, device performance will be increased, and the user experience will be improved overall with the help of this feedback. This project aims to lower energy consumption, boost home security, and enhance the user's quality of life by developing a more responsive and adaptable smart home system.

1.3 Project Objectives

This project has several objectives that want to be accomplished. The project is:

1. **To Facilitate Energy Efficiency**

To optimize energy consumption in the home, this project integrates automated systems. One such function that saves energy usage is the lighting system, which turns on automatically at night and off during the day. Mobile devices can also be used to remotely operate most home appliances. Everyday energy savings can be achieved by employing a mobile device to quickly and simply turn off an appliance in case the user forgets to do so.

2. **To Enhance Home Security**

By combining security elements including alarm systems, vibration sensors, CCTV cameras, smart locks, and smoke detectors, the project seeks to create a secure living space. These elements can offer instant emergency notifications, safeguarding both the house and its residents. For instance, the smoke detector can alert the user in the case of a fire, enabling them to immediately call emergency services. The project aims to improve the house's overall safety by making use of these security components.

3. **To Enable Real-Time Monitoring of Home Environment**

Using mobile devices like the MQTT panel, the project enables real-time home environment monitoring, including temperature, humidity, lighting, and security. This

enables users to make early choices about their living environment by keeping them always informed about the condition of their home.

4. **To Improve Control and Convenience**

The project uses voice control features to make using home appliances more convenient. Control becomes more effective and easier to use when a voice-controlled system is included since users can simply use simple spoken commands to operate a variety of devices and systems in the home.

1.4 Project Scope and Direction

In this project, the main delivery is a Node-Red based IoT system to monitor and control the house temperature, lightning and humidity of the house. This project also concerns the user self-security, so this IoT project has included some security related components inside the project. For example, this project has included an alarm system, CCTV camera, smart lock, smoke detector and vibrator in the window areas. This scope includes:

Measurement and Monitoring:

- Develop a Node-Red based system to measure and monitor the temperature and humidity of a house.

Lighting Control:

- Create a switch that allows a remote control of the house lighting system.
- Create a voice control system that can be used to control the lighting system.
- Create a motion control system also known as motion sensor that can capture the motion and trigger the lighting system.

Remote Control for Air Conditioner and Humidifier:

- Create an automatic system to turn on and off the air conditioner and humidifier when the temperature and humidity of the house is too high, it will auto turn it on.

- Create a voice control system that can be used to control the Air Conditioner and Humidifier.
- Implement remote control capabilities for the house's humidifier and air conditioner.

Real time Analytics and Monitoring:

- Provide real time analytics for temperature, humidity, lightning and security issues accessible via an IoT application such as IoT MQTT Panel.

Mobile Remote Control:

- Enable mobile control of the humidifier, air conditioner, lightning system, smart lock and alarm system through the IoT MQTT Panel application.

Smart Lock System and Alarm System:

- Create a smart lock system to make sure the house is safety from intruders like thieves.
- Create a smart lock system for the user to lock and unlock their house rather than the traditional padlock methods.
- Create a smart lock system to let the user lock and unlock their house from their mobile devices.

CCTV Cameras:

- Using CCTV cameras is to let the user have a safety living environment.
- Using CCTV cameras is to capture the incident happening when the intruders are trying to enter our house.

Remote Control for Curtain:

- Create an automated system for the curtain to open and close at a certain time.
- Implement remote control capabilities for the house's curtain.
- Able the curtain to open and close with a slight pull.

Smoke Detector:

- Create a smoke detector system to detect smoke when there is a fire.
- To alert the user when there is a fire.

Remote Control for Auto Gate:

- Implement mobile remote-control capabilities for the house auto gate.
- It can be used to replace the traditional remote control.

Alert System with Telegram Integration:

- Develop a system that sends alert messages to the Telegram app when specific environmental thresholds are exceeded, or some security incident has happened. Users will also be able to control the humidifier and air conditioner via Telegram.

1.5 Contributions

The contribution of this project will be remote controlling the house. The house light can be turned on and off from anywhere and anytime with mobile phone using an application call "IoT MQTT Panel" or I can been control by our sound. Not only these, in the house also have motion sensors installed on the car porch and the outside of the car porch, these motion sensors will trigger the light when there is an object passing across the sensors. The motion sensor installed is for the security of the house.

The house owner will also have a better living environment with this project. It is due to the temperature and the humidity of the house rising over a certain number, the air conditioner and the humidifier will automatically switch on. Besides, this project also being designed it can been switch on and off the air conditioner and humidifier by a mobile application called Twitter in case the automatically switch on is being malfunctioned. The system will send a notice to the user when the temperature or humidity is reaching a high number. The user can turn on and off the humidifier and the air conditioner through the Telegram application.

In the house we also have a CCTV camera in the living room area, dining area and lastly it is outside the car porch. This CCTV camera will be working in 24 hours, but they will only capture the special motion happening in and out of the house. There are also smart locks on both entrances, the front door and the back door of the house. Smart locks are using the capture of the people who are trying to enter the house by force. The smart lock not only has this function, the smart lock also will trigger the alarm system when there is a person who is trying to enter the house through the window. It is because

all the window there have installed vibrator to prevent someone who try to enter the house from there. The alarm system will be switched on and off through the smart lock or can been controlled through our mobile phone. In this house there is also a smoke detector installed in the middle of the cooking area. The smoke detector is to let the user know when there is a fire happening in the cooking area.

This smart home system also will help to save energy as when all the people are leaving the house, they might forget to switch off the light, but this kind of situation is not a very serious situation, the light still can be turned off using the IoT MQTT Panel application. This will help the user to save a lot of electricity.

CHAPTER 2

Literature Reviews

Based on my research at Google, I have successfully found some of the IoT structures with the floor plan of the house that can be implemented the project as design a brand-new design of the IoT structure with the house floor plan.

2.1 Review of Technologies

2.1.1 Blynk

The developer and company can effectively create, manage and expand connected devices by using Blynk, a low-code Internet of Things (IoT) platform [14]. It supports a variety of communication protocols, including Ethernet, Wi-Fi and GSM and offers tools for device connectivity using well-known microcontrollers like ESP32 and Arduino. Using a web-based interface, Blynk. Consoles allow users to remotely control hardware, monitor data, manage devices and build templates. Users can create personalized controls panels to communicate with their devices in real time using the Blynk mobile app. The platform has Blynk.Edgent, which makes user authentication, firmware updates, and device providing easier. Blynk's integrated data streams, event notifications, and API/webhook connectors make it easier for businesses and people who enjoy developing and using smart devices.

2.1.2 ThingsBoard

ThingsBoard is an open-source Internet of Things platform, it makes it possible to gather, process, visualize, and manage data from linked devices [15]. It is simple to integrate with a variety of hardware because it supports multiple protocols, including MQTT, CoAP, and HTTP. To automate tasks based on device data, such issuing alerts or starting workflows, the platform provides robust dashboards and rule engine features. ThingsBoard is appropriate for industrial and enterprise-grade IoT solutions since it comes with built-in support device provisioning, remote control, asset management, and data analytics. Both on-premises and cloud deployment options are available, offering scalability for big deployments and flexibility for various project requirements.

2.1.3 OpenHAB

OpenHAB is an open-source home automation platform that unifies and manages a variety of smart home technologies and gadgets via a single interface [16]. Users can automate tasks and manage devices from various brands in one location because of its support for hundreds of systems and protocols, including Z-Wave, Zigbee, MQTT and more. A robust rule engine, voice assistant integration and adaptable online, mobile and voice control user interfaces are just a few of the platform's many customizable features, because OpenHAB is compatible with several operating systems, including Windows, macOS, Linux and Raspberry Pi, it is a flexible option for both novice and expert users of smart homes.

2.1.4 Node-Red

Node-RED is a flow-based development tool for connecting web services, APIs, and hardware [17]. Its visual editor, which is based on Node.js, enables users to construct applications by joining nodes that stand for various services or functionalities. Its drag-and-drop interface and real-time event handling make programming easier, which is why it's particularly well-liked on the Internet of Things, home automation and rapid prototyping. Node-RED is open-source and compatible with a wide range of devices, including Raspberry PI and PCs.

2.2 Programming Language

2.2.1 JavaScript

JavaScript is an interactive, beginner-friendly resource for teaching JavaScript's foundations and a more complex idea is the W3Schools JavaScript tutorial [18]. Variables, data types, functions, loops, events, DOM manipulation, and current JavaScript features like ES6 are among the subjects covered. Users can practice coding instantly with the site's built-in online editor ("Try it Yourself"), quizzes and examples. It's through instructional resources for anyone wishing to use JavaScript to create dynamic, interactive websites.

2.2.2 Python

Web development, data analysis, AI, machine learning, automation and more all make extensive use of Python, a flexible and easy-to-learn programming language [19]. It is well-liked by both novices and experts due to its straightforward syntax and extensive library support. Python is also utilized for activities ranging from app development to big data analysis in sectors like technology, healthcare and finance.

2.2.3 C++

Operating systems, games, and real-time systems are just a few examples of software that can be developed quickly and efficiently using C++, an advanced, high performance programming language [20]. It adds object-oriented characteristics to the C languages, making it appropriate for programming at the system and application levels, because of its ability to manipulate memory and hardware, C++ is frequently utilized in sectors including embedded systems, gaming, and finance.

Summary of the Technologies Review

For this project I have chosen Node-RED as my technology for designing the project and the programming language that I choose in this project for me to program the project will be JavaScript. The reason why I chose to use Node-RED as my technology is because Node-RED is a very flexible and all-purpose platform that is perfect for creating Internet of Things systems that need local control, extensive protocol integration and custom logic. In opposition to ThingsBoard, which is designed for enterprise telemetry, or Blynk, which concentrates on mobile dashboards, Node-RED offers complete control over data flow through a visual editor and supports a variety of protocols, including MQTT, HTTP, and Modbus. It is not restricted to particular use cases like OpenHAB, which is primarily for smart home automation, and is sufficiently lightweight to operate on gadgets like Raspberry Pi, due to this Node-RED is a greater option for my projects. So, the reason for using JavaScript is because Node-RED is built on the base of Node.js, which uses JavaScript for server-side logic. This improves the efficiency and smoothness of JavaScript code in the flow-based environment of Node-RED. JavaScript integrates seamlessly into function nodes, eliminating the need for complicated setup or additional interpreters, in comparison with Python or C++. It enables developers to easily manage devices, generate logic, and alter data all within

the same interface. JavaScript is more appropriate for Node-RED, which makes it quicker and simpler to create real-time IoT workflows, even though Python and C++ are strong for certain software jobs.

2.3 Previous works on Deep Learning

2.3.1 Simple IoT design with the house floor plan

On the figure 2.1, it has shown clearly that which place have which components. For example, the figure includes various rooms such as the kitchen, living room, bedrooms, and garage, along with the storage areas. Surrounding the plan are icons representing different IoT components and system typically used in smart homes [21]. The component is:

- Security Camera: Monitoring for safety and security.
- Smart Garage Door: Automated control for opening and closing
- Smart Lighting: IoT-enabled lighting control.
- Smart Lock: Access control for the home's main entrance.
- Wi-Fi: Wireless network connectivity for all smart devices.
- Smart Thermostat: Temperature control for energy efficiency and comfort.
- Entertainment System: Connected audio system for home entertainment.
- Smart Air Conditioning: Remote control of the home's cooling system.

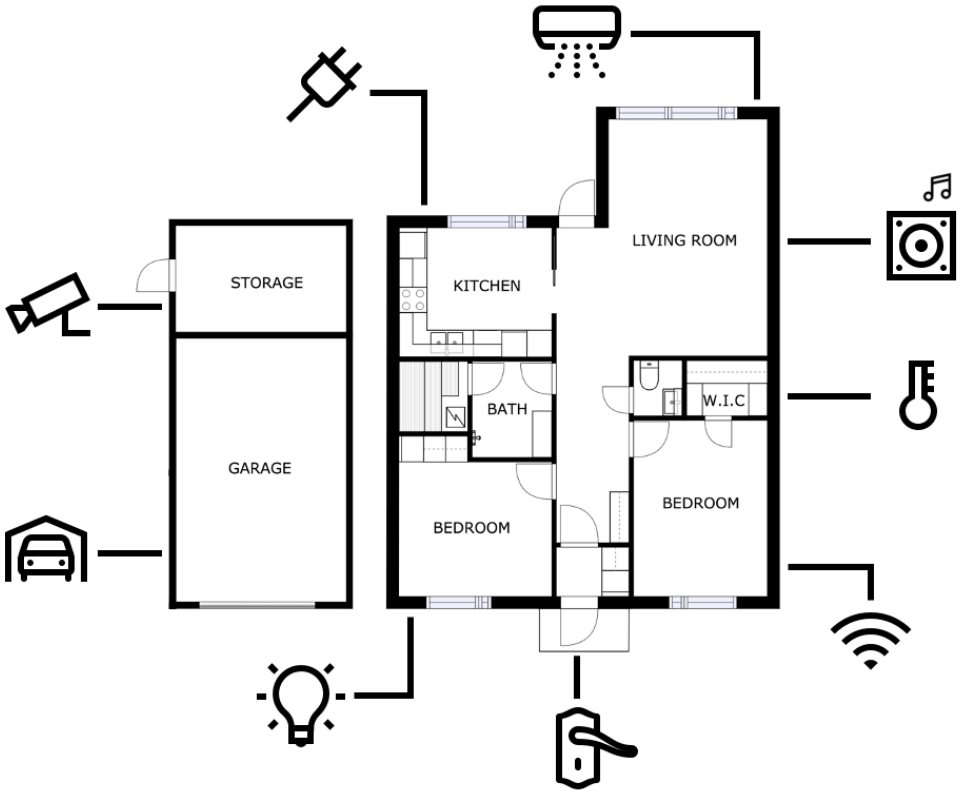


Figure 2.3.1 The simple IoT design with floor plan

Advantages

Based on the figure 2.1 it is the simple IoT design along with the floor plan. This design has its own of advantages too. The advantages of this design are the security of the will be better than does not have this IoT design [21]. It is because inside the IoT design have the smart lock and security camera components. It will enhance the house safety and provide the owner real-time alerts. Besides it is convenient to control the house devices. This is due to the lights; garage doors, air conditioner and the entertainment systems will be able to remote control. So, the owner of the house can control and monitor them from anywhere and anytime. This IoT design will also able the owner uses their energy more efficiency, due to the light and air conditioner able to remote control from the mobile devices. Next, the environment of the house is more comfortable than the house without this IoT system. The reason is this IoT design will

be able to real-time monitoring of temperature, it has allowed for creating an optimal indoor environment, improving comfort and well-being.

Limitations

Based on the figure 2.1 is the floor plan for the western country. It is because the floor plan has included the garage and the external storage area [21]. Mostly Malaysian house will not have an external garage and the external storage area for them to park the car and storing the unused item. So, the design will not be attracted the Malaysian citizen to use it as a reference. Although this IoT design have include security camera and smart lock but the security for the house is still not enough because it does not have a smoke detector, and the window are not secure too. The main limitation is this IoT design also not included the alarm system with it. Maybe this design is based on the western country.

2.3.2 More detail IoT design with the house floor plan

Based on the figure 2.2, this floor plan is more connected to us. It is because this floor plan is like our country houses. The figure has included the IoT components such as:

- Movement Detectors: For motion detection and security
- Smoke Detectors: For fire safety
- Thermostat: To regulate temperature
- Pressure Pads: Likely for monitoring movement or weight (e.g., detecting if someone is on the bed).
- On/Off Switch Sensors: For controlling connected devices
- Medical Devices: Indicating health monitoring capabilities
- Phone: Possibly for communication or control of the smart home system.

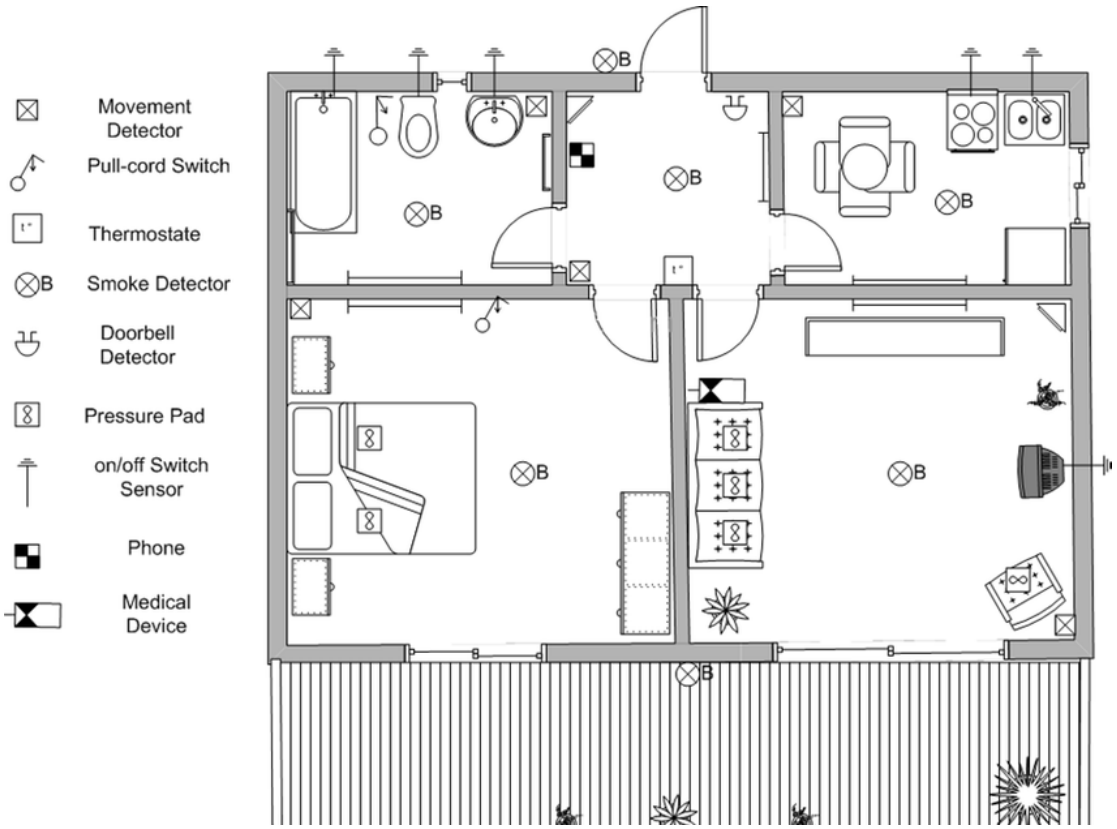


Figure 2.3.2 Detail IoT design with house floor plan

Advantages

The figure 2.2 is the more detail IoT design along with the house floor plan. This kind of design also has its own advantages. The advantages of this IoT design are the safety of the house and the owner are enhanced [22]. This is because the safety is improved by the incorporation of pull -cord switches, medical equipment, doorbell detectors, and the smoke detectors. It is safety especially for the elderly or vulnerable owners. These gadgets can notify the owners, emergency services, and carers about any risks or health problems. Besides the devices like movement detectors, pressure pads, and on/off switch sensors can automatically variously house appliances functions. So, it has made the control of the house is become more automation and convenience. The energy by this IoT design also efficiency. Due to the reason of the thermostats and the motion sensors contribute to energy conservation by minimizing energy usage by reducing the lighting, heating, and cooling systems according to occupancy and time. This IoT design have including a mobile phone. So, it has allowed the owners to monitor and

control their home remotely. The presences of medical devices can enhance the health monitoring of the owners. It can provide a real-time data and alerts for professionals or the other family members if the owner of the house is a senior citizen. The motion sensor and the doorbell sensors will help to keep the home secure by detecting unauthorized access or entry and sending an alerts message to the homeowners.

Limitation

Although the IoT is more likely to our country houses, but this design is not letting the house smarter enough [22]. It is because this house doesn't include the basic component that every smart home has that is smart lighting. Smart lighting is the basic component that needs to be included in the smart home nowadays. This design also does not include the appliances that need by the people nowadays, that is air conditioner. This design also included the pressure pad on the bed, the pressure pad on the bed for the smart home is not that good. Even though this design has included the smoke detector and the thermostat, but the security level of this house is still not enough because it does not include the alarm system, security camera and the window of the house are also not secure.

2.4 Proposed Solutions

This project aims to propose an IoT system for smart home applications. Based on figure 2.3 it has solved all the limitations that are faced in the previous work.

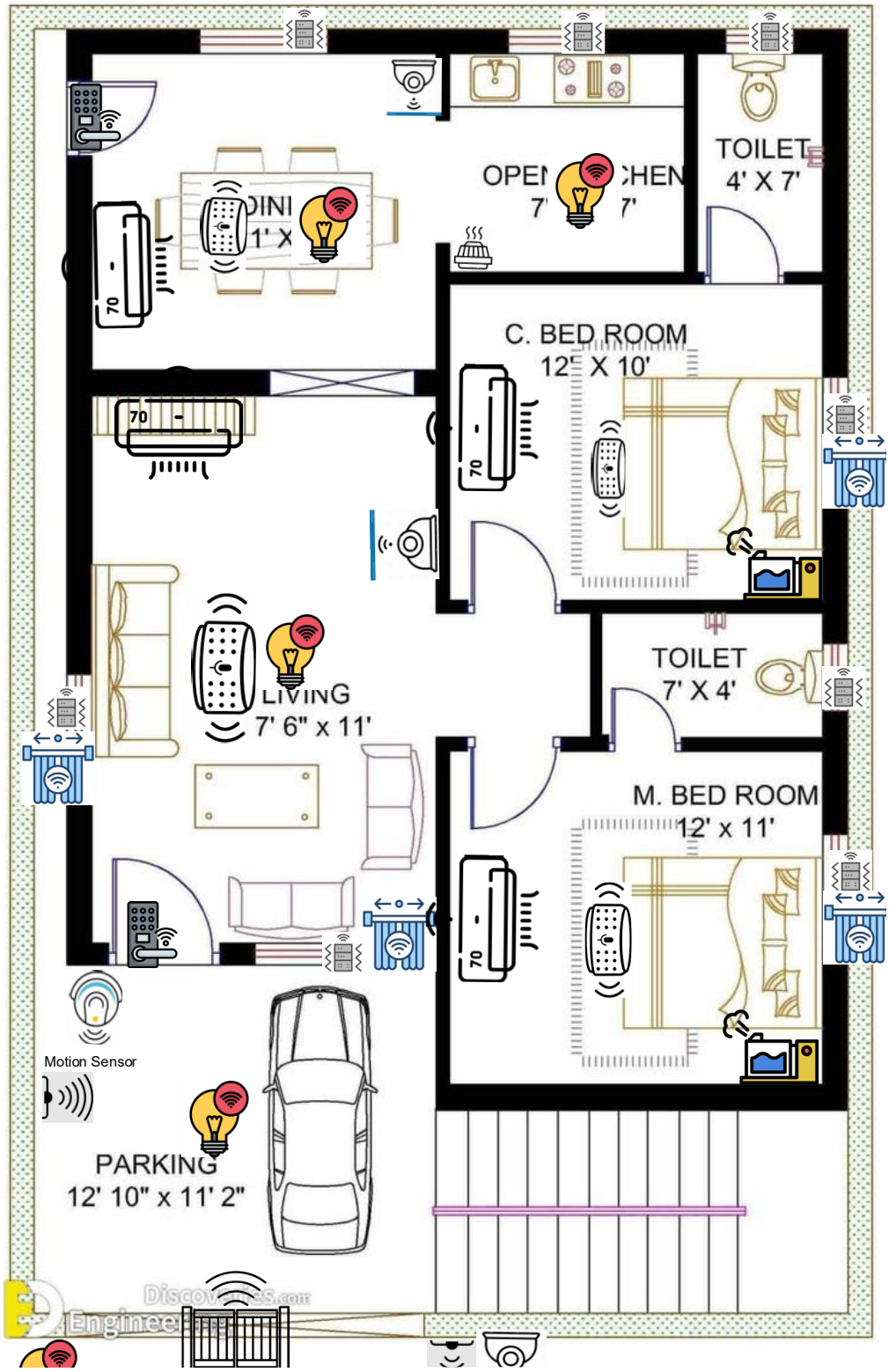


Figure 2.4 The proposed solution

In this design it has a lot of IoT components inside it. The components included are:

- Security Camera: Monitoring for safety and security
- Smart Auto Gate: Mobile remote control for opening and closing
- Smart Lighting: IoT-enabled lighting control
- Smart Lock: Access control for the home's main entrance and back house entrance and connected with the alarm system.
- Smart Air Conditioning: Remote control of the home's cooling system.
- Movement Detectors: For motion detection to control the lighting system.
- Smoke Detector: For fire safety
- Smart Humidifier: Remote control of the home's humidity system.
- Alarm System: For home security.
- Vibrator connected with Alarm System: For window security.
- Smart Curtain: Remote control for opening and closing the curtain.

Based on figure 2.4 this design is solving all the limitations that are faced with previous work. The house floor plan that used to design the IoT system for the smart home is a Malaysia's house floor plan so this floor plan might be easier to understand by the user in this country. Next, this design has solved the limitation that faced by figure 2.3.2 lack of smart home components. This design includes a lot of smart home components that have been listed above. So, the house compared with the previous work has become smarter. Not only that, this design also has solved the limitation of figure 2.3.1 lack of security components. In this design have include a lot of security component like smoke detectors, alarm systems, vibrator on windows side, smart lock systems, humidifier and air conditioner. By these components, the house living environment has become safer than the previous work.

Summary of Existing System

Existing System	Advantages	Disadvantages
Simple IoT Design with Floor Plan	Enhances home security through smart locks and cameras.	Less suitable for Malaysian homes, which typically lack garages and external storage.
	Offers remote control of devices like lighting, AC, and garage door, improving convenience	Missing critical safety features like smoke detectors and alarm systems.
	Promote energy efficiency by allowing smart control of lighting and air conditioning.	Windows and other physical entry points remain insecure.
	Improves comfort through real-time environmental monitoring and automation	Design seems tailored more for Western lifestyles.
Detailed IoT Design with Floor Plan	Offers enhanced safety, especially for elderly users, through medical devices, smoke detectors, and emergency alert systems.	Lacks basic smart features such as smart lighting and air conditioning.
	Provides automated control of household functions via motion and pressure sensors.	Still misses important security elements like cameras, alarm systems, and secure windows.
	Promotes energy conservation with thermostats and occupancy-based automation.	The inclusion of pressure pads on beds may be invasive or impractical for regular users.
	Supports remote monitoring and alerts, increasing both health and security awareness.	

For these two existing systems, I have a few critical comments on them. Each of the IoT systems has some helpful characteristics, they also have some serious disadvantages. For Figure 2.3.1 is less useful because it shows in a western-style floor plan with features, but in this project, we are basically for the Malaysian. It also highlights a gap in complex home security by lacking crucial safety elements like smoke detectors, alarm systems and protected windows. Based on my opinion, I think this element is important due to Malaysian criminal cases to the house is basically like

broke in, so the alarm system and the protected windows is important to protect the house not to been easily broke in. For Figure 2.3.2 has more IoT components that relevant to health and safety and is more matching with Malaysian home plans. But it doesn't include the basic smart home features that are considered standard, such as air conditioning and smart lighting. So, in my opinion these two things are the most common things that need to be included in the smart home project. If the project is without these basic smart home features, I think that the house is not smart enough.

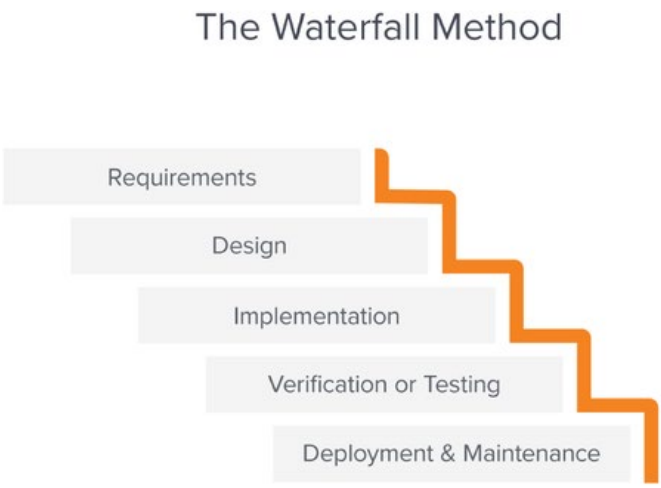
2.3 Concluding Remark

To conclude, this chapter has reviewed several existing programming languages, IoT platforms and smart home designs. It is clear from comparing a few technologies and the previous research about the current systems have certain beneficial aspects, they frequently lack essential elements or are not appropriate for the Malaysian environment. A more complex and localized IoT design has been developed based on the insights gathered from this research. The design I propose has solved the disadvantages of previous systems and provides a solid basis for the suggested smart home solution.

CHAPTER 3

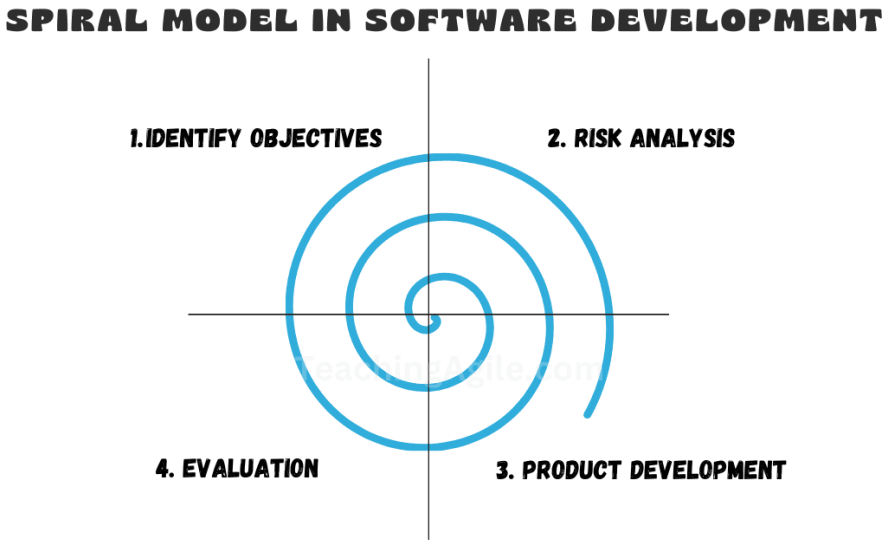
3.1 System Development Model

3.1.1 Waterfall Model



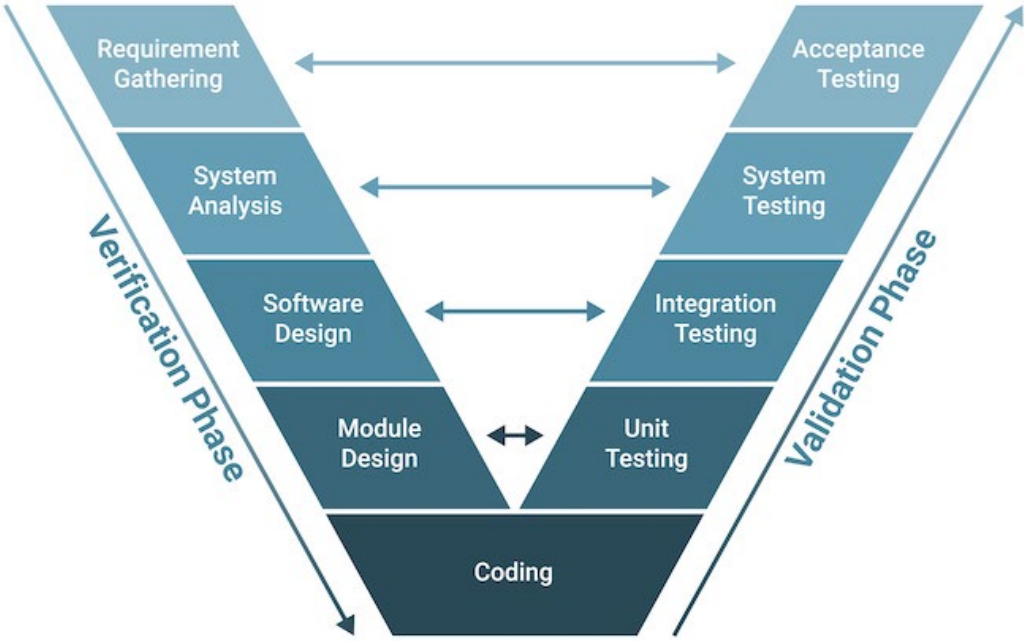
Every step of the Waterfall Model, which is a sequential and linear approach to project management, must be finished before going on to the next, including planning, design, development, and testing [10]. It is appropriate for projects with set objectives since it places a strong emphasis on comprehensive documentation and precise criteria from the outset. But because of its inflexibility, it is hard to adjust once the process has started.

3.1.2 Spiral Model



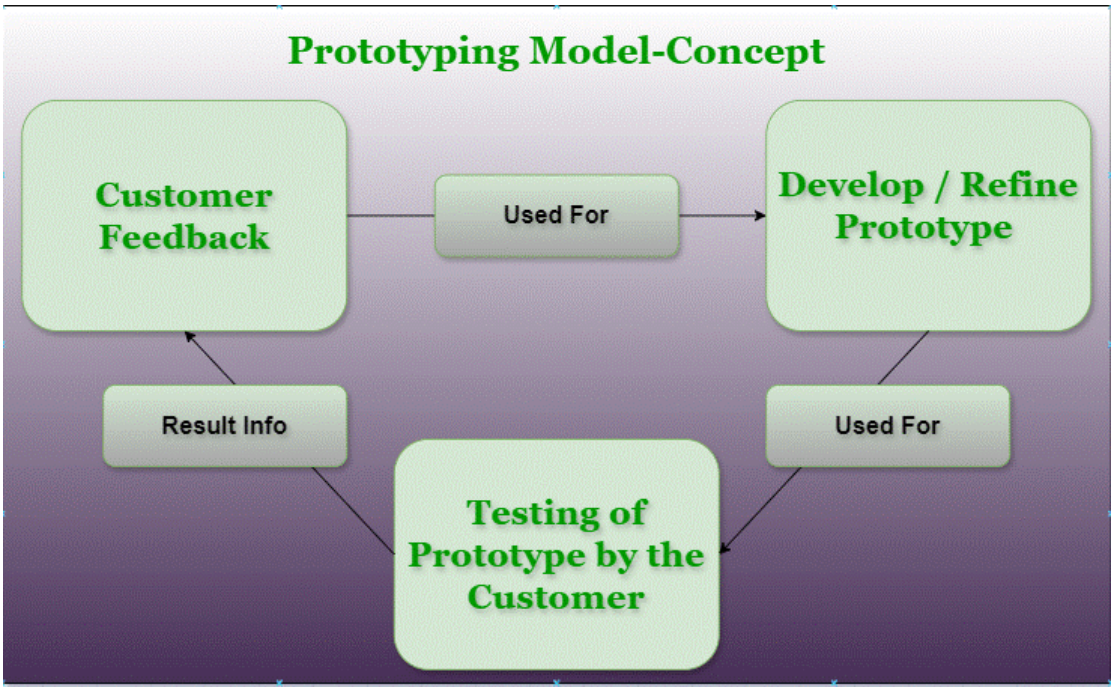
The spiral model is a software development process that incorporates aspects of both design and prototype in phases, the Spiral Model is risk-driven. It consists of recurring cycles, in which planning, risk analysis, engineering, and evaluation are all included. This model works effectively for complicated, large-scale projects that need to have flexibility and continuous improvement during development, and it enables the early identification and resolution of problems [11].

3.1.3 V-Model



The V-Model (Verification and Validation model) is an extension of the Waterfall model which plans development and testing tasks concurrently. A V-Shape is formed by the testing phase that corresponds to each step of development [12]. Higher quality and fewer errors are ensured by this model's emphasis on early testing and validation at every stage. It works well on projects with well-defined specifications and few anticipated modifications.

3.1.4 Prototyping



A working prototype is constructed early in the software development process as part of the Prototyping Model to comprehend user needs [13]. Prior to final development, this model assists in obtaining input and iteratively improving the system. It helps improve user interaction and minimize misconceptions in situations where requirements are confusing or available to change.

3.1.5 Proposed Method/Approach

The IoT Smart Home System in Node-Red based will be developed by using the Agile Software Development Method. Agile Software Development is a collection of techniques centered on iterative development, in which self-organizing, cross-functional teams collaborate to evolve teams collaborate to evolve requirements and solutions [6]. Agile places a great emphasis on responsibility, and customer alignment while emphasizing flexibility, regular inspection, and adaptability. Agile approaches encourage the quick delivery of high-quality software that satisfies client expectations. The reason for choosing Agile Software Development due to its flexibility, faster time-to-market and collaborative nature. It helps manage the complexities of IoT

development by breaking the project down into smaller, manageable tasks while ensuring continuous improvement and adaptation to changing requirements.

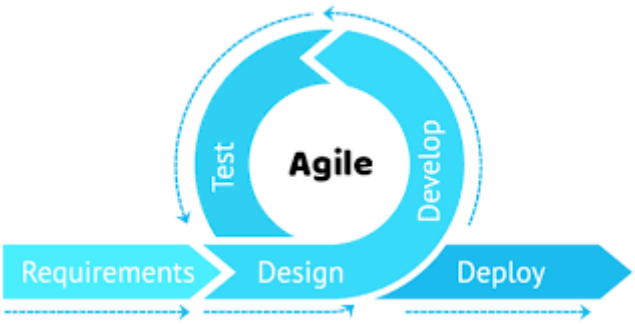


Figure 3 Agile Software Development Life Cycle

Agile Software Development

Based on the figure 3, the first phase of the Agile Software Development is requirements. In this phase, it is required to determine what is the user need for the system. It can be done by gathering and prioritizing user stories and defining acceptance criteria to ensure that we understand what needs to be built and what constitutes success. Next the requirements will be brought to the design phase. The design phase is focusing on creating the system's architecture, detailed component design, and security measures to ensure all technical aspects are well-structured before development begins. The development phase is more on writing, integrating code to implement the features and functionality as per the design specifications. Continue is the test phase, this phase is to validate the system to ensure that all components are function correctly and meet the user requirements. The final phase will be the deployment phase, after validating the system and make sure that the system is error free and can been launched in the market.

1. Requirement

   During the requirement phase, the objectives of this project have been identified which is to create a IoT for smart home that will Facilitate Energy Efficiency, Enhance Home Security, Enable Real-Time Monitoring of Home Environment, and Improve Control and Convenience.

2. Design

   During the design phase, the IoT system architecture will be designed. All the components that will be used in this project will also be listed out. Before continuing

to the development phase, the software application that will be used for this project will also be ensured to be well-structured.

3. Development

During the development phase, all the components that listed out will be used to develop the IoT software system. During the development phase, it continues with the objective of this project. This phase is the longest phase of all, but the Agile methodology helps design the software quickly and efficiently.

4. Testing

During the testing phase, the protocols of the IoT software have been successfully developed. Before launching the IoT software, need to make sure that the system does not have any error, and the system is meet the requirements means it meets the objectives of this project. After testing the system, and the system is error free and meet the objectives, it can continue to the last phase.

5. Deployment

During the deploy phase, the IoT software system are prepared to be launched in the market and let the user to install it in the house. After installation process is completed, the user can use the system to meet the objectives that have been set initially in the project.

3.2 System Requirement

3.2.1 Hardware

The hardware that involved in this project is laptop.

Description	Specifications
Model	Asus TUF Gaming A15
Processor	AMD RYZEN 7000 Series
Operating System	Windows 10
Graphic	NVIDIA GeForce RTX 4050
Memory	16GB DDR4 RAM
Storage	512GB + 1TB

Table 3.1 Specifications of laptops

3.2.2 Software

1. Node Red

In this project, Node Red will be used to development the IoT software system. Node-Red is a programming tool for wiring together hardware devices, APIs and online services in new and interesting ways [7]. It provides a browser-based editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime in a single click.

2. IoT MQTT Panel

In this project we will use IoT MQTT Panel. This application allows you to manage and visualize IoT projects, based on MQTT protocol. With this application, it can make DIY Smart Home project in a minute. The configuration is very simple. Well documented FAQ and User Guide are available on the application info page. MQTT is the most used messaging protocol for the IoT [8]. The protocol is a set of rules that defines how IoT devices can publish and subscribe to data over the Internet. The sender (publisher) and the receiver (Subscriber) communicate via Topics and are decoupled from each other. The connection between them is handled by the MQTT broker filters all incoming messages and distributes them correctly to the Subscribers.

3. Telegram

In this project we will use Telegram. Telegram is a secure messaging and audio calling cloud-based app that allows you to send messages, photos, videos and files of any type to your contacts for free [9]. Telegram also uses ‘bots’ (small applications which run inside the app) and provides support for developers wanting to create their own. Telegram bots may have a variety of functions including as a payment platform. So, this project will use the bot’s application in the Telegram as a channel to receive the alert message from the system and able to let the user immediately control the system through Telegram.

4. Google Home

In this we will use Google Home. Google Home is a smart control application powered by Gemini or Google Assistant. It allows you to control the smart home devices, on/off air conditioning, control light and so on through voice commands or the button generate by the google home app. It integrates with a lot of services and third-party apps, so it enables to let the user to control different smart home devices. Google Home act as a hub for manage your smart home devices hands-free.

3.3 Functional Requirements

The project that I have done via node-red and a Telegram bot to allow real-time remote control of the home devices. The system is modular and scalable, designed to control auto gates, door, lighting, air conditioning, humidifier and curtain automation, as well as providing instant feedback to the user via Telegram messages.

1. **Auto Gate Control**
    - Open Gate: User can send a command to open the gate remotely through Telegram.
    - Close Gate: User can also control the gate to close via same command use in the open gate.
    - Gate Light ON/OFF: The gate light can be turned on when the gate is open, and it will close when the gate is closed.
    - Telegram Reply: The telegram application will provide confirmation feedback to the user via a telegram message after each gate action is performed.

2. **Door Control**
    - Open Door: Allow remote door access through Telegram interaction.
    - Close Door: Allow remote door access through Telegram interaction.
    - Door Light ON/OFF: The light will been auto turn on when the door is open and will turn off when the door is closed.
    - Telegram Reply: Confirmation messages are sent to the user via Telegram after each door action.

3. **Lighting System**
    - Turn ON Light: User can activate the lighting system remotely via telegram.
    - Turn OFF Light: User can deactivate the lighting system remotely via telegram.
    - Telegram Reply: Each lighting system action triggers a reply message through a telegram messages.

4. **Air Conditioning Control**
    - Turn ON Air Conditional: The air conditioning system can be turned on remotely via telegram.
    - Turn OFF Air Conditioning: The air conditioning system can be turned off remotely via telegram.
    - Telegram Reply: A status confirmation message is sent after executing the air conditioning system action via telegram message.

5. **Humidifier Control**
    - Turn ON Humidifier: Users can remotely activate the humidifier via telegram.
    - Turn OFF Humidifier: Users can remotely deactivate the humidifier via telegram.
    - Telegram Reply: Feedback message is provided for each action that has been done to confirm the status of the humidifier.

6. **Curtain Automation**
    - Curtain Open: The curtain will automatically open when the door is open or the control remotely via telegram.
    - Curtain Close: The curtain can be remotely controlled to close via telegram.

3.4 Expected System Testing and Performance

The expected system testing will be the overall system able to be control using telegram and with MQTT applications. Not only this, but it also has its own user dashboard for

the user to control it. Besides the system has also been expected to be control by using our voice not only with MQTT, Telegram and the dashboard.

3.5 Expected Challenges

The expected challenge first will be how I can let the telegram to control the node-red. After that I found out the way to solve it. For now, the current challenges are how can I using the voice to control my Smart Home System. I have finding out a lot of solutions, but these solutions are based on OS that can use Google, but currently my phone was Huawei brand so it might be a big challenge for me to find out the way to voice control my Smart Home System.

3.6 Project Milestones

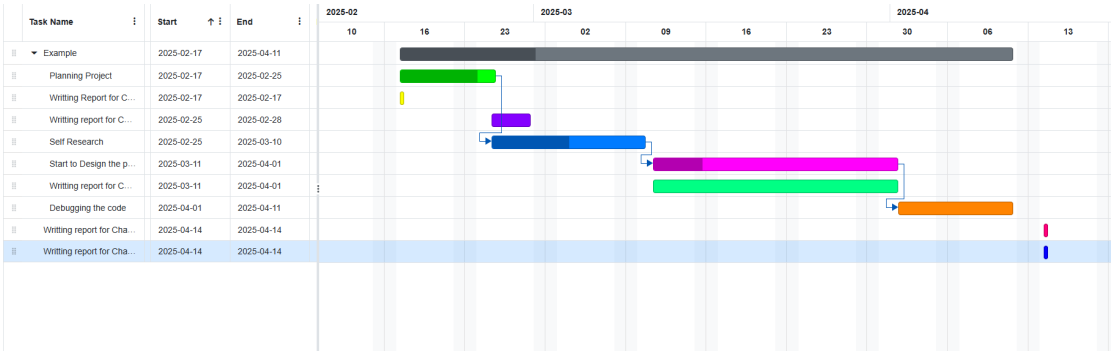


Figure 3.6.1 Project Milestones FYP 1

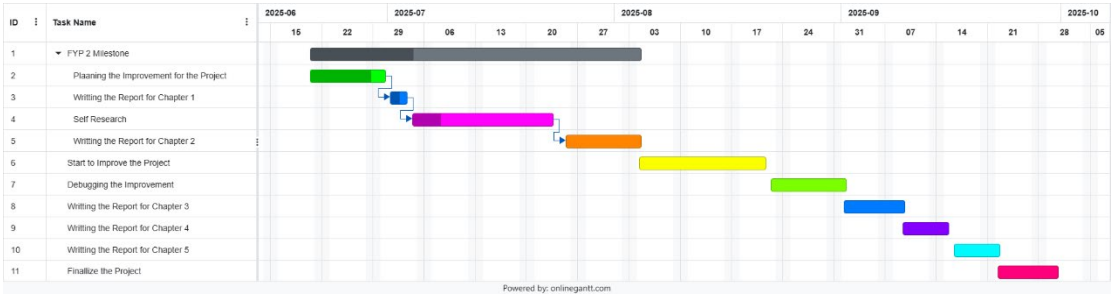


Figure 3.6.1 Project Milestones FYP 2

3.6 Concluding Remark

The development process, system requirements, functional features and expected difficulties when designing the project have all been described in this chapter. The project gains flexibility and continuous improvement throughout the Agile Methodology. Node-RED integration with MQTT and Telegram creates a flexible and responsive system that satisfy current smart home requirements. For the voice control connection, the connection has been done through Google Home apps work together with Gemini to reach a hands-free smart home control.

CHAPTER 4

Preliminary Work

Preliminary Research is research on a topic that helps you get a better understanding on what types of sources are available and what is being said about a topic. This type of research helps solidify a topic by broadening or narrowing it down. This research can also help you when choosing Search Terms.

4.1 System Architecture

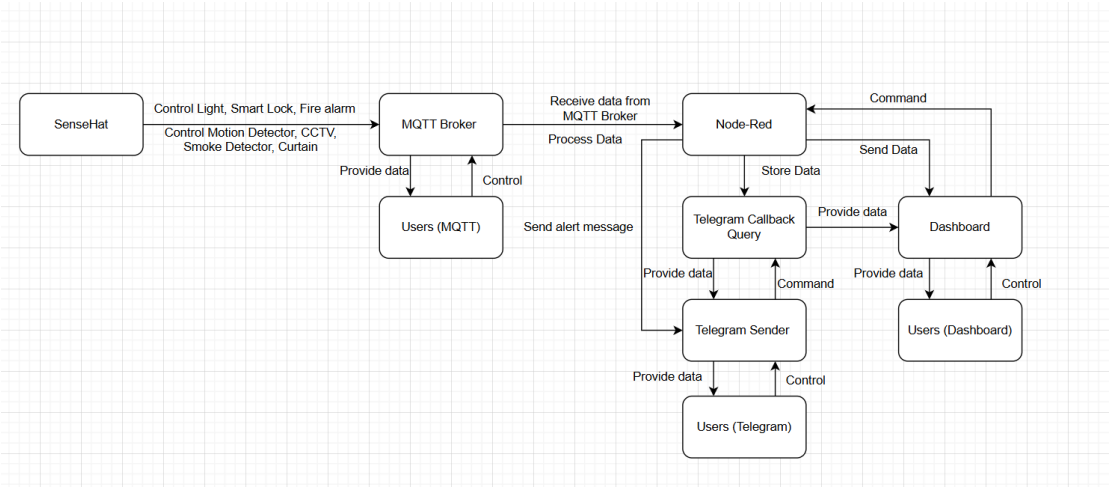


Figure 4.1 System Architecture

Figure 4.1 show the overall system architecture of the smart home system. The Sense Hat will collect the data and sends it to the MQTT Broker. Then the MQTT Broker will forwards the data to Node-Red, which will process it and sends information to the dashboard for the real-time display. If the certain condition is met, the Node-Red will send an alert message to users through Telegram. Users can also control devices like lighting system, smart locks and alarms using Telegram or the Dashboard. For MQTT, the users able to view the data and control the system remotely. This system is allowing the user to monitor and manage the home more easily through different platforms have been uses.

4.2 Functional Modules in the System

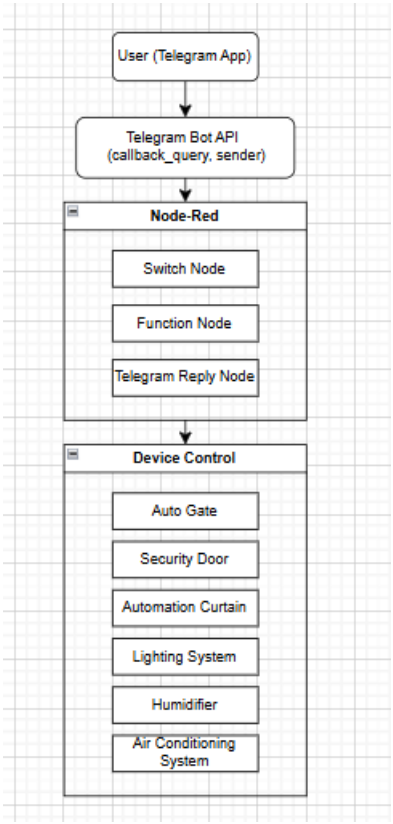


Figure 4.2 Functional Modules

Figure 4.2 show how the Telegram-based smart control system functions through several modules. It starts with when a user interacts with the system using the Telegram app. When a user sends a command, it will handle by the Telegram Bot API using the callback queries and sender functions in Node-Red, which pass the command to Node-Red for the further processing. In Node-Red, the command also flows through the different nodes to. The switch inside the Node-Red is to responsible to identify which action the user wants to perform it. Then function node will process the logic behind the command to determine what needs to be done. Once the action is determined, the Telegram reply node sends a confirmation message back to the user for the information about their request have been process. After the command been processed, Node-Red will communicate with the all-device control's module. This have included auto gate, security door, automation curtain, lighting system, humidifier, and air conditioning system. Each of the devices performs according to the requests action by the user's input. This flow allows the user to remotely manage and monitor the house using the Telegram App, creating a convenient control system.

4.3 System Flow

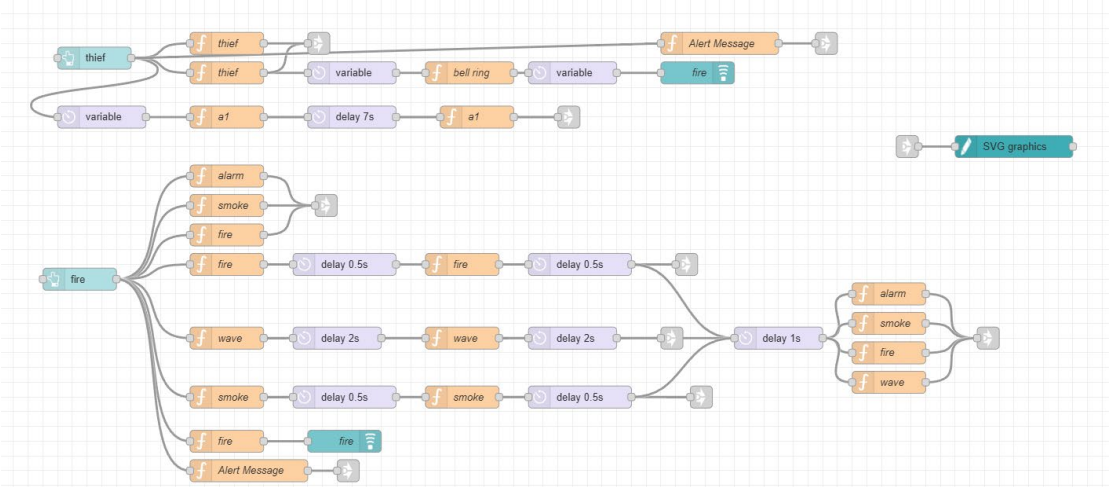


Figure 4.3.1 Smoke Detector & Trigger Sensor

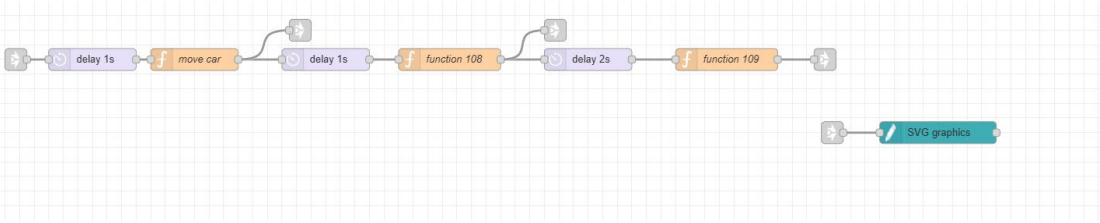


Figure 4.3.2 Car Porch Motion Sensor

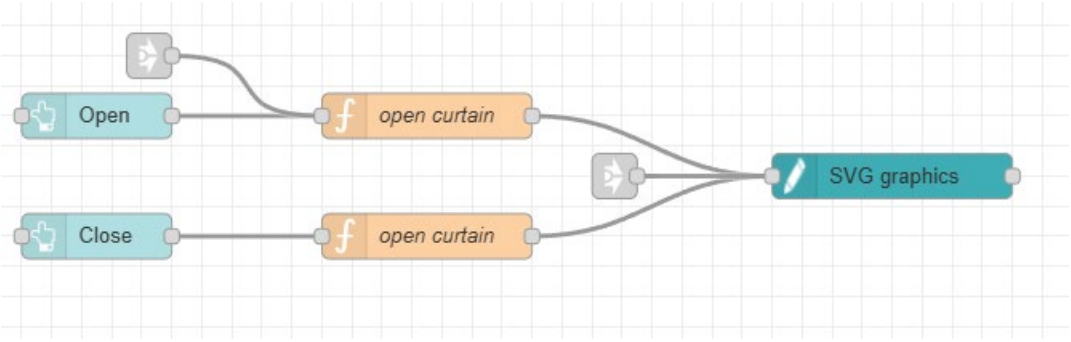


Figure 4.3.3 Automation Curtain

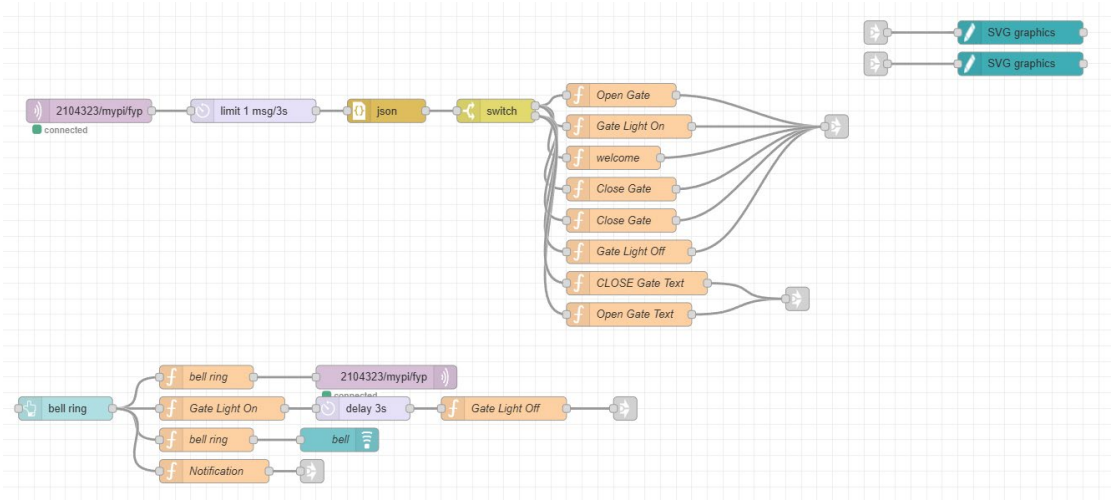


Figure 4.3.4 Auto Gate System

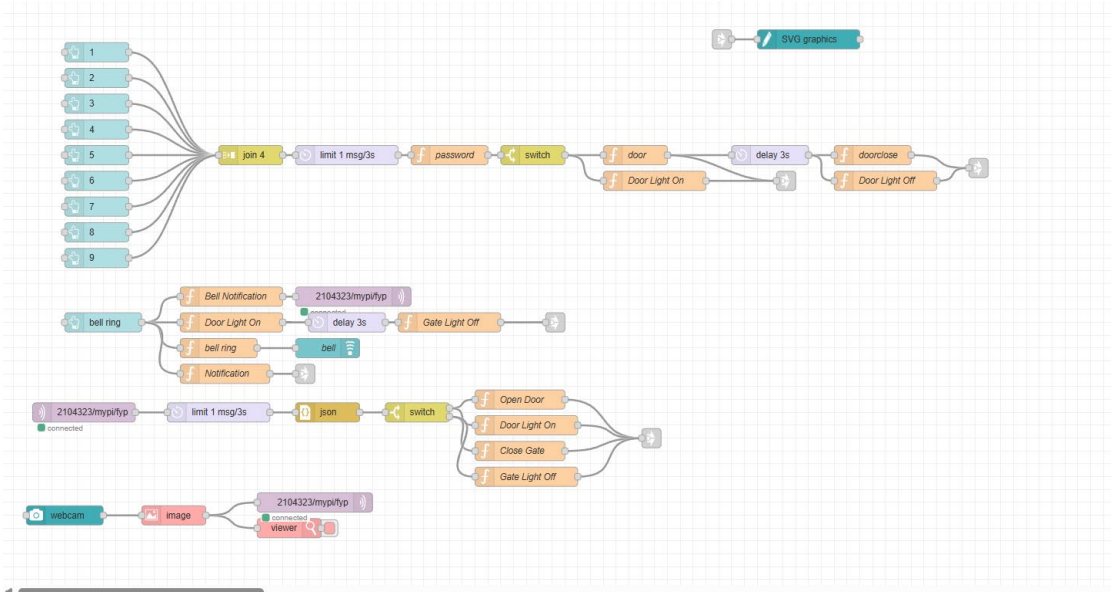


Figure 4.3.5 Security Door System

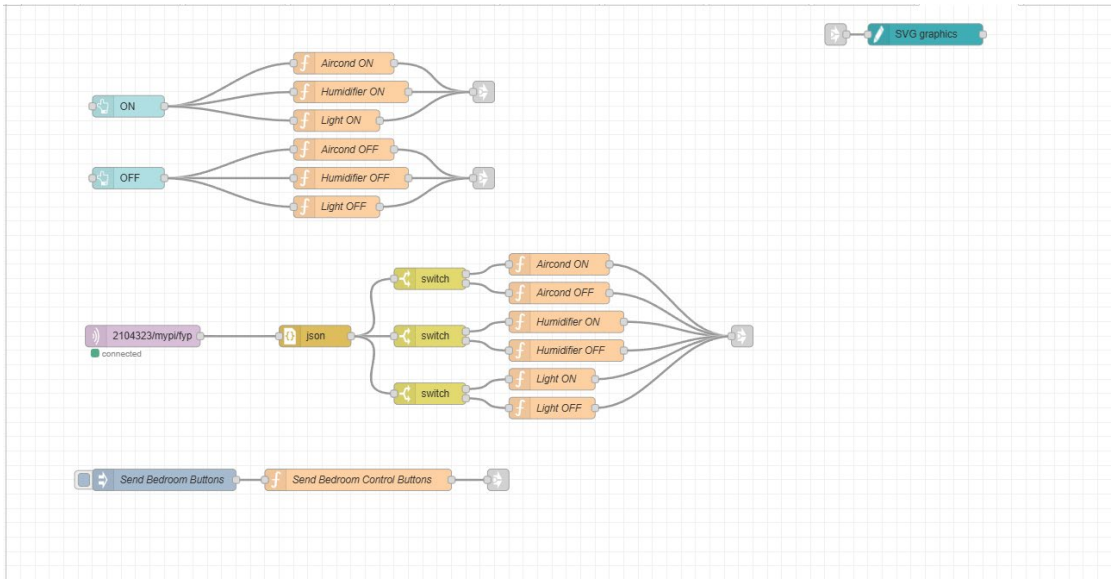


Figure 4.3.6 Bedroom System

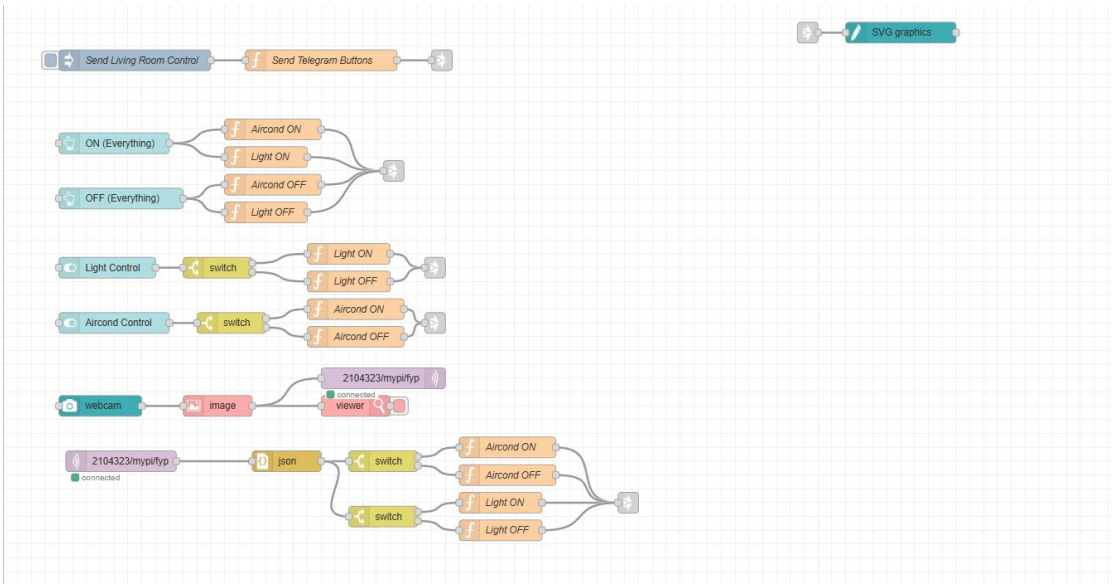


Figure 4.3.7 Living Room System

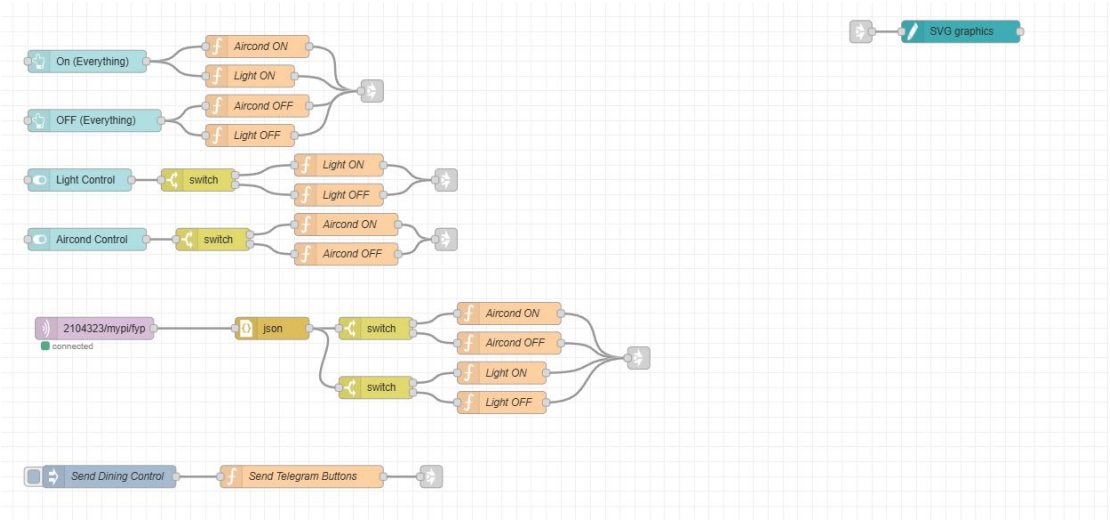


Figure 4.3.8 Dining Room System

For the figure 4.3.1, it shows that the alarm will be trigger when the house is on fire and even it has been broke in. Then the information will be sent to the telegram and will notify the user about their house situation so the user can be able to do an immediate action to protect their house. Next is the Figure 4.3.2, it shows that the system will be run as this way. When the auto gate is on the and the car porch have installed motion sensor on it, so when it detects some movement the light system in the car porch will be automatically turn on then after a few minutes the light will turn off again. Continue is the Figure 4.3.3, it has shown that how the system controls the curtain. The curtain will be automatically turned on when the front door has been open. Then the curtain will also been control through the dashboard. Then is the Figure 4.3.4, this picture has shown that how the system controls the auto gate. The auto gate can be turn off and on by using MQTT application. It will also send a message to the user through telegram when the gate bell is rung. After that telegram will pop out a message and ask user their action either want to let the people in or not, all the action can been control through telegram. Moreover, is the Figure 4.3.5, this picture has shown that, how the security gate has been controlling by the system. The security door has been set it can open through password login or by MQTT application. It also has the same function as the auto gate, when the doorbell is ring, the system will send a pop out notification to the user through telegram and asking their action rather to want to let the people in or not. Not only this the security door also has included camera on it for the safety purpose, it will capture the picture send it to the user by MQTT application. For Figure 4.3.6, this picture has shown how the user can control their bedroom. There are two ways to

control the bedroom. First is it can been control by MQTT application. The second is it can been control by telegram. The user able to control the air conditional, lighting system and the humidifier. In the future, the bedroom also might been control by using the user voices. Figure 4.3.7, in this picture has shown that the user able to remote control their living room. The user can control the lighting system and air conditional. The living room also have installed a security camera on it for the safety purpose. The product not only can been control through the dashboard, it also can be control through MQTT application and telegram application. In the future, the living room also might been control by using the user voices. Lastly is the Figure 4.3.8, in this picture has shown that, how the user can remote control their dining room. The user can control their dining room lighting system and air conditional by dashboard or control by MQTT application or it can be control by telegram. So, in the future the dining room might also can be control through the user voices.

4.4 GUI Design

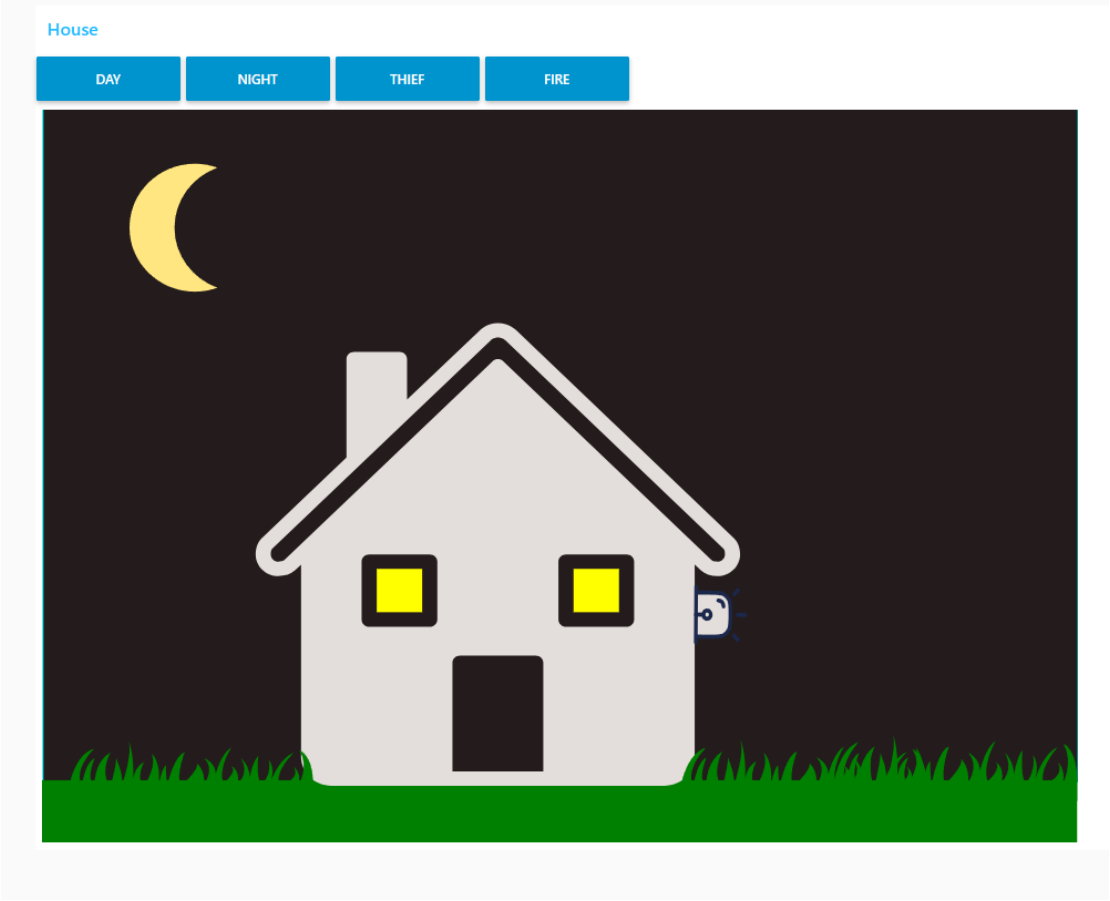


Figure 4.4.1 Trigger Sensor & Smoke Detector GUI

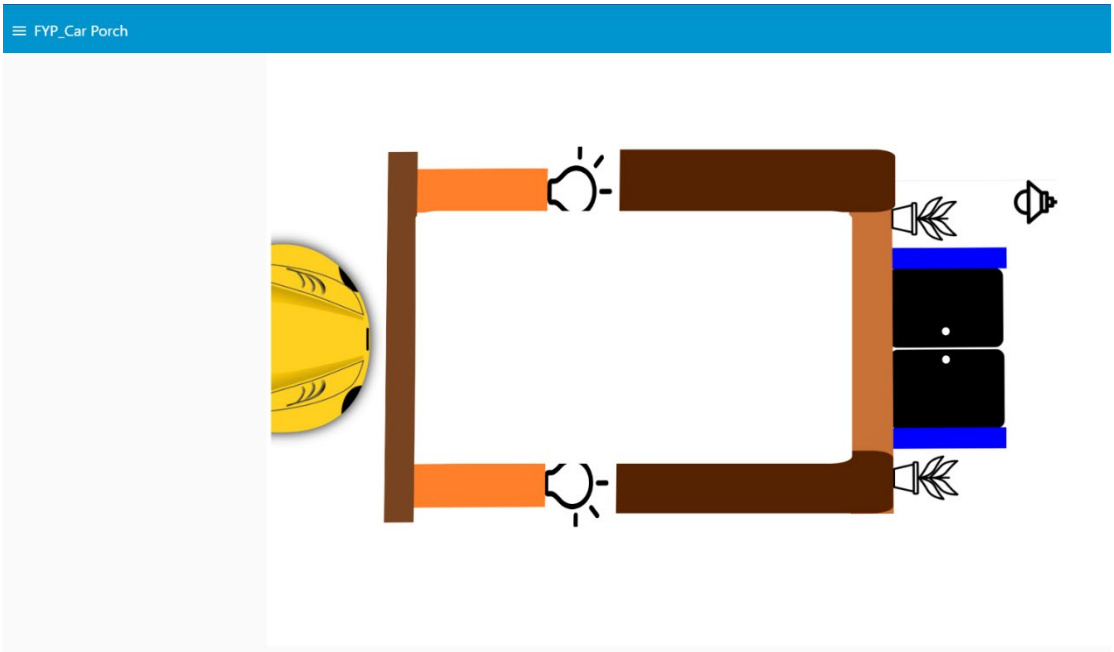


Figure 4.4.2 Motion Sensor GUI

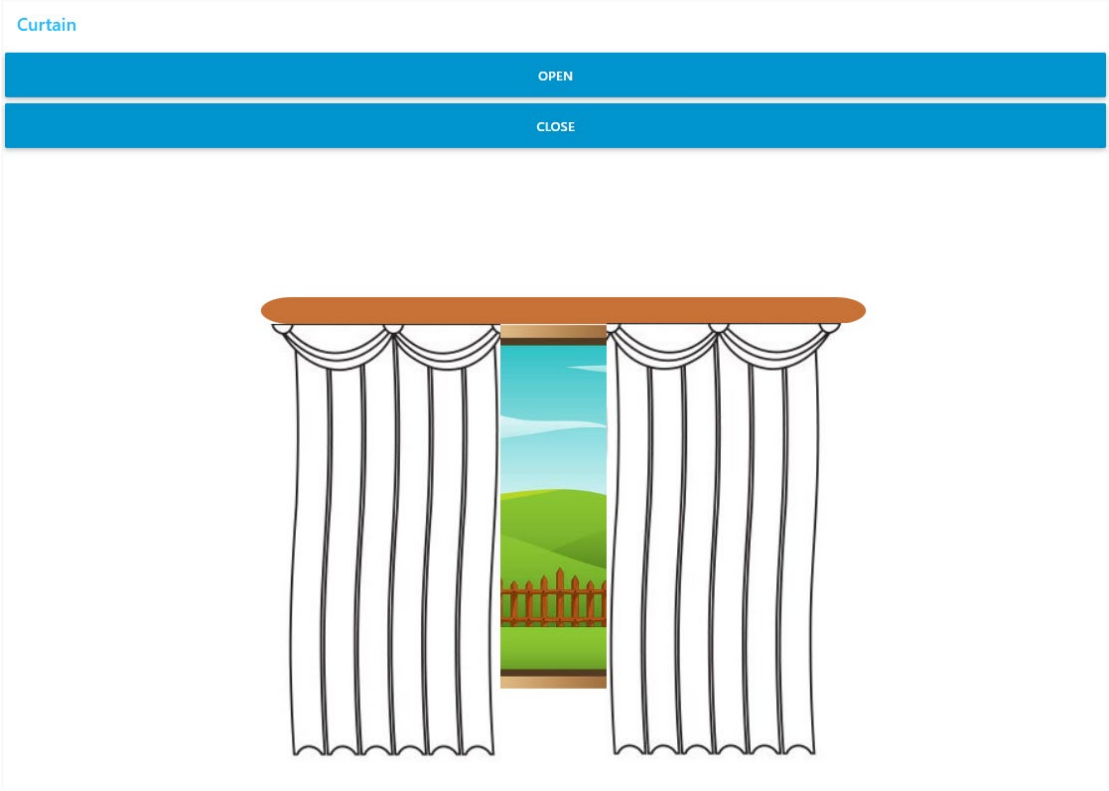


Figure 4.4.3 Automation Curtain

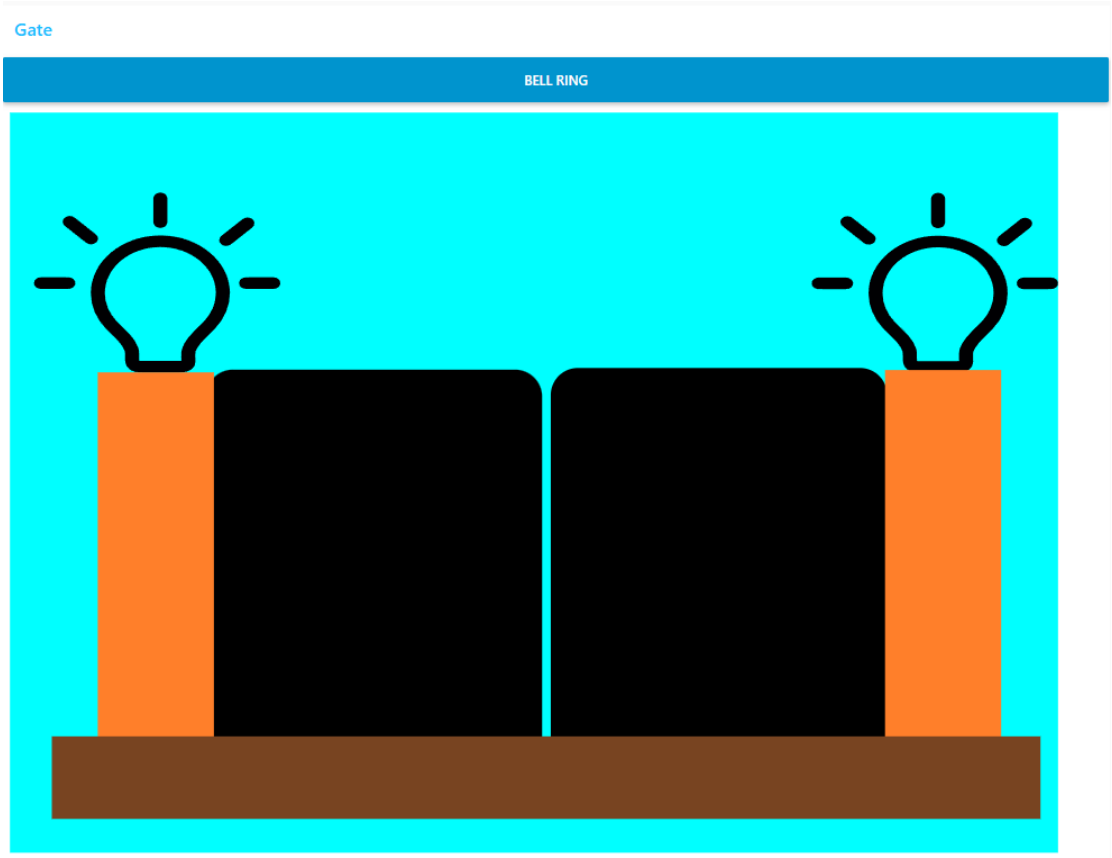


Figure 4.4.4 Auto Gate GUI

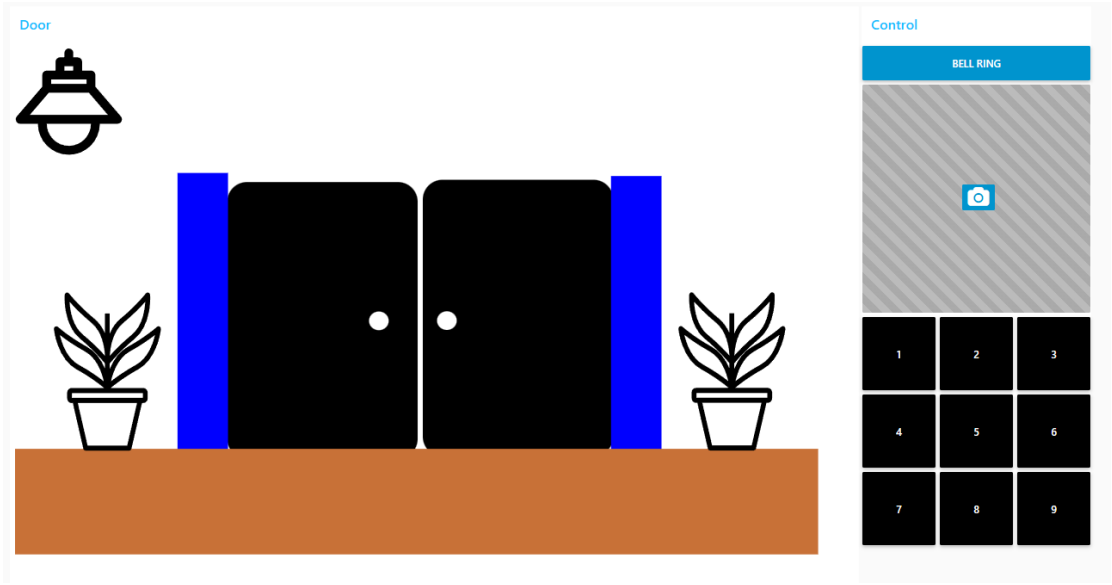


Figure 4.4.5 Security Door GUI

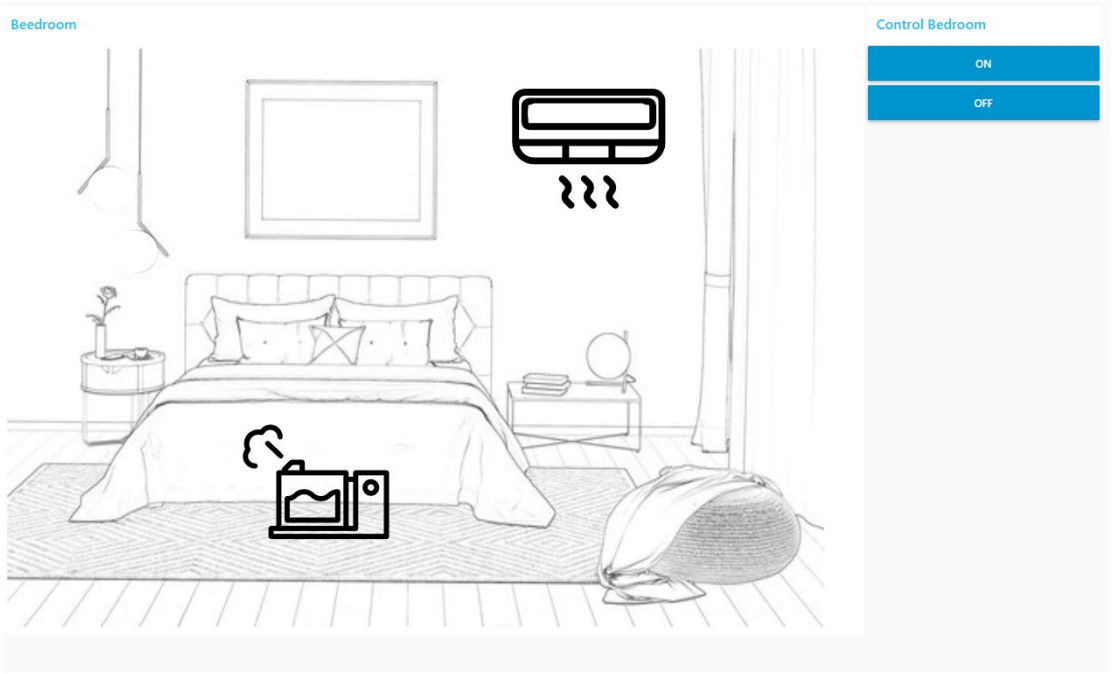


Figure 4.4.6 Bedroom GUI

Figure 4.4.7 Living Room GUI

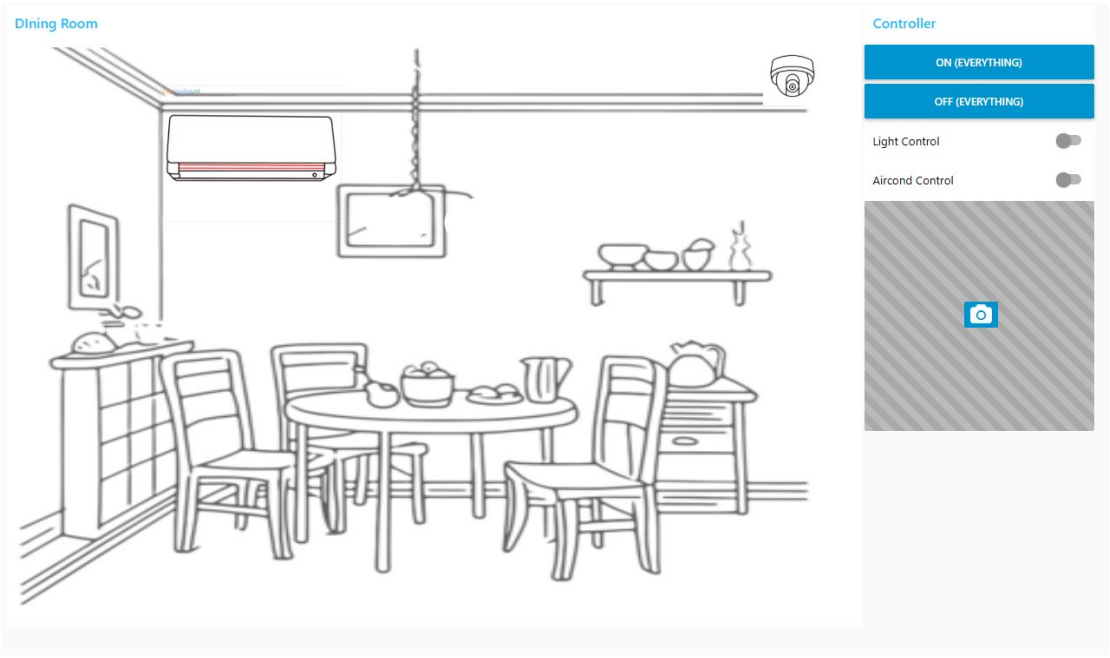


Figure 4.4.8 Dining Room GUI

For **Figure 4.4.1** is the GUI about the Trigger Sensor & Smoke Detector. This GUI is to detect whether the house is safe from fire and the house is stay out with someone the user doesn't know. It will trigger the alarm when there is fire, and someone try to break in the house. For **Figure 4.4.2** is the GUI about the Motion Sensor in the Car Porch. This GUI is work as when the car pass through the motion sensor that place on the top of the car porch, the light will automatically turn for a time, and the light will continue to turn off when the time has passed. For **Figure 4.4.3** is about the Automation Curtain

GUI. This GUI will work as when the front door of the house is open it will trigger a message via telegram to the user and ask whether want to open the curtain. If the user chooses to open the curtain, the curtain will automatically open. Continue is **Figure 4.4.4**, this GUI is about the Auto Gate. This GUI will work as when someone ring the bell the system will send an alert message to the user via telegram and the user can control the auto gate through telegram either the user wants to open it or close it. Another method to open the auto gate is using MQTT application or using the system dashboard to open the auto gate. Then is **Figure 4.4.5**, this GUI is the Security Door GUI. The Security Door have a few methods to open it. First is the user can enter the password to open the door. Second, method is same as the auto gate when the bell rings, the system will trigger an alert message to telegram to let the user to control it. The last method is control by MQTT application. For the **Figure 4.4.6, 4.4.7 and 4.4.8** is the GUI about the bedroom, living room and the dining room. These GUI will work as when the user triggers them in the system, it will also send an alert message to the user via telegram to let the user to control the lighting system, air conditioning system and the humidity system in the bedroom.

4.5 Concluding Remark

In this chapter, the project's preliminary work, including the system architecture, functional modules, system flow and system GUI design has been included in. The combination of Node-RED, MQTT and Telegram has been shown to produce a flexible and interactive smart home system through via images and explanation. Real-time monitoring and control are made possible by the modular flow and simple interfaces, providing a basis for upcoming improvements like voice control. This foundation guarantees that the system is functional, well structured, and prepared for additional testing and development.

Chapter 5

5.1 Hardware Setup

1. Asus TUF Gaming A15

In this project I have using this laptop to done major of my project. For example, I have used this laptop to run node-red and design the overall project flow on it. Not only that, this laptop also as a prototype GUI design showing platform that showing out how is the prototype of the project run. I also going through a lot of literature review on this laptop too.

2. Honor Magic 8 PRO (smartphone)

In this project I have using this smartphone to have a voice control to my node-red project by using Gemini and the connection is going through an application called Google Home. By using this device, I able to reach my one of the objectives of this project is to have a hands-free smart home control.

5.2 Software Setup

1. Node-Red

In this project I have using node-red to design my project flow. Besides I also using node-red to do all my mobile connections to Telegram and Google Home. I also showing out the GUI design through node-red too.

2. Telegram

In this project I have using Telegram as a one of my mobile controls to my project. I have using Telegram to show the alert message like house on fire and house been broke in. Besides, I have using Telegram to mobile control all my bedrooms, living room, dining room, gate, security door and curtain. This have let the project able to be use more efficiently. Not only that, I also using Telegram to check the overall condition of the houses. For example, using Telegram to check whether the light in the bedroom is

either on or off when we are not at home rather than checking them based on the GUI that I design for.

5.3 Setting and Configuration

1. Google Home

In this project I have using Google Home as a platform for me to voice control my node-red on smartphones. The configuration of the Google Home is simple, just need to register the account by using the email and created an own password for the apps. Next is to connect the Google Home with an adapter called Node-Red Google Assistant Bridge to let the Google Home able to connect with Node-Red.

2. Node-Red Google Assistant Bridge

In this project I have using Node-Red Google Assistant Bridge as an adapter to let the node-red flow able being voice control through an application that supports this adapter. First, need to register a username and password for this adapter. Later on, the username and password will be use on the node in node-red called Google Assistant, I will use the username and password to recognise the user. Next, create the devices that wanted to be voice control inside the Node-Red Google Assistant Bridge. After we just need to call the adapter in the node-red to let it to able to receive the voice command from Gemini and pass to it to perform the action that have been command too.

3. Google Gemini

In this project I have using Google Gemini to receive my voice command and pass it to Google Home and Google Home will pass it to node-red through the Node-Red Google Assistant Bridge to let the node-red able to be voice control. The configuration of the Google Gemini is simple, just need to make sure the email address to have been used to register for is similar with the email address that use on Google Home. Otherwise, both software will not be able to link up due to different email address use.

5.4 System Operation

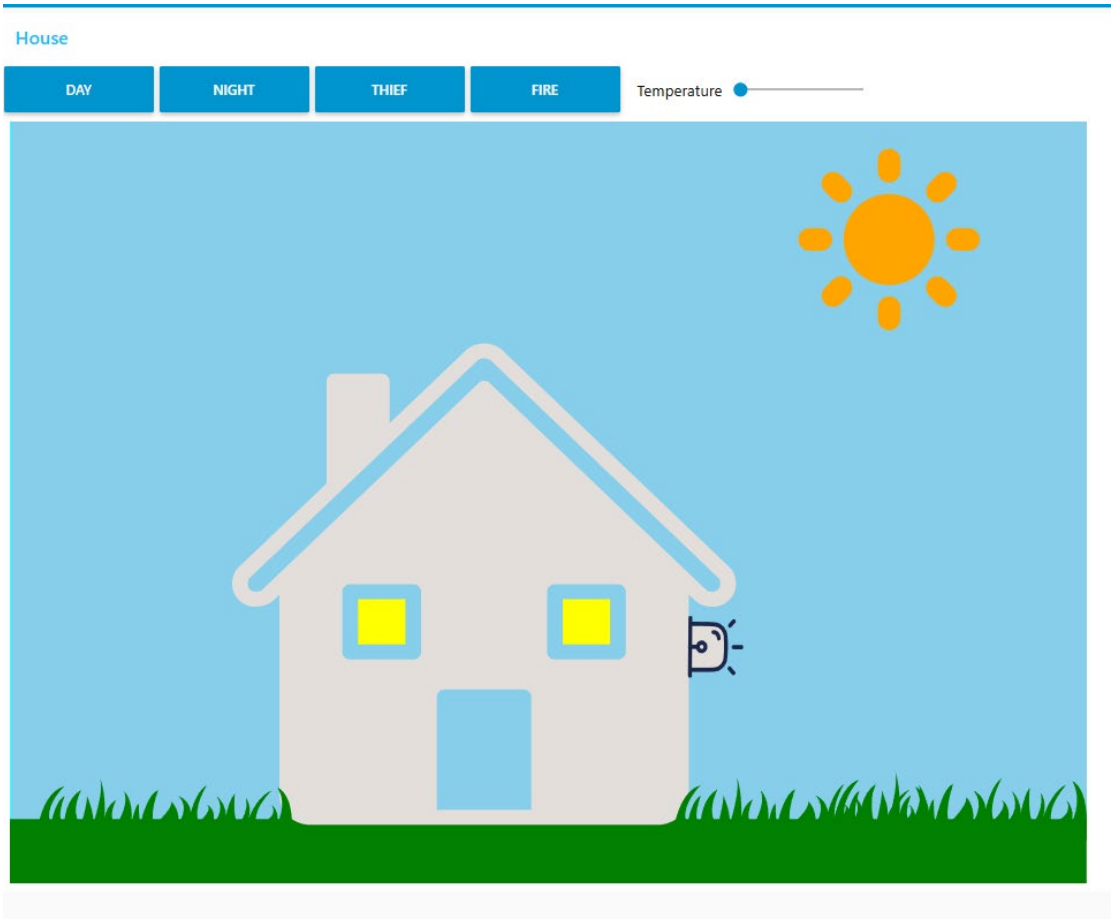


Figure 5.1 House GUI with Day Scenario

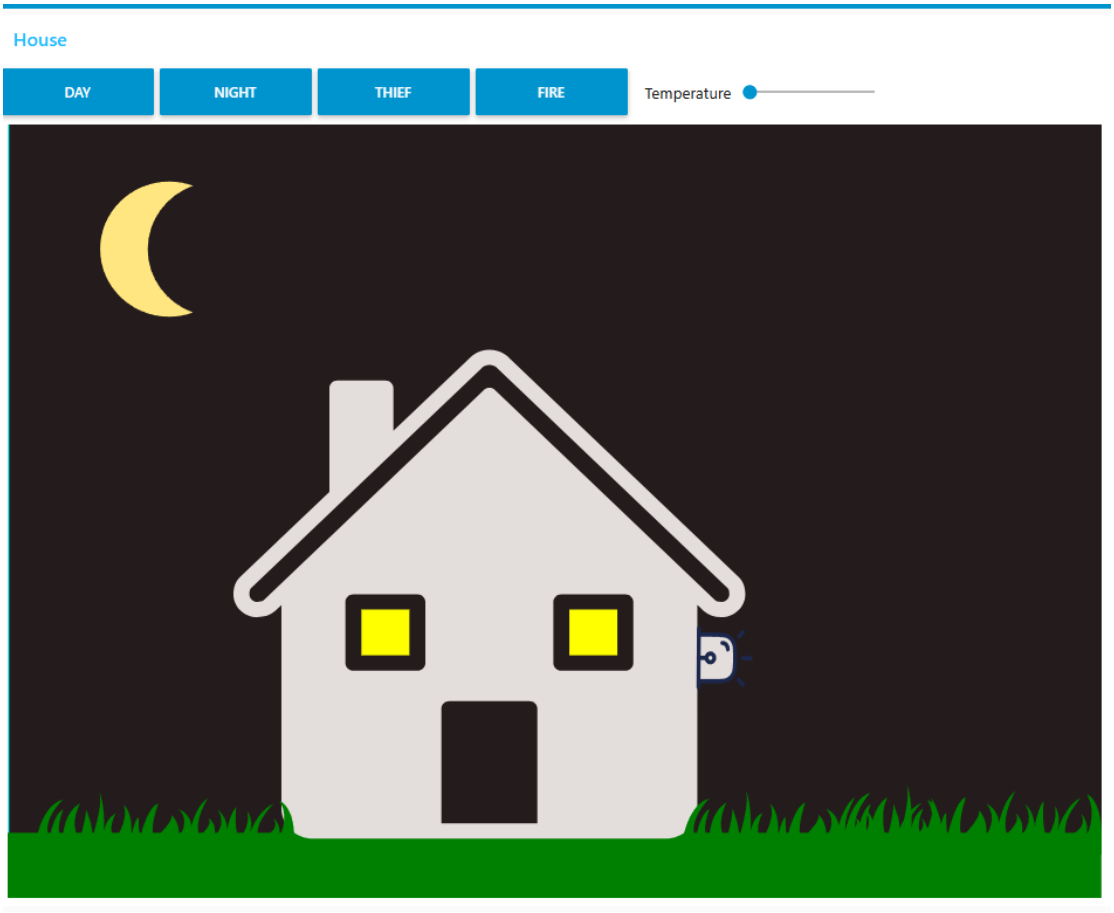


Figure 5.2 House GUI with Night Scenario

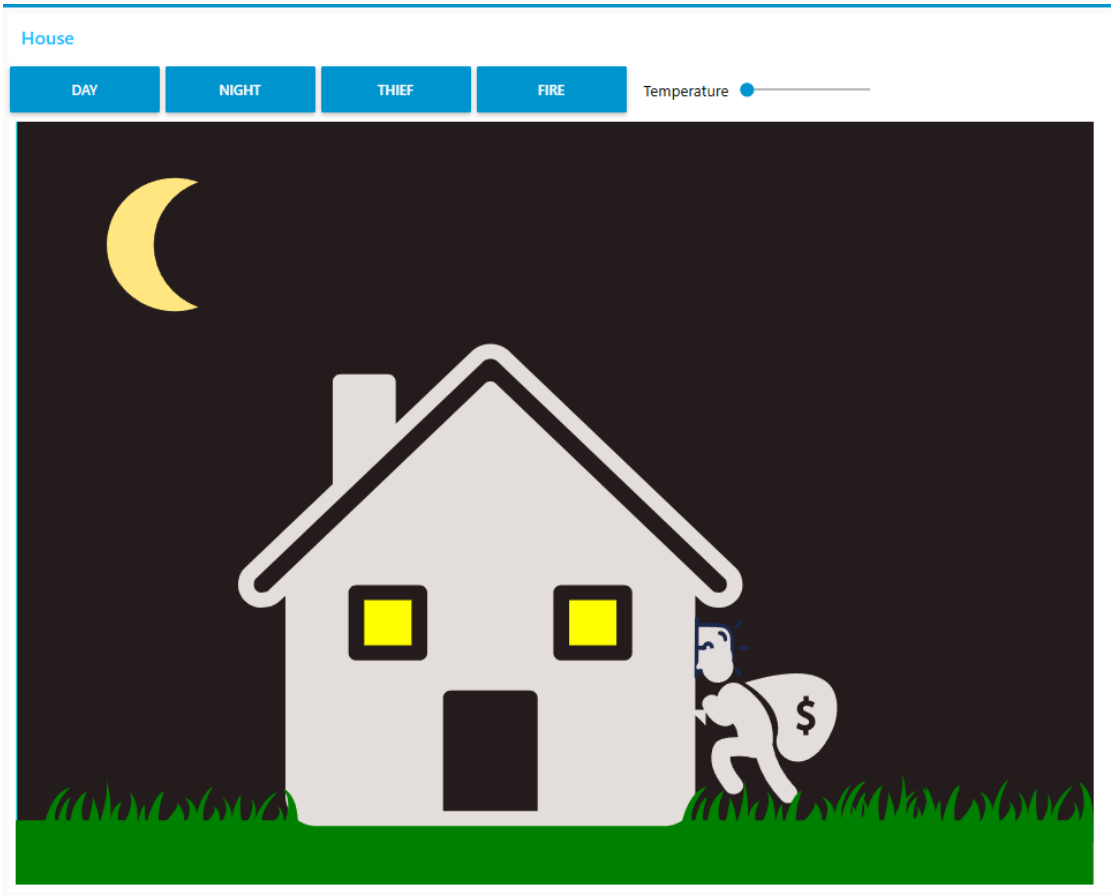


Figure 5.3 House GUI with Thief Scenario

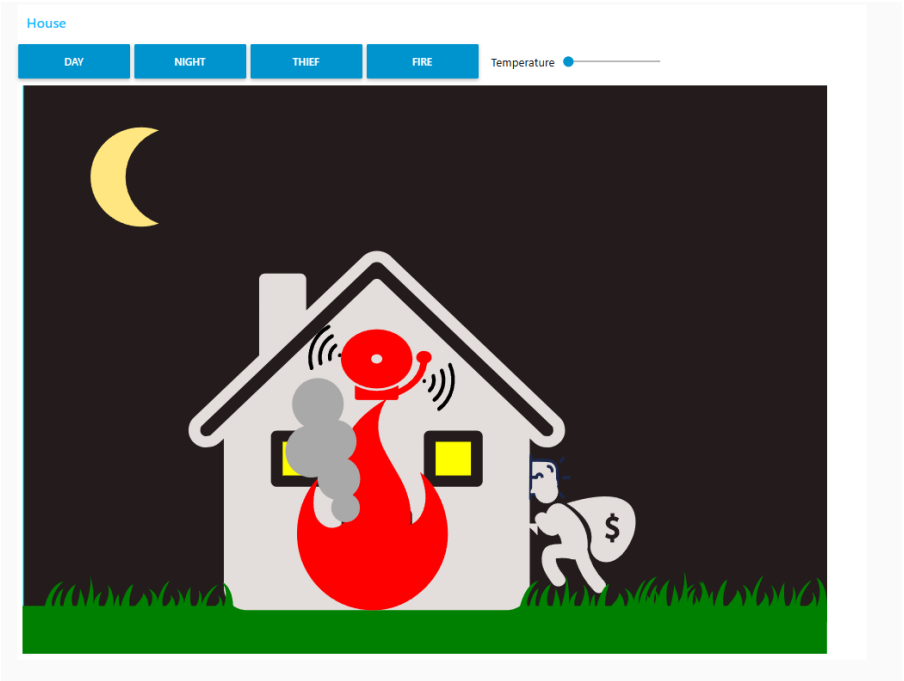


Figure 5.4 House GUI with Fire Scenario

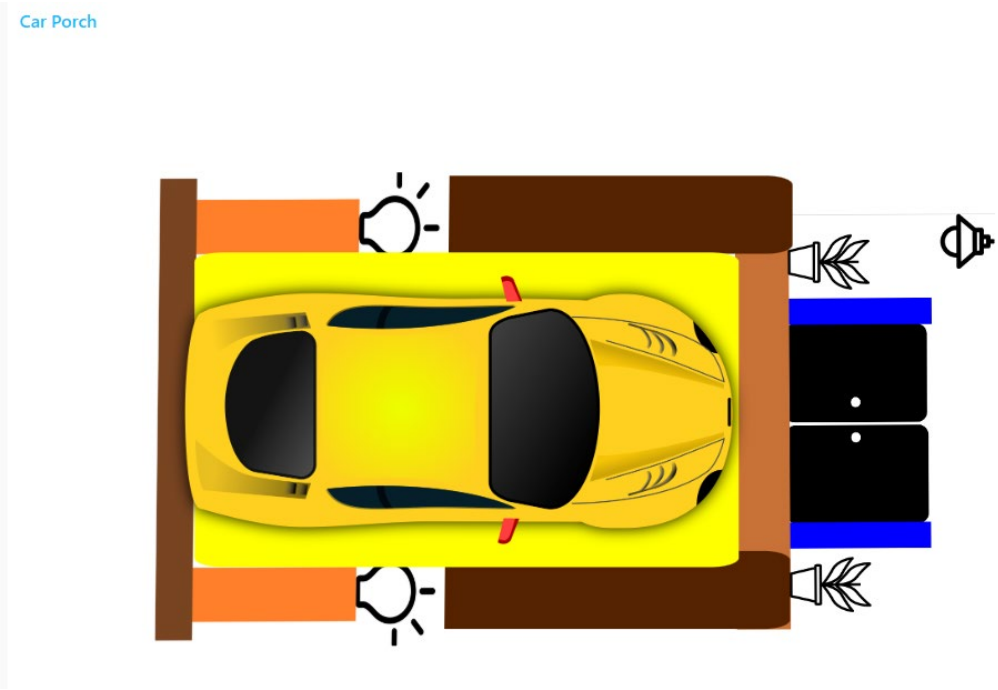


Figure 5.5 Car Poarch GUI when the gate is open

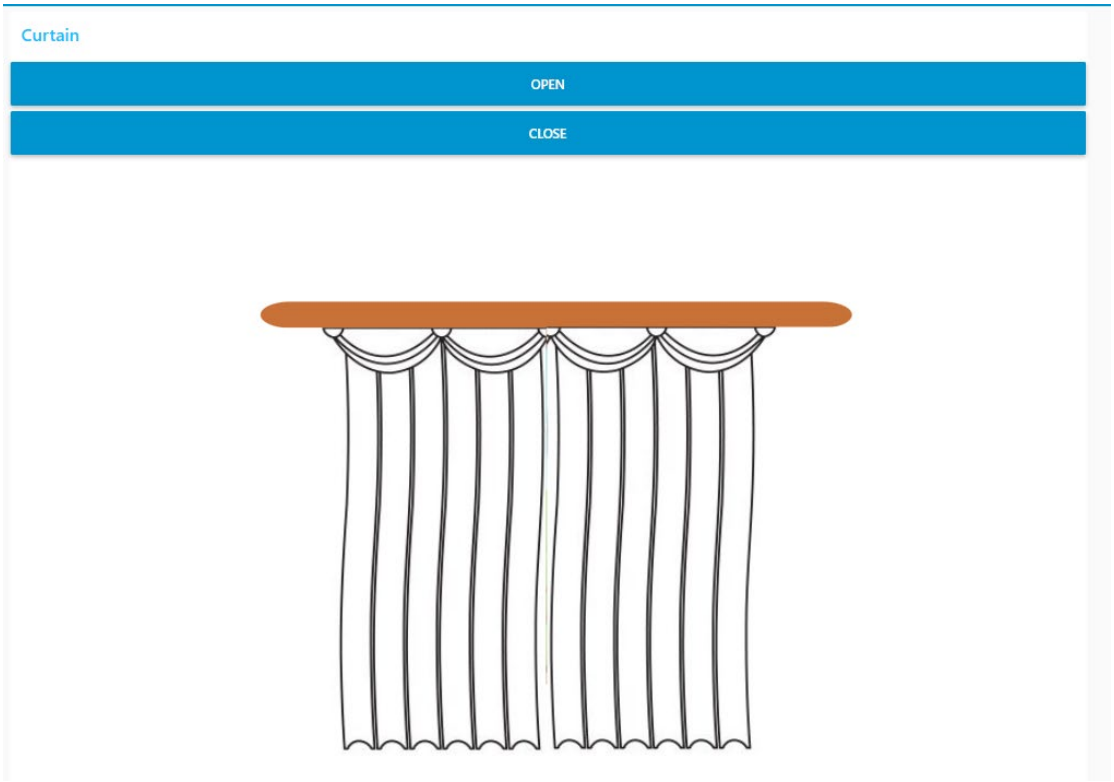


Figure 5.6 Close Curtain GUI

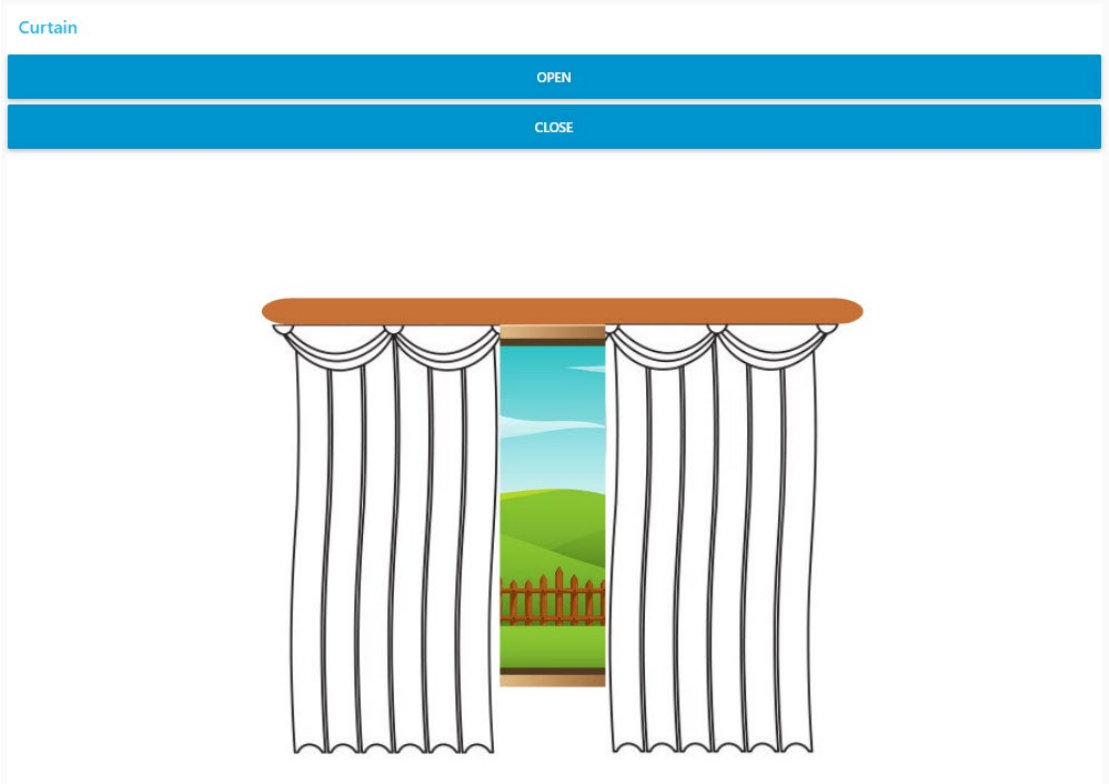


Figure 5.7 Open Curtain GUI

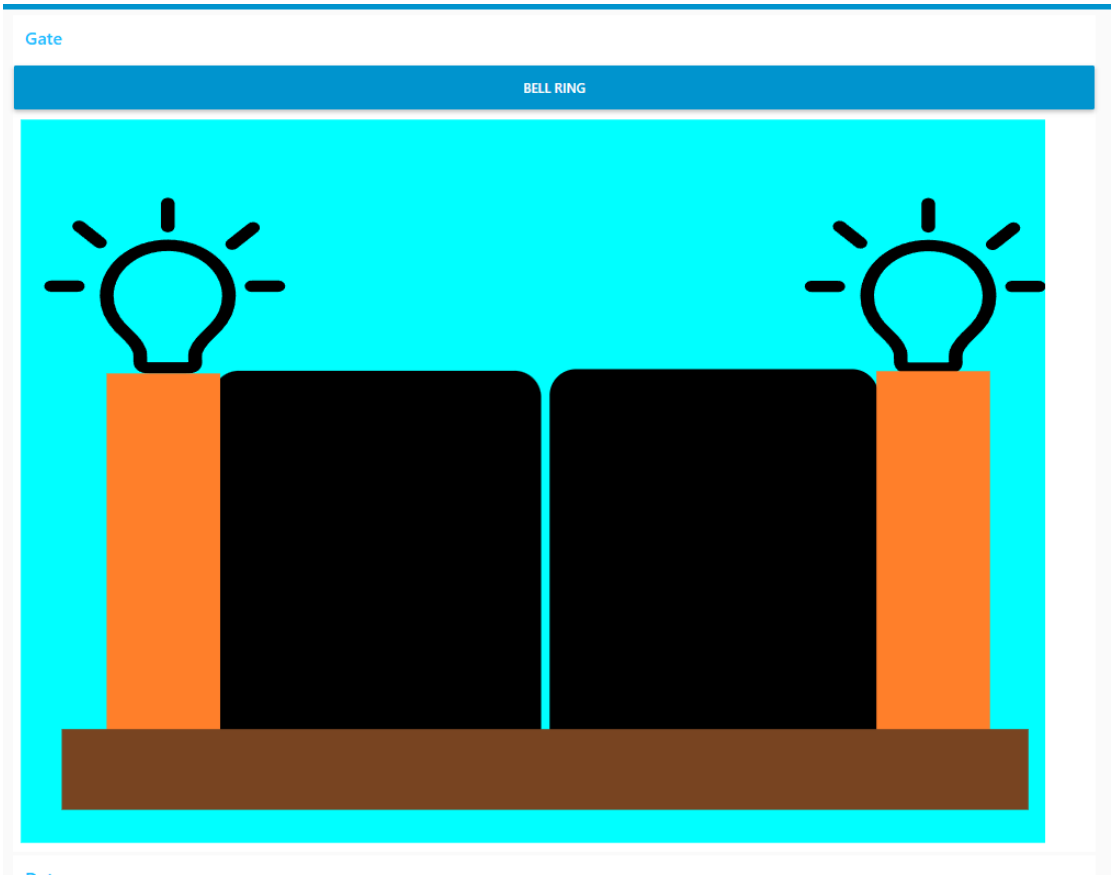


Figure 5.8 Gate Close GUI

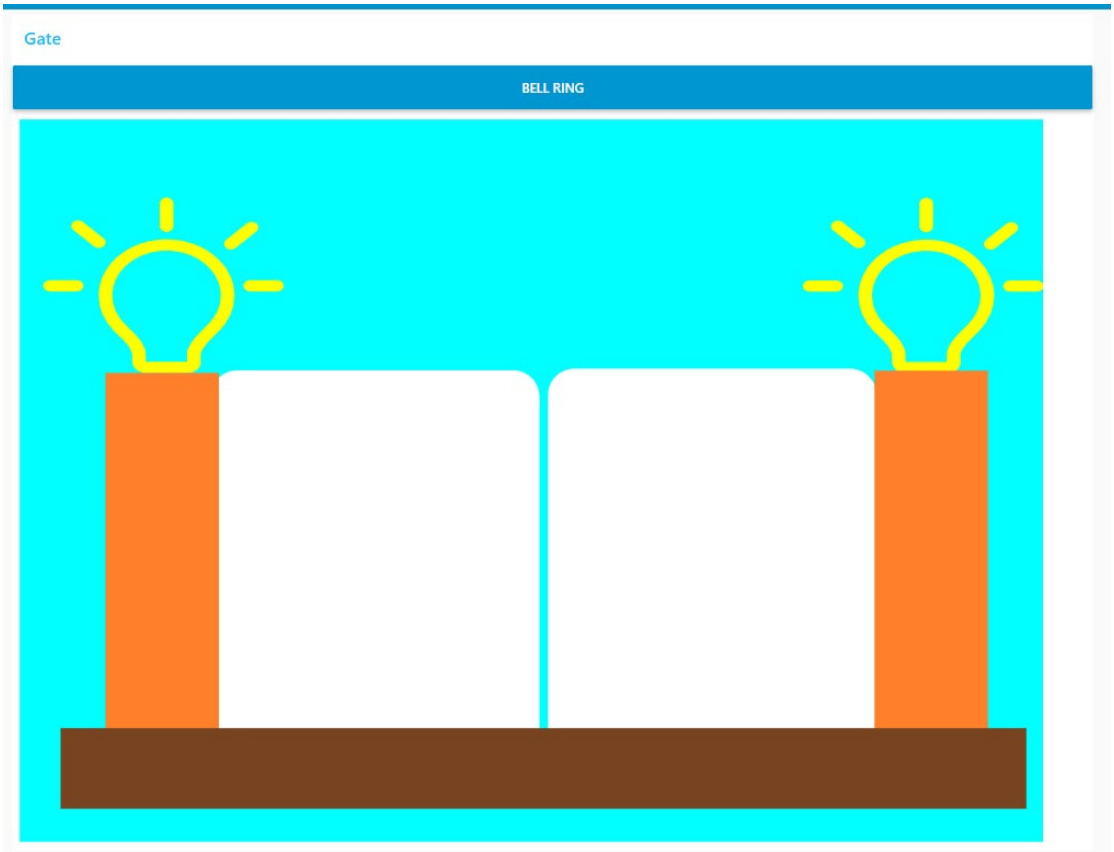


Figure 5.9 Gate Open GUI

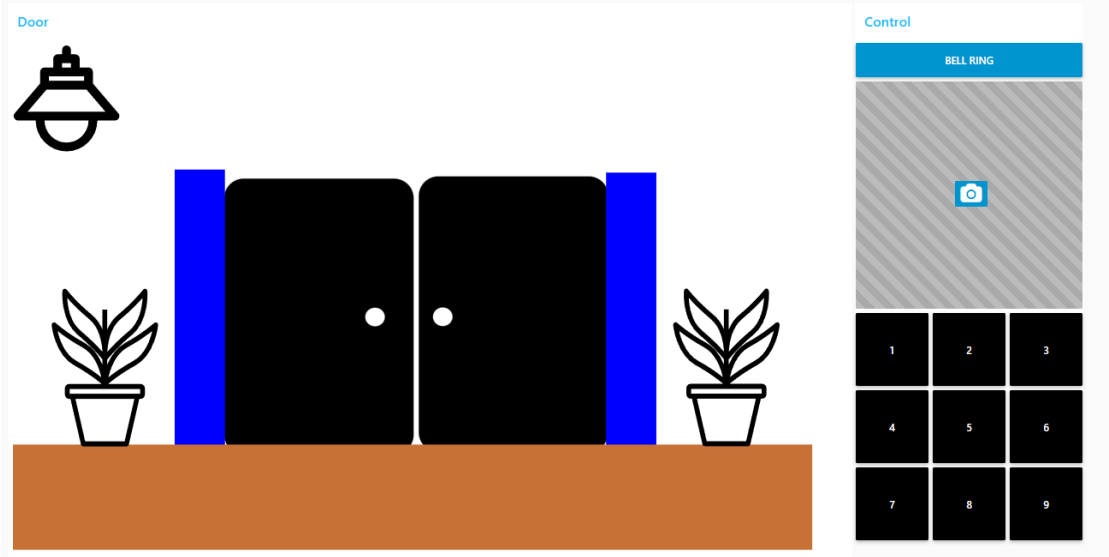


Figure 5.10 Door Close GUI

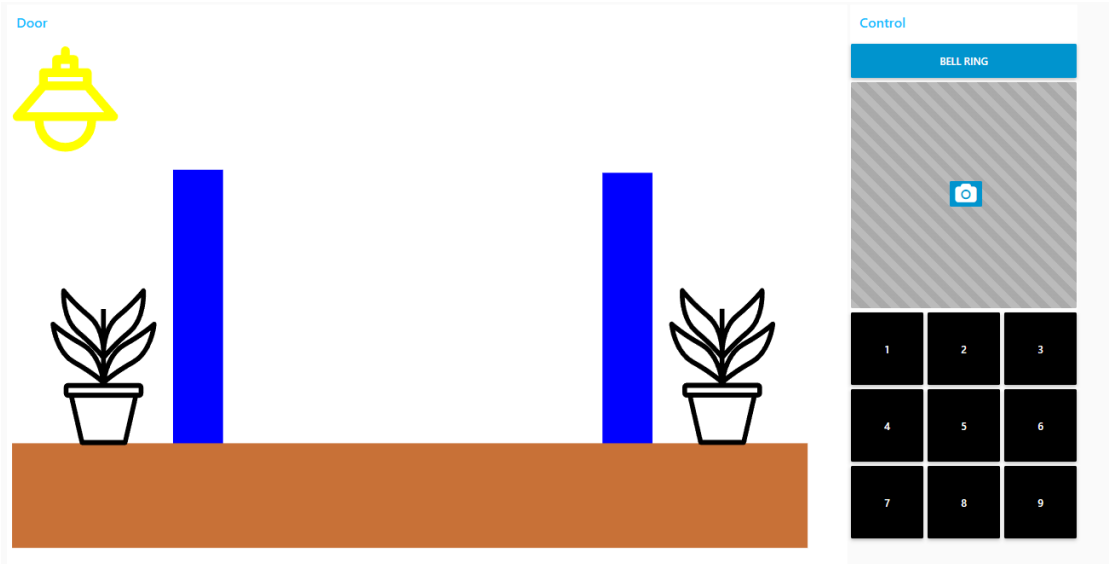


Figure 5.11 Door Open GUI

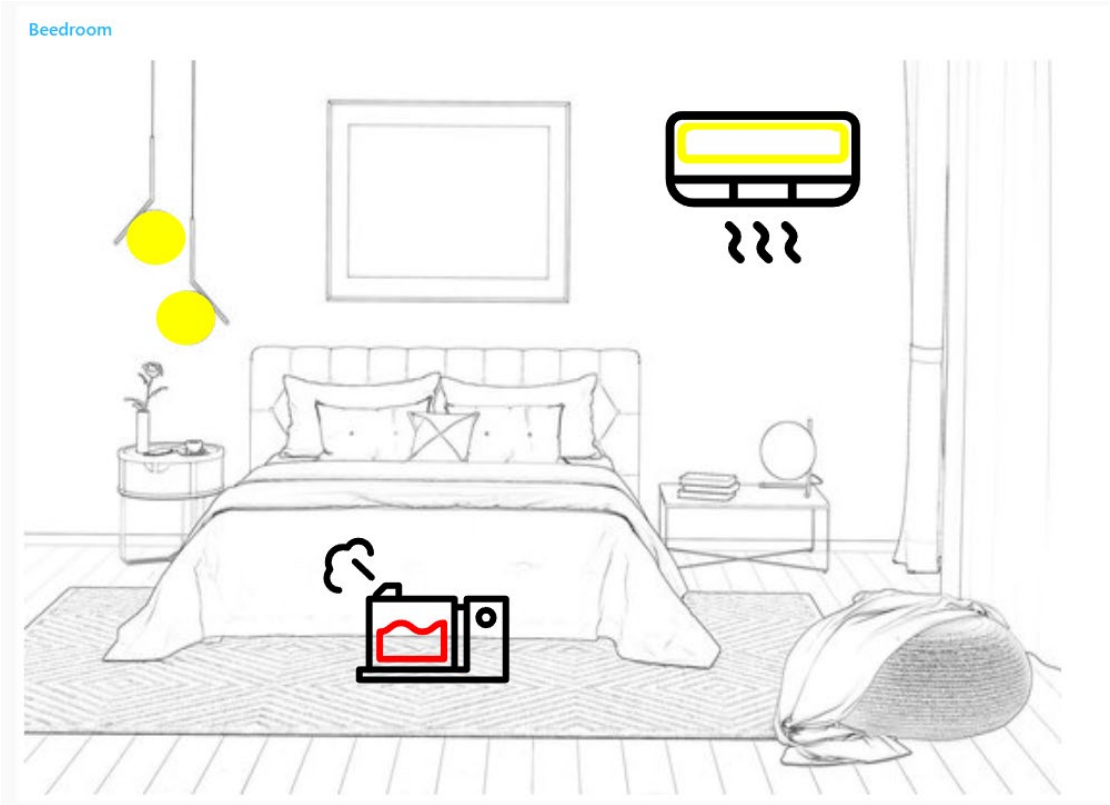


Figure 5.12 Bedroom GUI with everything ON

Figure 5.13 Living Room GUI with everything ON

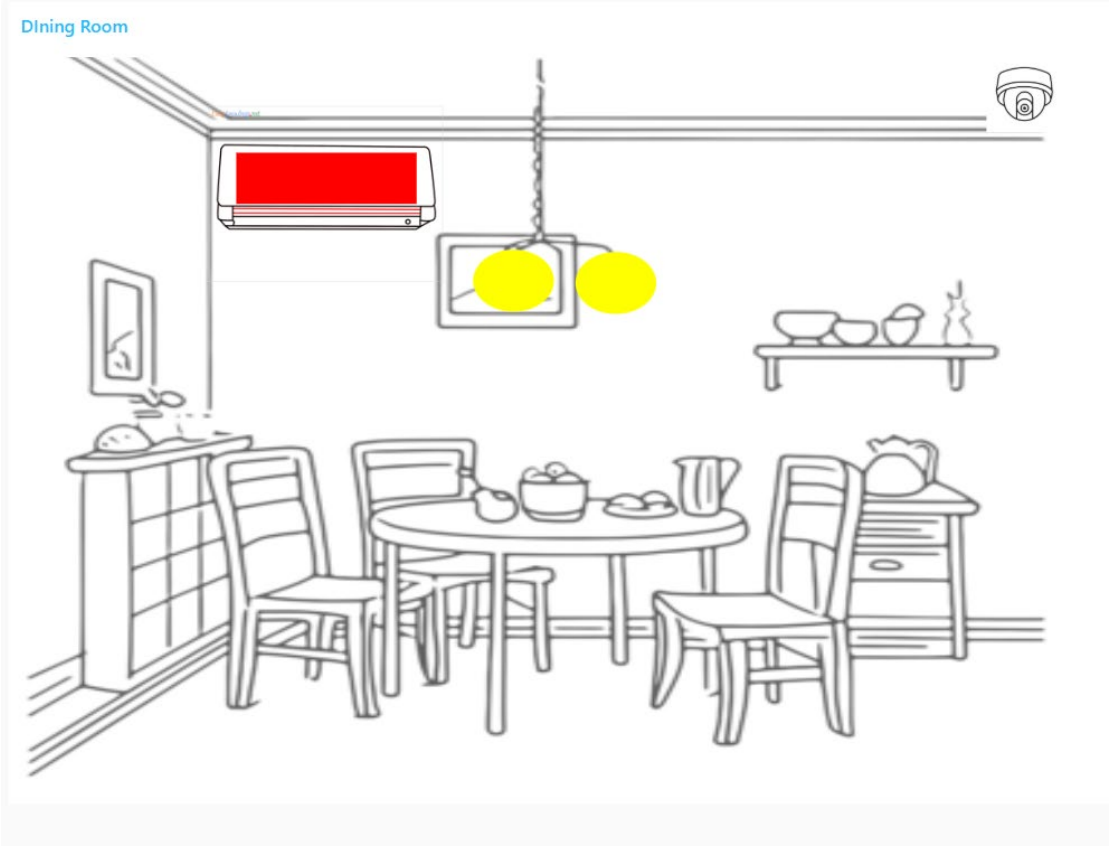


Figure 5.14 Dining Room GUI with everything ON

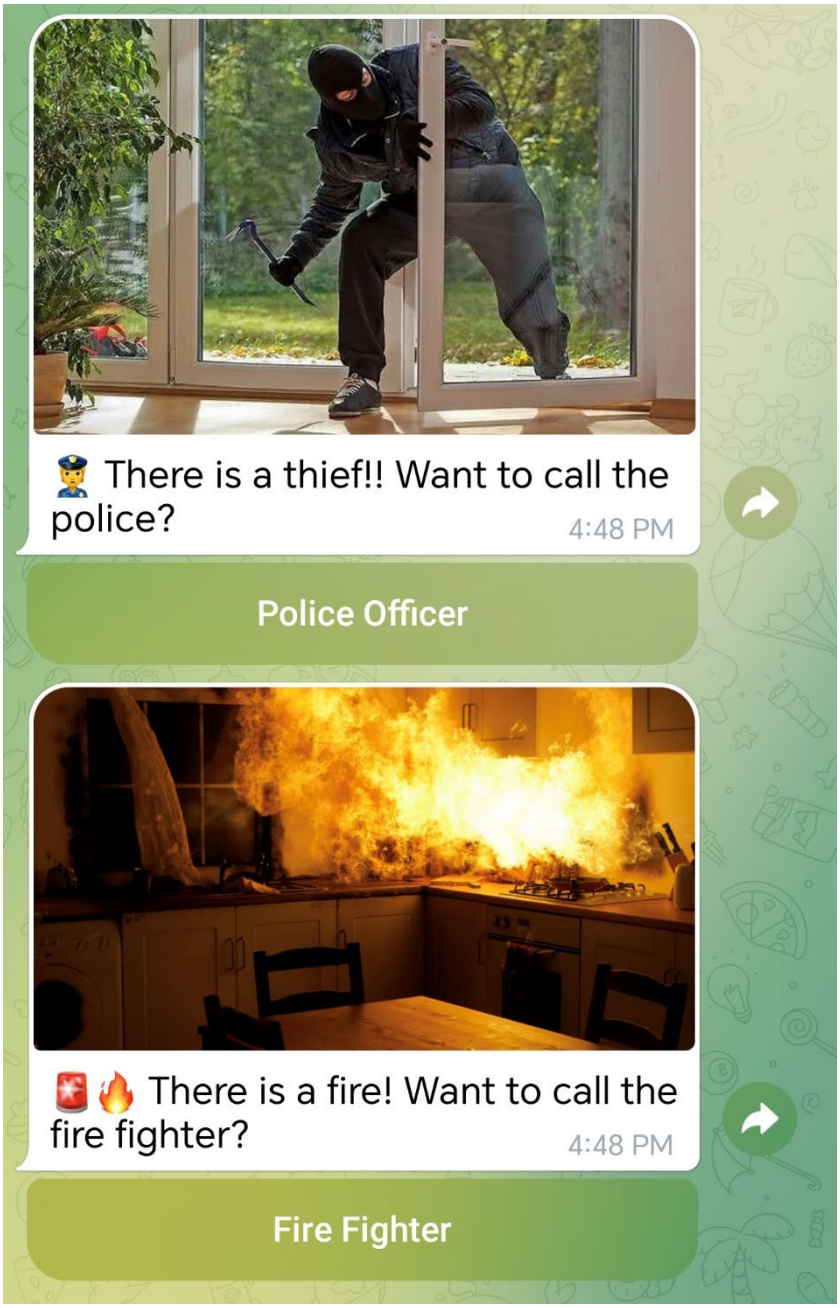


Figure 5.15 Alert Message Prompt

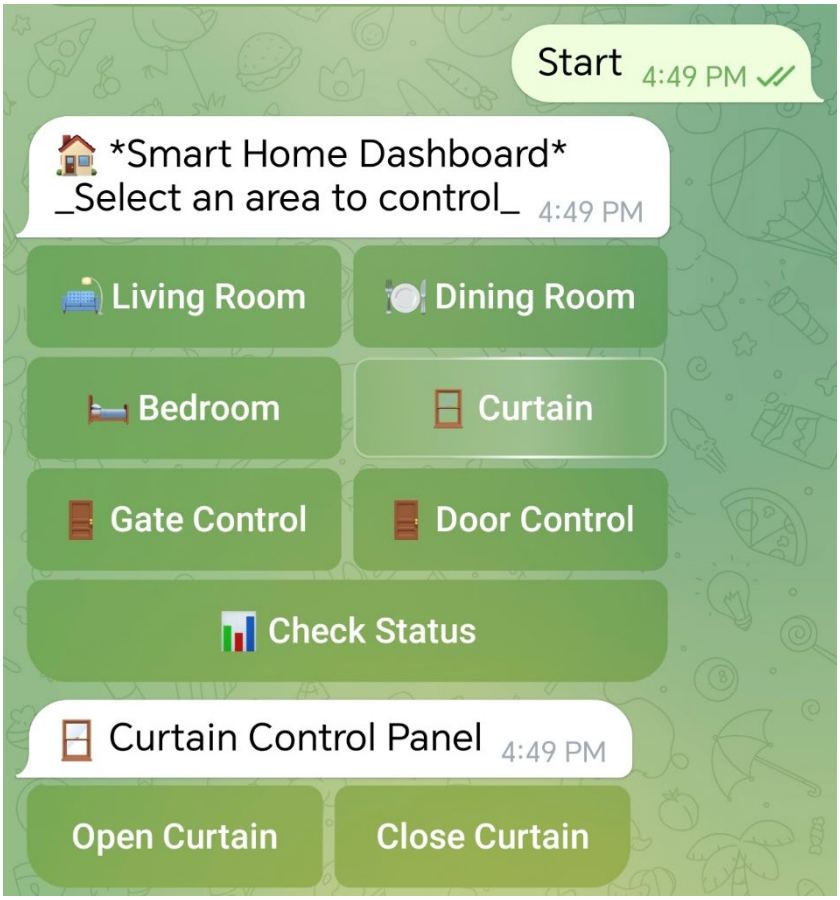


Figure 5.16 Telegram Curtain Control

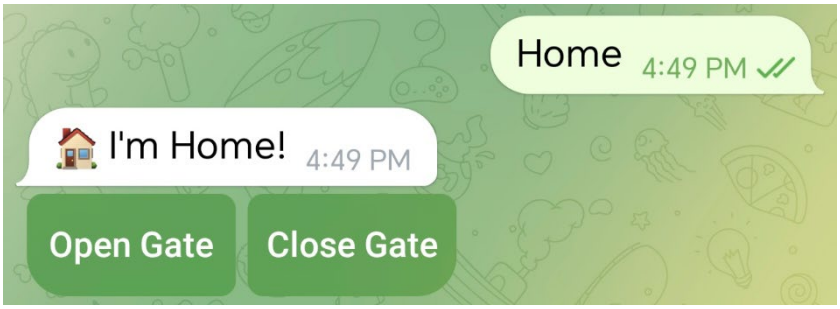


Figure 5.17 Telegram Gate Control

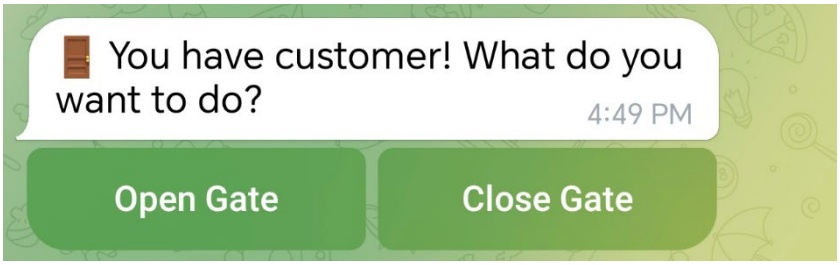


Figure 5.18 Visitor Alert Message

Figure 5.19 Telegram Security Door Control

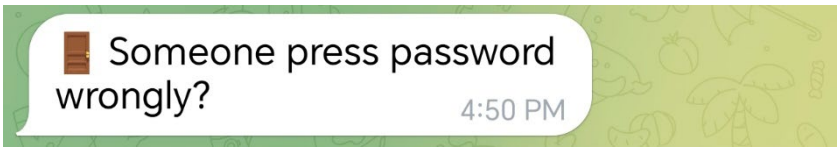


Figure 5.20 Alert Message Prompt

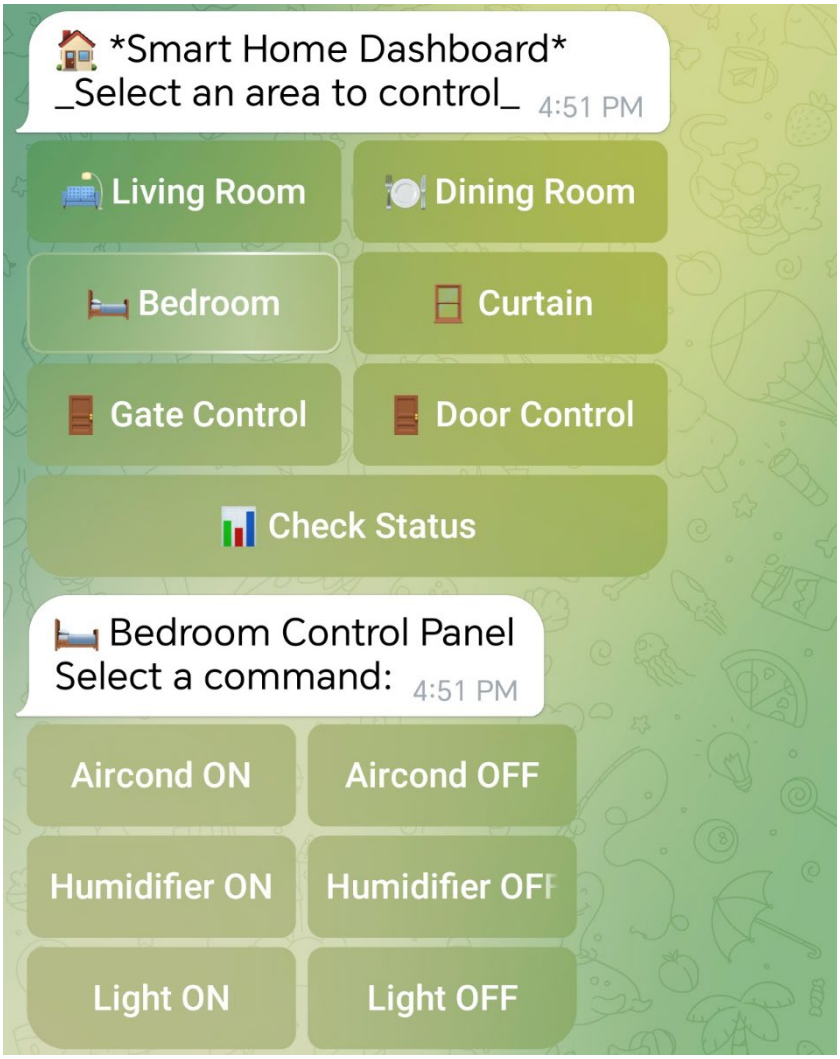


Figure 5.21 Telegram Bedroom Control

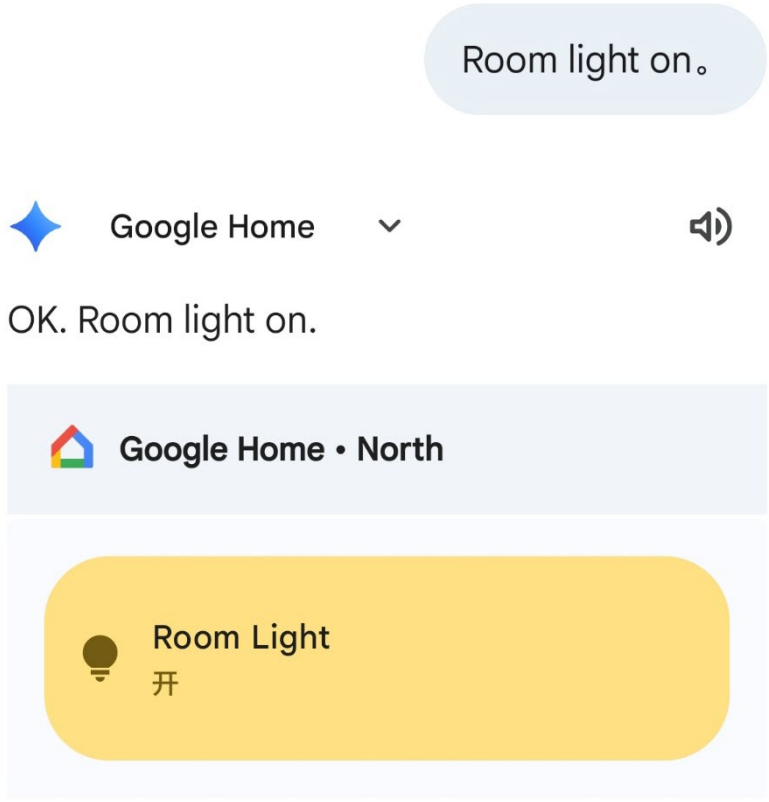


Figure 5.22 Voice Control Bedroom

House

For figure 5.1, this figure is showing when the user pressing the day button at the GUI design the background colour will change from black into blue. This is to assume current time is daytime. While for figure 5.2 is opposite, this figure is to assume current time is nighttime when the user press night button in the GUI. For figure 5.3 and 5.4, these two figures are showing the house is being broke in by a thief and the house is accidentally on fire, it will raise up the alarm and prompt an alert message to the user telegram account like the figure 5.15.

Car Porch

For figure 5.5, this figure is to declare the motion sensor that using in the car porch. When the sensor sensing an object the light in the car porch will automatically turn on, after a few seconds the light will turn off again without any control needed. This is to save the energy consumption.

Curtain

For figure 5.6 and 5.7, these two figures are to identify the curtain on and off. The curtain is being control either by the button on the GUI design or the control the is prompting on the user telegram account like Figure 5.16.

Gate

For figure 5.8 and 5.9, these two figures are to assume the gate is on and off. This is a keyless gate; it only can be control by the user telegram by entering “Home” this command to enter the gate command for turning on or off the gate like the figure 5.17. Not only this, when there is the visitor, the telegram will receive the alert message in the telegram and asking the user what the current decision is made by the user either open the gate or leave the gate close for example figure 5.18.

Security Door

For figure 5.10 and 5.11, these two figures are to assume the security door is on and off. This also is a keyless door; it only can be enter using user telegram for example figure 5.19 or entering the password to enter the house. The password is 4 pin numbers, when the pin is wrongly entered it will send an alert message to the user telegram account like figure 5.20.

Bedroom

For figure 5.12, this is roughly GUI design that show the application in the bedroom being control on and off. The devices can be control by the button on the GUI or using user telegram accounts like figure 5.21 or using voice control with Google Gemini like figure 5.22.

Living Room

For figure 5.13, this is also a roughly GUI design that show the application in the living room being control on and off. The devices can be control by the button on the GUI or using user telegram accounts like figure 5.21 or using voice control with Google Gemini like figure 5.22.

Dining Room

For figure 5.14, this also a roughly GUI design that show the application in the dining room being control on and off. The devices can be control by the button on the GUI or using user telegram accounts like figure 5.21 or using voice control with Google Gemini like figure 5.22.

5.5 Concluding Remark

In this chapter have including the hardware and software setup for my project. Not only that, but this chapter also including how I set up my software to make this project is more reach with my objective. The lastly is I also include the screenshot about how my system is operate and explain picture by picture clearly how it works. The use of various hardware and software like the laptop (Asus TUF Gaming A15), my smartphone (Honor Magic 8 Pro), the software that I use to design my entire project (Node-Red) and the application the I use to voice control my project (Google Home and Google Gemini). These had enabled the hands-free smart home system.

Chapter 6

6.1 System Testing and Performance Metrics

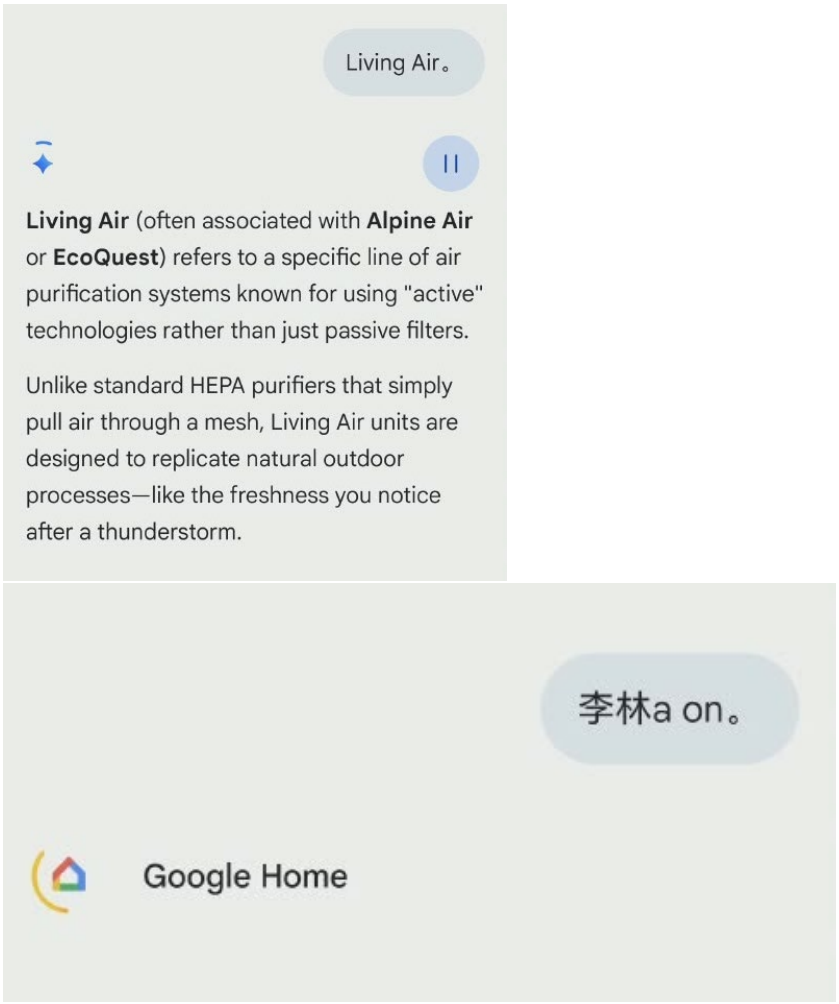


Figure 6.1 Misunderstanding of Google Gemini

For this project is all mainly about the node-red control and the voice control of the node-red. The overall of the project that need to be test a few times is voice control through Google Gemini. It is because of our country English accent the Google Gemini will misunderstanding our commands given out. For example, figure 6.1 I try to give the voice command “living light on” to turn on the living room light. The Google Gemini maybe will receive correctly but it might leave one word and turn the entire command into another new commands or maybe the Google Gemini will think that we are currently speak Chinese and prompt out the voice command that I give is Chinese. It will be successful to receive after a few commands is prompting.

6.2 Testing Setup and Result

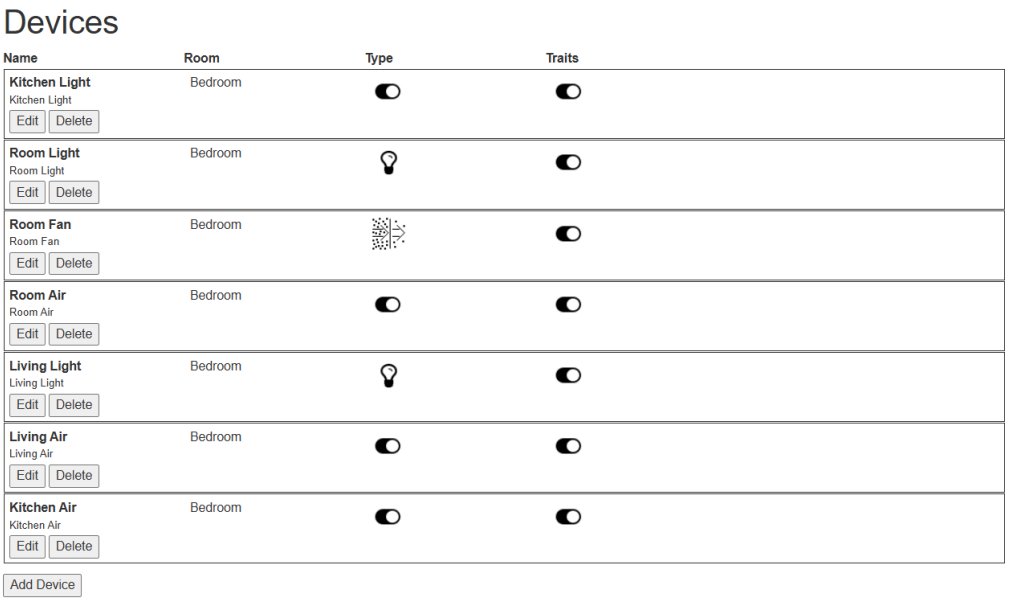


Figure 6.2 Setup for Node-Red Google Assistant Bridge

For figure 6.2, this setup is to create a bridge for Google Gemini connect to Node-Red with Google Home app. For the voice control I have created Kitchen Light and Kitchen Air to control Dining Room air conditioning and light. Next, for Living Room I have created Room Light and Room Air to control the Living Room Light and Living Room Air Conditioning. For Bedroom is special, the voice command that I created to control Bedroom Light, Air Conditioning and Humidifier are Room Light, Room Air and Room Fan. These are the voice commands that I decided to use to control my system.

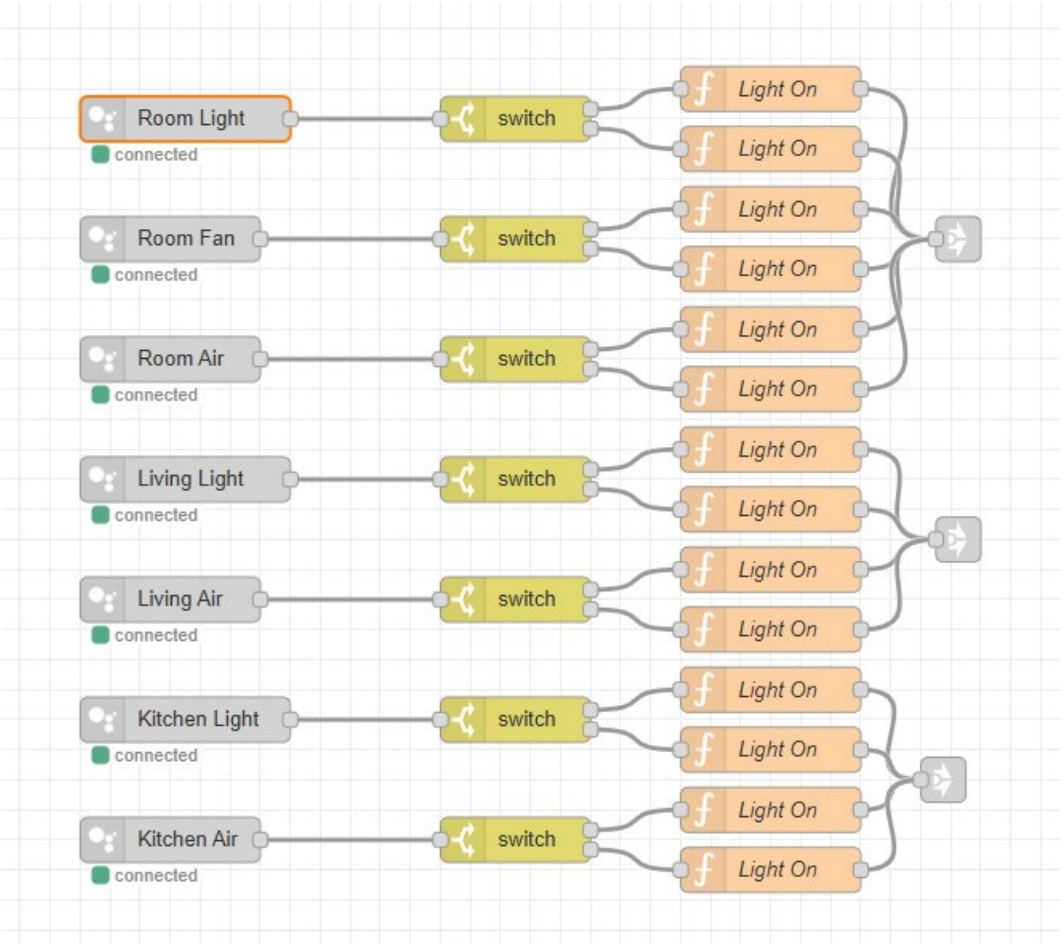


Figure 6.3 Node-Red Setup for Google-Home node

This figure shows that the way that how I connect the Google-Home node to their corresponding function and to their corresponding SVG. Each Google-Home node before use it must login to the Node-Red Google Assistant Bridge then it will automatically link to the devices that I created in the Node-Red Google Assistant Bridge.

Figure 6.4 Google Home Setup

The configuration on figure 6.3 if it successfully the Google Home will show like figure 6.4. It will show every device that created in Node-Red Google Assistant Bridge. When saw this in Google Home it means that Node-Red is successfully connected with Google Home. For now, the user able to voice control their system through Google Gemini pass through Google Home and send to Node-Red and control the system.

6.3 Project Challenges

The main challenge of this project is voice controlling. In first I have faced a lot of challenges to find a best way to voice control the node-red. It is easier to control directly from the GUI design I created for just add a microphone GUI design on it and let it able to receive the voice commands that I give out then it should be able to control it. But in this way, it is not so effective and convenient, so I decided to receive my voice command through my mobile phone.

1. Created Devices Limited by NORA with Google Home

For the beginning I have try to use NORA with Google Home to voice control my node-red flow to let it able to voice controlling my bedroom, dining room and living room.

But using NORA with Google Home have a main problem is NORA have a limited number of devices can be used with Google Home, so I have made me had to find another method to voice control my node-red flow since the devices created has been limited.

2. English Accent Issue

After that, I have successfully found another way to voice control the node-red flow. By using Node-Red Google Assistant Bridge. This way still works together with Google Home, but it can cooperate with Google Gemini to receive the voice command that I give out. In here has the main challenges that I have faced in this project. The challenges are our English pronounce accent is different with the US country so Google Gemini may take a lot of attempts to recognise the voice command given out. For example, in the voice command I have design like Room Light On to turn on the bedroom light, but Gemini will fail to receive the command given out, it will recognize to like prompting out a Chinese sentence and so on. Therefore, I will make me to have a few attempting until the Google Gemini have recognize the actual command and control the flows in the node-red.

6.4 SWOT

Strengths

1. Cost-effective and Time-efficient.

This project is mainly emulating the IoT devices in a virtual environment, node-red. So, the project had minimized the need for buying the physical hardware, speed up the development process and testing process.

2. Real-Time Monitoring and Control

The system that I design for this project allow the user to remote monitoring and control the devices, it has enhanced the user experience by making the system more convenience and functionality.

3. Enhanced Security

In this project I had also include some of the security features like smart locks, smoke detectors and CCTV cameras. This is to increase the safety of the user house environment, offer the user a real-time alerts and monitoring to their house environment when the alerts messaging is prompting out.

Weaknesses

1. Dependency on Internet Connectivity

The system that I design is relies on IoT protocols and remote applications like Telegram. So, any problem that is related to Internet could directly affect the reliability of and control of the devices.

2. Complex Integration for voice Control

Giving the voice control to node-red will face some of the challenges with some of the devices or platforms. For example, this project is designed to using Google Gemini work together with Google Home to receive the voice commands so it will have the challenge with Google Home integration and Huawei devices since Huawei devices currently are no longer support Google services.

3. Initial Setup Complexity

I design this project with a lot of software applications and devices. So, this project requires an extensive setup. For example, Telegram and Node-Red. Therefore, this project required all devices and applications are properly linked so that the system will be worked properly.

Opportunities

1. Market Expansion for IoT Solutions

The increasing of the demand for smart home solutions, this project able to be expanded to a wider audience, providing a more different IoT system that can be used in a various of home types.

2. Potential for Future Integration

The system that I designed for this project is flexible. The system is allowing to work together with other platforms and voice assistants. This had provided a further opportunity for expansion and user convenience.

3. User Feedback Integration

The system that I designed had the ability to gather the real-time user feedback. So, it had presented an opportunity for continuous improvement and making the system adaptable to change the user preferences.

Threats

1. Security vulnerabilities

The IoT system are apt to being hacking and data of the system may have the potential to been leaked out. Therefore, the system of this project will need to have a constantly security protocols update. So, the user's data and privacy can be protected.

2. Technological Advancements

The system may require a frequently updates or changes due to the evolution speed of IoT technologies and platforms. So that the system able to maintain their compatibility and competitive edge to others IoT system so that I make the system I designed is hard to be replace.

6.5 Objectives Evaluation

1. Facilitate Energy Efficiency

The objective of this project is to reduce energy consumption. This has successfully been accomplished through Telegram control with Node-Red. Node-Red will prompt out the alert message to the user Telegram account about whether the temperature is too low or too high, so the user is able to make decisions through the current temperature whether they wanted to turn on or off the air conditioning. The remote control via mobile devices is ensuring the user can easily turn off the application if letting on, so it can reduce the energy consumption.

2. Improving Home Security

Another objective of this project is to improve home security. This has also been successfully achieved by adding security components into the system such as Smart Locks, CCTV Cameras, Motion Sensors, Smoke Detector and Alarm System. The system that I designed for this project able to provide a real-time alert to the user Telegram account when something happens to the user house, by pop out the alert message to the user Telegram account and telling the user their current house environment status.

3. Enable Real-Time Monitoring to the Home Environment

One of the objectives of this project is to make a real-time monitoring IoT system. This is being achieved. I have designed the system able to send an alert message to the user Telegram account if anything happens to his house. For example, Fire alert messages or Thieves alert messages. Not only this, but the user is also able to check their house status through telegram too. The Telegram connection with Node-Red allows the user to monitor their house remotely, provide the user with control over their house environment from anywhere and at any time.

4. Improve Control and Convenience

The objective of this project is to design a IoT system that can improve the ability of the user to control the system in more convenience way. This has achieved by connecting Telegram and Voice Control through Google Gemini with Google Home to the Node-Red. This has allowed the user to control their home devices like light, air conditioning and so on remotely and can be able to give voice commands through Google Gemini and Google Home will control the Node-Red system. This had enhanced the user able to use the system in more convenient ways.

6.6 Concluding Remarks

In this chapter, having shown that the system is been developed by using Node-Red, Telegram and Google Gemini. Developed with this application that had enabling the efficiency of voice control and remote monitoring. The system also successfully hit the main objectives of this project, that is, the system will help to improve energy usage more efficiently; the system will be enhancing home security and always offering the user real-time monitoring through Telegram and even though with voice command

interfaces. Next is the main issue of the entire project is voice recognition problem due to our country English accent. In conclusion the entire smart home system focuses more on user usage convenience and the energy usage of the entire smart home system.

CHAPTER 7

7.1 Conclusion

Facilitate Energy Efficiency

The main objective of this project is to design a system that can improve the energy usage of the houses. This objective in my opinion is being achieved. It is because the smart home system that design for this project had allow the users to control the home devices such as air conditioners, lights and humidifier by their mobile phones. Using the apps such as Telegram and Google Gemini able the user to control their home devices when they are accidentally forgotten to turn it off. Besides in this project also had include a motion sensor in the car porch area. This will also reduce the energy consumption, the lights in the car porch only will turn on when it senses something is movement after a few seconds the lights will turn off again. By this design the main objectives of this project had been really achieved.

Enable Real-Time Monitoring of Home Environment

Another objective of this project was enabling real-time monitoring of home environment. In my opinion, this objective also been achieved. The system that designs for this project allowing the user to monitor their home environment in anytime and anywhere through their own telegram accounts and on Google Gemini. The user able to receive an immediate alert message in their telegram account when there is something happens in their home environment. For example, the house is on fire. Not only that the user also able to check their house status in telegram account such as lights, air conditioners, humidifiers, gate, security doors and also allow the user to control it when necessary.

Improve Home Security

One of the objectives of this project is to improve the home security. This objective also been achieved by this project. The system in this project had include a lot of security features devices such as CCTV, motion sensor, smoke detectors and alarm systems. These devices in the system able to send the user an alert message through telegram when there is a fire, break-in-attempt, wrong password entry on the security door. This security that been included had highly improve the home security let the house become more safety and let the user not so panic to their house when some emergency happens in their house.

Improve Control and Convenience

The last objectives of this project were to improve the control and convenience of the user. The system that designs for this project provide a several convenience control methods for the user. First is Telegram control. The user able to control the smart home system based on the user telegram account by clicking on the button that design and display on the telegram. Next, is the GUI control methods. The GUI control methods is a directly controlled methods. It allows the user to directly on the GUI to control the respective devices that on the current GUI. The most convenient control methods are using Google Gemini to be having a voice control to the system. Due to our country English accent issues that could faced when using Google Gemini to voice control the system and need to have a major improvement in the future. So, in my opinion, this objective is partially achieved

7.2 Future Works

1. Improve the Voice Control Functionality

The voice control function that used in the system is going through Google Gemini then pass through by Google Home. There is a major problem in this function, the accuracy of the voice command given by the user due to the country English accents and their pronunciation issues. In the future work can be more focus on the voice recognition in the system. So, it able to handle different country English accents and able to improve the accuracy of the voice commands given. This can be achieved by using a more advanced voice recognition system or having a AI system in it to help it to easily recognize the command given.

2. Work with Another Smart Home Platform.

The system that designs is work with Google Home and Telegram to control the devices in it. In future can plan to work with other smart home platforms such as Alexa, Apple HomeKit or more advanced smart home platforms. This could provide the user with more flexibility to different smart phones that had been used. It is because current system the voice control function cannot be used for the user that currently using a Huawei phone due to Huawei company is no longer support google services. This future works will let the system become more flexible to more types of smartphones.

3. User Interface and Experience Improvements

The GUI that design for this system can be further improved. This is to enhance the user experience. Let the GUI become more relative and smoother. The future work to be done in this part is to improve the GUI design from 2D into 3D and let the GUI is based on the user house design so it can let the user have a more understand and clearer real-time visual feedback on their home environment. A smoother and relative interface will improve the ease of the user interact with the system.

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Poster


IoT for Smart Home
WHAT IS IOT ?
It refers to the network of physical objects embedded with sensors, software, and connectivity, enabling them to collect and exchange data
WHAT IS SMART HOME ?
Smart home technology revolutionizes the way that we interact with our living spaces by connecting various devices, appliances, and systems into a unified network
IOT
SMART HOME
OBJECTIVE
• Boost Energy Efficiency – Automate lights and appliances for smarter power use.
• Enhance Security – Integrate alarms, sensors, and CCTV for safer living.
• Real-Time Monitoring – Track temperature, humidity, and security anytime via mobile.
• Smart Control – Use voice and mobile commands for seamless home control.
PROPOSED PROJECT
A smarter, safer Malaysian smart home system with:
• Complete IoT Coverage – Lights, gate, aircon, humidifier, curtains, and more.
• Enhanced Security – Alarms, smoke detectors, smart locks, CCTV, and window sensors.
• Local-Friendly Design – Based on a familiar Malaysian house layout for easy adoption.
CONCLUSION
Proposed Smart Home Solution
An integrated IoT system designed using a Malaysian house floor plan to enhance security, comfort, energy efficiency, and usability.
Key Features:
• Full Automation – Lighting, gate, curtains, aircon, and humidifier control
• Enhanced Security – Smart locks, alarms, smoke/vibration detectors, CCTV
• Local Relevance – Tailored to Malaysian homes for better adoption
Solves Previous Issues:
✓ Adds missing smart components
✓ Improves security coverage
✓ Provides a locally practical layout
Student : Jason Lim Jun Hong
Supervisor: Dr.Goh Hock Guan