SMART LIVING
Arduino Home Automation System

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GROUP 01

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Thank you all for being a part of this enriching experience

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1. Chapter 01

1. 1 Introduction

The most important objective of the home automation system will be to control and monitor a specific house. Let's jump back to history to see how the remote control was like back in the day. The PBS.org (pbs.org, 2020) says that the first ever remote controller was founded by Nikola Tesla to control a toy boat, and it was exhibited in 1898. According to Rebecca (Greenfield, 2011) the very first TV remote controller was founded in 1950 by the Zenith radio cooperation and it was called "Lazy Bones". According to the provided sources, since the last time the people need to ease off their lives with remote controls. Back in the day remote control was widely used.

This is the 21^{st} century and almost everything in the 21st century is being converted into smart technology. Nowadays even a car can be remote controlled with the phone and has advanced options like self-driving. So, why a house shouldn't be converted into smart. There are already several home automation systems released yet like Amazon Alexa, Google Home, and Home Assistant in the world. These things help to make the hard and busy lifestyle easier. But the problem with these systems is they are very expensive, and everyone cannot afford such a bigger price tag. Also, these devices do not provide the option to modify the source code, and they do not have the possibility to have gas sensors, rain sensors and auto door facilities.

The ESP32 microcontroller, with its advanced features and capabilities, provides an excellent platform for creating a cost-effective and customizable home automation system. The researcher's project aims to develop a smart home solution that allows users to control and monitor various devices in their house using a single interface. The system will consist of multiple modules, each responsible for controlling specific devices such as lights, fans, and appliances. These modules will be connected to the central hub, which will be powered by the ESP32 microcontroller. The hub will act as a communication center, receiving commands from the user's smartphone or tablet and sending them to the appropriate modules. To make the system more versatile, we will incorporate sensors such as gas sensors, rain sensors, and door sensors. These sensors will provide real-time feedback to the user, allowing them to take necessary actions in case of emergencies or unexpected events. For instance, if the gas sensor detects a high level of toxic gas, the system will automatically alert their smartphone.

1.2 Problem statements

For many people, the prohibitively high cost, coupled with additional installation and maintenance expenses, makes these systems impractical. Furthermore, the limited compatibility with different devices and systems complicates integration into existing homes or services, leading to additional costs and frustration. The lack of customization options adds another barrier, as users with specific requirements find themselves unable to tailor the systems to their needs, resulting in dissatisfaction with the overall user experience. Also, the lack of customization options exacerbates the challenges faced by users with specific needs or preferences. Many individuals have unique requirements, ranging from specialized device configurations to the use of specific sensor types or the desire for customized user interfaces. The incapability of existing home automation systems to adapt to these individual needs results in frustration and dissatisfaction with the overall user experience. Moreover, the proprietary nature of many commercially available home automation solutions restricts innovation and collaboration within the smart home community. Users are often confined to the features and functionalities provided by the system's manufacturers, limiting their ability to experiment, modify, or enhance the system according to evolving needs or emerging technologies. Considering these challenges, there is a compelling need for a home automation system that not only addresses issues of affordability, flexibility, and compatibility but also empowers users with the freedom to tailor the system to their specific requirements. Such a system would not only enhance accessibility but also foster a culture of innovation and collaboration within the smart home community, allowing users to actively participate in shaping the future of home automation technology. The proposed ESP32 home automation system aims to fill this void by offering an advanced, affordable, and customizable solution that encourages user engagement and adaptation to diverse needs.

According to the search results, the global home automation market is experiencing significant growth. The market is expected to reach a value of USD 136.5 billion by 2033, with a projected CAGR of 10.6% for the period 2023-2033. Statsca.com (Statista, 2021) argues that in the United States, the smart home market is projected to grow by 9.13% from 2024 to 2028, resulting in a market volume of US$55.0 billion in 2028. Smart Home Lady (Smart Home Lady, 2023) says that the smart home industry automation in U.S. households is projected to reach 53.9% by the year 2023. According to Statista (Statista, 2023) in Sri Lanka, the smart home market is also expected to grow, with a projected growth of 11.38% from 2024 to 2028, resulting in a market volume of US$204.8 million in 2028.As for the global impact of smart homes on climate change, smart home devices are enabling improvements to energy efficiency and sustainable living, with the potential to combat climate change by reducing emissions and energy usage.

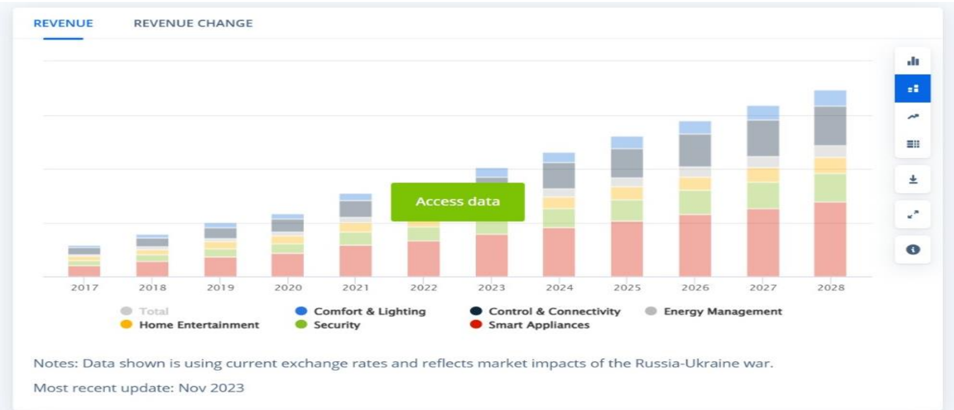

Figure 1.1 Global Smart homes comparison

Home automation systems have been found to reduce CO2 emissions, and early studies suggest that these systems can reduce CO2 emissions by 13%. 59% of US citizens are willing to pay more for smart home systems. According to Alexis Curls (Curls, 2023) this shows concern about climate change. The global home automation market is expected to reach a value of USD 136.5 billion by 2033, with a projected CAGR of 10.6% for the period 2023-2033. In the United States, the smart home market is projected to grow by 9.13% from 2024 to 2028, resulting in a market volume of in 2028.

Figure 1.2 Global Smart homes comparison

Statista (Statista, 2023) argues that, the Smart Home market in Sri Lanka shows a forecast revenue of US $ 133.1 million in 2024. Furthermore, it points to an expected annual growth rate of 11.38% from 2024 to 2028, resulting in projected market volume. 204.8 million US dollars by 2028. These statistics suggest a positive trajectory for the Smart Home market in Sri Lanka over the specified period.

In terms of household statistics and penetration rates Focuses on key statistics related to the number of active households participating in the Smart Home market. The report expects active households to reach a certain number by 2028. Additionally, it discusses the domestic penetration rate, indicating that it is expected to grow from 5.7% in 2024 to 9.5% by 2028. This indicates that Smart Home technology is increasing among Sri Lankan households.

Average income and global comparison the average income of an installed Smart Home in Sri Lanka is estimated at US$ 250.80. This metric gives an indication of the economic impact and consumer spending in the Smart Home market in the country. Furthermore, the paragraph compares this figure globally, emphasizing that the United States is expected to generate the highest revenue in the Smart Home market, with a projected revenue of US$38,800.0 in 2024. This global comparison helps to contextualize Sri Lanka's market situation. In the larger context of using Smart Home technology.

Briefly summarizes the rising adoption of Smart home technology in Sri Lanka as adoption trends and market overview. This indicates that the smart home market is gaining popularity in

Sri Lanka, driven by awareness and preferences for advanced technologies that contribute to a smarter and more connected living environment.

Figure 1.3 Sri Lanka smart homes region comparison

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Figure 1.4 Sri Lanka Smart homes region comparison

According to Alexis Curls (Curls, 2023), there are more than 300 million smart homes in the world and 60.4 million smart homes in the United States are reported to be actively using smart home systems in 2023, and 60% of its citizens say smart technology has a positive impact on their lives. has had an impact. It is predicted that smart home automation in US homes will increase by 53.9% by the end of 2023. Researchers suggest that the home automation market will be worth more than $81.6 million by the end of 2023.

Below is the number of smart homes used in the past years.

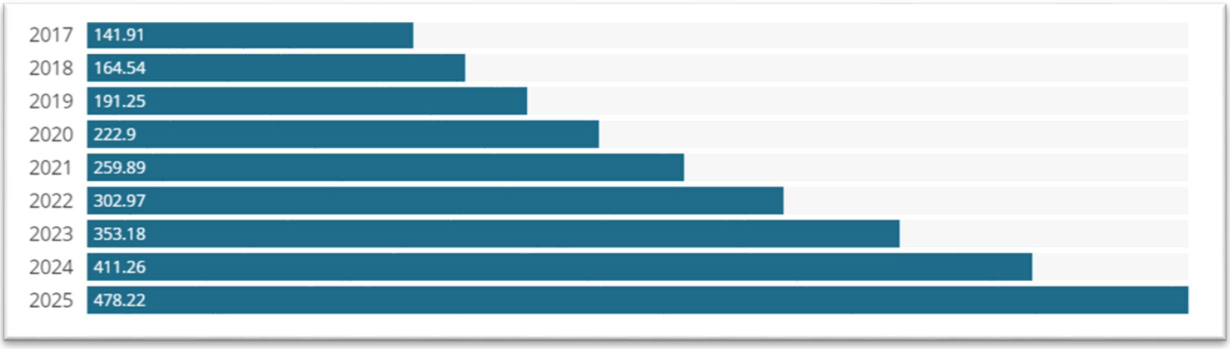


Figure 1.5 Number of Smart Homes Globally 2017-2025 (in Millions)

So mainly researchers could identified some general issues related home automation as following.

- Compatibility and Integration: One of the most common issues with home automation systems is compatibility and integration among different devices and systems.
- Security and Privacy: This can lead to problems such as sub-systems not integrating, insufficient features and functionality, and too many home automation control apps.
- Security and Privacy: Home automation systems can raise concerns about data protection and unauthorized access, which can compromise the security and privacy of the users.
- Ease of Use: Home automation systems should be user-friendly and easy to use, but some systems can be challenging to set up and control, leading to automation issues.
- Reliability and Stability: Home automation systems should be reliable and stable, but some systems may experience frequent issues such as power source drain, automation failures, and voice assistant problems.
- Cost-effectiveness: Home automation systems can be expensive, and cost-effectiveness is an important consideration for users.

So in order to solve those limitation as the Researchers the problem occurs, How can the researchers design and implement an efficient and user-friendly home automation system using Arduino technology that allows for the remote control and monitoring of various household devices? Also, how can the integration of the ESP32 microcontroller in home automation systems address existing challenges and provide an advanced, affordable, and customizable solution for effectively managing day-to-day home activities?

1.2.2. Research questions.

How come the Arduino home automation system can be used to address identified challenges in home automation and effectively manage day to day home activities?

1.2.3. Research motivation.

The research motivation behind this project is to create comforting routines inside a home by assuring safety and security using IT technologies.

1.2.4. Research aim

The proposed research aims to **fill the research gap by implementing Arduino technology** for home automation including new two innovative functions **rain detection and gas detection** sensors among other features.

1.2.5. Research objectives.

- To identify the problems with IOT based home automation systems.
- To analyze the needs of the customers of using home automation systems.
- To implement a cost-effective mobile app with a user-friendly UI to control and monitor the home.
- To evaluate the effectiveness of Arduino based home automation system

1.2.6. Research scope.

The proposed project scope aims to provide a tangible solution to identified challenges in home automation while providing valuable insights into future developments in integrating Arduino technology into smart home systems.

1.2.7. Project Deliverables.

- A functional Arduino based home automation system prototype.
- A user-friendly mobile application for remote control and monitoring.
- Evaluation reports describing system performance, advantages, and limitations.
- Documentation that provides insight into future implications and innovations in the field.

1.3. Literature reviews

1.3.1 Domain reviews.

According to Margaret Roos (Technopedia, 2023) automation is the creation and application of technologies to produce and deliver goods and services with minimal human intervention. The implementation of automated technologies, techniques and processes improves the efficiency, reliability and/or speed of many tasks previously performed by humans. Generally, automation is used to reduce labor or replace humans for the most menial or repetitive tasks. Automation is present in almost all verticals and locations, though it is most prevalent in manufacturing, utilities, transportation and security. For example, many manufacturing plants use an automated process in the form of robotic assembly lines. Human input is required only to define and monitor processes, leaving the assembly of various components to machines, which automatically transform raw materials into finished products. In the technology domain, the impact of automation at both the software/hardware and machine layers is increasing rapidly.

Celeste Tholen says (Security, May 02, 2023) Home automation allows access to home control devices from a mobile device anywhere in the world. While these applications can be used for home security systems, such as smart thermostats and sprinkler systems, autonomous programmable devices, home automation is more accurately described as smart light switches, appliances and smart outlets that connect heating and cooling systems to a network that can be controlled remotely. Houses this includes alarm systems and all doors, windows, locks, smoke detectors, surveillance cameras and other related sensors.

1.3.1.1Advantages of home automations.

Convenience→ Home automation systems offer users the convenience of controlling various devices and systems in the home through a centralized interface. This can include lighting, heating, cooling, security systems and more.

Security→ Home automation systems often include security features such as smart locks, surveillance cameras, and motion sensors. These increase overall home security by allowing users to monitor and control access remotely.

Customization and Personalization →Users can tailor home automation systems to suit their preferences and routines. This level of customization allows for a personalized and comfortable living environment.

Remote access→ with the help of mobile apps or online platforms, users can monitor and control their home automation systems remotely. This is especially useful for security purposes or to make adjustments while away from home.

1.3.1.2Disadvantages of home automation systems.

Cost→ a primary drawback of home automation systems is the initial cost of purchasing and installing the necessary devices and infrastructure. High-quality smart devices can be expensive, and retrofitting an existing home may require additional investment.

Complexity→ setting up and configuring home automation systems can be complicated, especially for non-technical people. Complexity can lead to difficulties in installation, troubleshooting and maintenance.

Compatibility→ Issues Different smart devices may use different communication protocols, leading to compatibility issues. Users should ensure that their devices are compatible with the chosen home automation platform to avoid integration issues.

Privacy and Security→ Concerns The increased connectivity of devices in a smart home raises data privacy and security concerns. Hacking or unauthorized access to smart devices can put residents' privacy and security at risk.

With the advent of voice-activated assistants for smart homes, smart home ecosystems, artificial intelligence integration, sensor and detection systems, user-friendly interfaces, energy efficiency and sustainability, and more, the field of home automation technology has grown. The field has advanced significantly. However, it is also critical to address significant issues such as affordability, ease of use, privacy and security, compatibility and integration, and stability and reliability. The future of home automation promises even more integration, personalization and intelligence in home automation systems due to the introduction of new technologies such as the Internet of Things (IOT), 5G connectivity and advances in sensor technology. Utilizing these state-of-the-art developments in the field, the proposed project proposal attempts to utilize these state-of-the-art developments in the domain. The researchers proposed project-specific applications by integrating Arduino technology for gas and rain detection. Through a broad exploration of Arduino's potential and a commitment to addressing specific challenges, this proposal aligns with the trajectory of the domain, making a forward-looking and impactful contribution to the field of home automation. (2023Symmetry Electronics).

1.3.2. Existing research.

According to Dave (Rye, 1999) Home automation technology has been evolving for over a century, with the first self-contained electric or gas-powered home appliances becoming viable in the 1900s. In 1975, the first general-purpose home automation network technology, X10, was developed, which primarily used electric power transmission wiring for signaling and control. Since then, home automation has become increasingly popular, with 1.5 million home automation systems installed in the United States by 2012. According to Taiwo (Taiwo, Ezugwu and Oyelade, 2022) researchers have been studying home automation technology for decades, with over 1,700 research papers published in the last five years alone. Grafiati (Grafiati, 2021) argues that, some relevant books on the topic include "Approaching Home Automation" by Hilary Payne and "Smart Home Automation with Linux" by Steven Goodwin.

According to Mikrut (Mikrut, 2019) today, home automation systems are more sophisticated and widespread, with smart homes integrating various devices and technologies to improve comfort, security, and energy efficiency. Despite the progress made, there are still issues with the current state of home automation, such as a lack of standardized security and data-sharing capabilities. However, the future of home automation is expected to bring even more advanced technologies and greater connectivity between devices and systems.

In 2023 November research was carried out in Computer Science and engineering student’s University of American International University in Bangladesh. According to Sayeduzzaman (Sayeduzzaman et al., 2023) this was aimed at creating an automated Secure Computing for

Next-generation System. They aim to create with the advancement of IoT technology, creating an automatically controlled security system based on artificial intelligence. The smart home automation with a security system was enhanced for the following reasons:

- To monitor and control home appliances from a distance.
- To conserve time and use energy electively.
- To monitor the camera-equipped security system

Research conducted at the Department of Computer Science, Western University, Romania, on May 15, 2021. This aims to create lighting switches that can be turned on and off using a smartphone or voice command, thermostats that adjust indoor temperatures and generate energy reports. According to Crisan and Butunoi (Stolojescu-Crisan, Crisan and Butunoi, 2021) consumption, or smart irrigation systems that start at specific times of the day. Research has been done on custom monthly schedules that control water wastage.

Figure 1 shows an example of a smart home that uses different IoT-connected utilities.

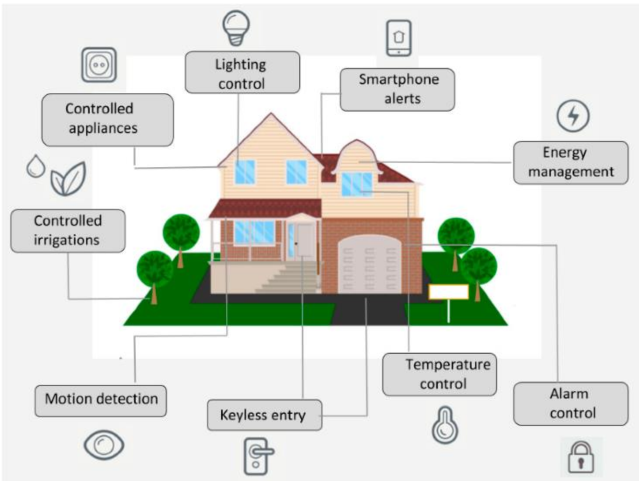


Figure 1.6

According to Majeed (Majeed et al., 2020) in 2020, October 29 research was carried. This research also aimed to develop an intelligent, secure and smart home automation system. The purpose of the grant to produce this is to achieve the objectives and provide an effective solution to overcome all the problems that arise on that day. Among their solutions: the proposed solution is less expensive because it did not use IP-based devices such as bulbs and lights. The proposed solution provides device recovery, which means when you restore a computer or other electronic device, you bring it back to the previous state and the proposed solution is a cloud-based solution, which means it controls home appliances over the Internet.

In 2020 march institution Mahindra Engineering College, Salem-Tiruchengode Highway, Mahendhirapuri, Mallasamudram West, Namakwa, Tamil Nadu - 637503, India research was carried they was showing their problems list down their sheets. According to Majeed (Majeed et al., 2020) they try to improve their problems with the Arduino system. These are their problems:

- Fire hazards in home or kitchen due to high voltage and human activity.
- Wastage of water from leakage of tanks and taps and overflow of water in tank when it is unnoticed.
- Eliminate the presence of unwanted gases.
- Maintains the moisture content of soil for plants.
- Ads high level security to home avoids unknown person to enter.
- Smart switches for avoiding electrical shocks.

Existing research summery

Table 1.1 research gap propose systems

Research ID	Light Controlling System	Auto Door	Auto Light	Rain recognition sensor	Gas recognition sensor
Research A	✓	x	✓	x	✓

Research B	✓	x	✓	x	x
Research C	✓	x	✓	x	x
Research D	✓	x	✓	x	x
Proposed Home automation System	✓	✓	✓	✓	✓

1.3.3 Existing systems.

1.3.3.1. Amazon Alexa – Echo Dot

Figure 1.7 Amazon Alexa

The Echo, Amazon's inaugural smart speaker, represents the standard and original model that marked the introduction of Alexa to the world. Serving as the flagship device, it has undergone significant evolutions since its initial release.

As Tyler says (Lacome, 2021), Amazon first introduced the Echo in 2014, initially available to select Amazon members before its broader release to the general consumer market the following year. Notably, Jeff Bezos, Amazon's founder, played a pivotal role in shaping the device's capabilities. Recognizing the importance of achieving low latency for a more natural conversational interaction with voice assistants, Bezos directed the Alexa team to reduce latency to one second, a groundbreaking feat at that time. This order exceeded the team's initial goal of achieving the lowest possible latency of two seconds. Once the team successfully met Bezos's directive, the first Echo was deemed ready for market launch.

According to Sharon Profits (Profits, 2021) the Amazon Echo Dot can do following tasks,

- Make phone calls and block unwanted calls.
- Control the smart home.
- Get important news.
- Play music with Spotify.
- Train the Alexa to practically do it.
- Shop with Alexa.

And many more.

1.3.3.2. Google Home/Nest

Figure 1.8 Google Home

As the Encyclopedia.pub (Encyclopedia.pub, 2020) says, Google Home, a series of smart speakers developed by Google under the Google Nest brand, allows users to interact with various services through the Google Assistant virtual assistant via voice commands. It supports both in-house and third-party services, enabling users to perform tasks like playing music, controlling media playback, receiving news updates, and managing smart home devices using voice commands. The initial release, Google Home, took place in the United States in November 2016, followed by global releases from 2017 to 2019.

Over time, software updates have expanded the functionality of Google Nest devices and Google Assistant. Notable features include synchronized music playback across multiple speakers, multi-user support distinguishing between up to six individuals by voice, and updates like hands-free phone calling, proactive reminders, visual responses on compatible devices, Bluetooth audio streaming, and the ability to add reminders and calendar appointments. The original Google Home speaker, launched in November 2016, had a cylindrical design with colored status LEDs on top. In October 2017, Google introduced two new additions to the lineup: the compact Google Home Mini and the larger Google Home Max. In October 2018, the Google Home Hub, a smart speaker featuring a 7-inch touchscreen, was released. In May 2019, Google rebranded Google Home devices under the Google Nest banner and unveiled a larger smart display known as the Google Nest Hub Max.

According to Sarah and Dale (Smith and Mitroff, 2021) Google Home can do following cool things.

- Talk to Google Assistant.
- Listen to music and podcasts.
- Control the smart home equipment.
- Set a timer, set an alarm, and perform a calculation.
- Call Uber and many more.

Simon Cocks & Jason Murdock say (Good Housekeeping, January 10, 2024) there isn't much difference between Alexa and Google, but there are a few key things to be aware of. Alexa can do a few things Google can't, such as track customer Amazon orders, detect irritation in voices, or whisper its responses when everyone's asleep when they prefer silence. Meanwhile Google has better natural language understanding to deal with multiple commands in one sentence. For example, it is possible to set an alarm and execute a plug without issuing both instructions separately. Google says its Assistant works with more than 50,000 smart home devices, but more than twice as many as Amazon. Although technically both Google and Alexa speakers can be kept under the same roof, more trouble is a reader.

The existing smart speaker systems, Amazon Alexa (Echo Dot) and Google Home/Nest, leverage advanced computational techniques to provide users with a seamless and intelligent interaction experience. Below are key features of their computational techniques and a reflective analysis of their significance.

Table 1.2 Advantages of existing systems

Amazon Alexa - Echo Dot	Google home/nest
Natural Language Processing (NLP) NLP is a core computational technique employed by Alexa to understand and respond to user commands conversationally. The ability to interpret and process natural language allows for a more human-like interaction, enhancing user experience.	Google Assistant's Knowledge Graph Google Assistant leverages its extensive Knowledge Graph to provide context-aware responses. This computational technique allows Google Home/Nest to offer more personalized and relevant information to users based on their preferences and historical interactions.
Low-Latency Voice Recognition Achieving low-latency voice recognition, as directed by Jeff Bezos, contributes to the responsiveness of the Echo Dot. Reduced latency enhances the natural flow of conversations with Alexa, making the interaction more intuitive and user-friendly	Multi-Device Synchronization The synchronization of music playback across multiple speakers is facilitated by advanced computational techniques. This feature enhances the user experience, allowing for a seamless audio experience throughout the home environment
Skill Development Kit Amazon's Skill Development Kit enables third-party developers to create custom skills for Alexa. This extensibility enhances the system's capabilities, allowing it to perform an extensive range of tasks beyond the built-in functionalities.	Smart Display with Visual Responses The addition of a smart display with visual responses showcases the evolution of computational techniques. Google Home Hub and Nest Hub Max utilize visual elements to complement voice interactions, providing users with more dynamic and interactive responses.

1.3.4. Existing Computational techniques.

Thermostats control home's temperature and ensure HVAC efficiency. As the central control console for a complex system of heating and cooling components, the thermostat plays a major role in cost savings and quality of life. There are different types of thermostats including manual, programmable and smart. Many people are adding devices like google home and Alexa because of their energy saving capabilities and proven cost-effective over time.is chosen as the second. But the price of the device and installation costs are higher than the old, traditional models. By Nafeesah Allen (Updated on August 22, 2023).

1.3.4.1. Smart thermostats.

Figure 1.9 smart thermostats

Smart thermostats are devices that allow users to remotely control the temperature in their homes and create energy-saving schedules that can reduce energy consumption. They are programmed with multiple settings, and users can control the temperature of individual rooms with the zoning feature and can be programmed to adjust based on conditions such as high humidity. Smart thermostat can save consumers 10% on their electricity bill when they install a smart thermostat at home or when they are away. However, smart thermostats are more expensive than manual thermostats and some units require professional installation. The software and touchscreen display panel can be difficult to learn, and if the smart thermostat system isn't installed and set up properly, users won't see the savings. .by (UGIHVAG, on 07 February 2022).

Table 1.3 Advantages and Disadvantages of Smart thermostats

Advantages	Disadvantages
Smart Thermostats Can Save Money: Smart thermostats can save consumers	Smart Thermostats Can Be Expensive:

money by optimizing heating and cooling based on user habits. They learn when they're at home or away, using "Eco Mode" to prioritize saving electricity. On average, users with smart thermostats save around 10% electricity bills. .by (UGIHVAG, on 07 February 2022).	The initial expense of smart thermostats can be a barrier, ranging from $100 to $250 or more. While energy savings can eventually offset the cost, the upfront investment may pose challenges for some consumers. .by (UGIHVAG, on 07 February 2022).
Smart Thermostats Are Easy To Use: Equipped with touchscreens and intuitive interfaces, smart thermostats are easy to navigate. Users can make temperature adjustments using smartphones, even remotely. Integration with virtual assistants like Alexa or Google Home enhances user control. .by (UGIHVAG, on 07 February 2022).	Installation Can Be Daunting For Some: Installation can be daunting for those unfamiliar with exposed wiring or lacking installation experience. Though instructions are provided, some users may find it intimidating. Compatibility with various HVAC systems also adds complexity. .by (UGIHVAG, on 07 February 2022).
Smart Thermostats Can Help With Maintenance: Smart thermostats help with maintenance by sending reminders for filter changes and notifying users about preventative maintenance. This proactive approach contributes to the longevity and efficient operation of HVAC systems. .by (UGIHVAG, on 07 February 2022).	Security Can Be An Issue The internet connectivity of smart thermostats raises security issues. As with any connected device, there's potential for security breaches or hacking. While manufacturers release updates, ongoing vigilance is required to address emerging threats. .by (UGIHVAG, on 07 February 2022).

1.3.4.2. Smart lock systems.

Figure 1.10 smart door lock system.

Smart door locks are an innovative device that has revolutionized traditional locking mechanisms, offering convenience, improved security and peace of mind to millions of homeowners. Smart door locks use advanced technologies like biometric authentication, PIN codes, and facial recognition to ensure that only authorized people can gain access to home. Unlike traditional lock systems where keys can be easily lost, copied or stolen, smart door locks minimize the risk of intruders. In addition, some smart door locks send instant notifications to User smartphone every time someone tries to access the system, providing an extra layer of security. However, Smart Locks can be expensive to fix if they fail, which is a given because they are battery operated. Moreover, like any other Internet-connected device, smart door locks are not completely immune to cyber threats, smart door locks are vulnerable to hacking attempts, which can compromise user home security. by Ellise Pierce (GEICO, 1996-2024)

Advantages and Disadvantages smart lock systems.

Table 1.4 Advantages and Disadvantages home lock systems

Advantages	Disadvantages
Convenience: Smart locks provide convenience by allowing users to create and manage special codes for guests or house sitters. These codes can have expiration times, offering flexibility in granting access. Changing codes is easy, eliminating the need to replace physical locks, especially	Potential For Hacking: While some smart locks remove the threat of lock picking, they may be subject to attempts by hackers to override the entry code that can unlock the door. On the plus side, the system may be able to notify user (and the police) if an unauthorized user

useful when anticipating visitors or when security concerns arise. By Ellise Pierce (GEICO, 1996-2024).	accesses the system. By Ellise Pierce (GEICO, 1996-2024).
Peace Of Mind: Smart locks offer peace of mind through activity tracking. Users can monitor entries and exits, ensuring awareness of who is accessing their home. Additionally, many smart locks enable remote checking of door status, allowing users to confirm whether the door is locked or unlocked from anywhere in the world using their smartphones. By Ellise Pierce (GEICO, 1996-2024).	Cost: Smart locks are significantly more expensive than lock-and-key systems and may require Bluetooth and Wi-Fi to install and operate the lock. Smart locks can be expensive to fix if they malfunction. By Ellise Pierce (GEICO, 1996-2024).
Protection From Lock Picking: Smart locks enhance security by eliminating traditional key slots that are susceptible to lock picking or bumping. While this doesn't guarantee complete security, it reduces the risk of certain break-in methods. It's important to note that the overall security of smart locks may vary and should be considered alongside other factors by Ellise Pierce (GEICO, 1996-2024).	

1.3.5. Refection.

In addition to home automation systems like google home, amazon Alexa, devices like smart lock systems and smart thermostats are used and these can be used to automate homes and not all facilities are available. Google home and amazon Alexa do everything from the same source, but smart lock systems and smart thermostats only do one specific thing with these devices. Part of this, analysts hope, is to create a home automation system that's easier than existing devices.

While existing studies have looked into home automation using various technologies such as IOT, AI, and cloud-based solutions, there is a definite gap regarding the widespread integration of Arduino technology into smart home systems. As the literature review reveals that only a limited number of studies have used Arduino systems for home automation purposes, the use of Arduino in the proposed system shows areas that are not widely explored based on the literature survey, so it fills the gap through the proposed survey by researchers.

As important as filling research gaps, understanding the advantages and limitations of Arduino in the context of specific applications adds valuable knowledge to the existing literature on home automation. The research aims to address a significant gap in the existing literature by investigating the feasibility, efficiency and practicality of Arduino-based home automation systems. This initiative holds great significance as it seeks to contribute valuable insights that could shape the future landscape of smart home technology. By exploring the advantages and limitations of using Arduino technology in the specific context of home automation, the research seeks to provide practical knowledge that can be applied to real-world scenarios. As a result, the findings of this study are expected to have a profound impact on society by influencing the development and implementation of smart home solutions. In the future, the results of the research project could revolutionize the way homes are automated, making them more accessible, efficient and user-friendly. Arduino-based system integration can pave the way for cost-effective and customizable smart home solutions that enhance the overall quality of life for individuals and families. Moreover, this research can lead to more innovations in the field of home automation by encouraging the use of Arduino technology for various applications beyond the scope of this study. As a result, society can see many Arduino-based solutions for various aspects of daily life, contributing to a more interconnected and technologically advanced living environment.

The research proposal underscores a critical intent to address a significant research gap in the field of home automation by implementing an Arduino-based system focusing on rain detection, gas detection, lighting control, and automatic doors. The central objective revolves around proactively identifying and addressing research gaps related to harnessing the potential of Arduino in smart homes. The initiative was motivated by recognition of the widespread acceptance and financial benefits associated with smart thermostats, a prominent part of current home automation trends. As research explores the field of smart thermostats, it extends beyond their current applications and focuses on Arduino's unique contributions and lessons learned during the development process. Acknowledgment of homeowners saving up to 8% on heating and cooling costs through smart thermostats, as highlighted in Hvac Tips & Tricks (August 8, 2023), highlights the growing consumer demand for energy-efficient solutions, further highlighting the potential for Arduino technology. . In this landscape. Despite the promising landscape, the research identifies persistent technological barriers that hinder the establishment of universal standards in the smart home industry. The literature review reveals a significant underutilization of Arduino technology in smart home systems, revealing a critical research gap characterized by a lack of extensive investigations and practical applications. This understanding acts as a catalyst for the proposed research, which aims not only to identify the gap but also to provide a tangible solution through the creation of an advanced home automation system.

In reflection, this research not only identifies the untapped potential of Arduino in home automation, but also positions it as a transformative initiative to fill this void. By proposing a practical demonstration through the development of a comprehensive system that integrates rain and air detection sensors, the research seeks to make a significant contribution to the development of smart home solutions. The proactive approach to addressing identified barriers and leveraging Arduino's capabilities positions this research as a promising endeavor with implications for the broader field of home automation and its technological evolution. The scope of the project includes several main components. They are described below.

- Filling research gaps

Implementation of a home automation system using Arduino technology to address the challenges in the field. Filling the gap identified through literature review by integrating rain detection and air detection sensors with other features into the proposed system.

- System Components

    - Light Control System: Arduino technology is included in this remote light control system project. All its controls are done through the android app.
    - Automatic Door Automating doors to improve convenience and security.
    - Manual door controlling system: Here the Arduino technology allows the user to control the door of the house through the android application.

- Rain Detection Sensor: Confirmation of a rain detection sensor to provide real-time information about weather conditions. The customer is informed through SMS.
- Gas Detection Sensor: Incorporation of gas detection sensor for air visibility and safety. Here the customer is informed through a text message.

- Feasibility and Feasibility Analysis

Evaluation of feasibility, efficiency and practicality of Arduino based home automation system in real world applications. Assessing the advantages and limitations of Arduino technology in the context of home automation.

- User-friendly mobile app

Development of a cost-effective mobile application with user-friendly interface for controlling and monitoring home automation system. Ensuring that the mobile application provides an intuitive and seamless experience for users.

- Evaluation of effectiveness

Conducting a comprehensive evaluation of the effectiveness of Arduino based home automation system. Gather user feedback and assess system performance in meeting identified needs and solving identified problems.

- Future Implications and Innovations

Exploring future implications and innovations that may emerge from integrating Arduino technology in home automation. Investigating how project findings impact the development and implementation of smart home solutions.

- Social Impact

Assess the potential social impact of research by providing practical knowledge that improves the quality of life of individuals and families. Investigating how Arduino-based solutions can pave the way for more accessible, efficient and customizable smart home solutions.

- User-Centric Design

Both systems prioritize user-centric design through natural language processing and personalized interactions. This reflects a commitment to making smart speakers more accessible and user-friendly.

- Continuous Evolution

The continuous software updates and feature additions demonstrate a commitment to evolving computational techniques. Both Amazon and Google strive to enhance the capabilities of their systems over time, adapting to user needs and technological advancements.

- Integration with Ecosystems

The integration of smart speakers with broader ecosystems, including smart homes and third-party skills, emphasizes the significance of computational techniques in creating versatile and interconnected platforms.

- Multimodal Interaction

The inclusion of visual responses in Google Home Hub and Nest Hub Max reflects a move towards multimodal interaction. This evolution in computational techniques expands the ways users can engage with the system beyond voice-only interactions.

- Personalization and Context Awareness

The emphasis on personalized responses and context-aware interactions highlights the sophisticated computational techniques in play. Both systems aim to understand users on a deeper level, providing more relevant and valuable information.

In summary, the research gap elucidates the untapped potential of Arduino in home automation. This unsolved problem serves as an opportunity to delve deeper into and harness the capabilities of Arduino technology within the context of smart homes. The proposed solution is multifaceted, intending not only to delineate the extent of the research gap but to showcase its practical implications through the development of a comprehensive system. By incorporating rain and gas recognition sensors, researcher’s research aims to underscore Arduino's unique contributions, thereby offering valuable insights to guide future research and development endeavors in the swiftly evolving field of Arduino-based smart homes.

1.4. Proposed Solution

The proposed solution for the home automation system, with a focus on gas and rain recognition sensors, seeks to address specific challenges and enhance the overall functionality of smart homes. Several reasons justify the need for such a solution.

1. Safety Concerns

- Gas Recognition: Gas leaks can pose serious safety hazards. An automated gas recognition system can detect leaks promptly, triggering alerts and preventive actions, thus ensuring the safety of occupants.

- Rain Recognition: Monitoring rainfall is crucial to prevent potential water damage, especially for homes in flood-prone areas. An automated system can trigger actions like closing windows or adjusting irrigation systems based on real-time rain data.

2. Energy Efficiency

- Gas Recognition: Efficiently managing gas-consuming appliances can lead to energy savings. An automated system can control gas appliances based on usage patterns and user preferences, optimizing energy consumption.
- Rain Recognition: Adjusting energy-intensive systems like heating or cooling based on weather conditions, informed by rain recognition, can contribute to overall energy efficiency.

3. Convenience and Comfort

- Gas Recognition: Automation allows users to remotely monitor and control gas-powered appliances, providing convenience and peace of mind.
- Rain Recognition: Automated responses to rain events, such as closing windows or adjusting outdoor lighting, enhance the comfort of living spaces.

4. Preventing Property Damage

- Gas Recognition: Timely detection of gas leaks can prevent potential property damage and financial losses.
- Rain Recognition: Taking preventive actions based on rain data can protect homes from water-related damage, preserving property value.

5. User-Friendly Interface

- Gas Recognition: Providing a user-friendly interface for gas monitoring allows users to easily interpret information, set preferences, and receive alerts.

- Rain Recognition: A user-friendly interface for rain monitoring enables homeowners to make informed decisions about outdoor activities and property maintenance.

6. Remote Monitoring and Control

- Gas Recognition: Enabling remote monitoring and control of gas appliances enhances security and provides flexibility for users who are away from home.
- Rain Recognition: Remote monitoring allows users to stay informed about weather conditions affecting their homes, enabling them to take necessary actions.

7. Adaptability to Local Context

- Gas Recognition: Different regions may have varying gas usage patterns and safety regulations. An adaptable system can cater to local needs and ensure compliance.
- Rain Recognition: Adapting the system to local weather patterns ensures that automated responses are relevant and effective.

8. Advancements in Technology

- Gas Recognition: Leveraging advancements in gas sensor technology, machine learning, and connectivity enhances the accuracy and reliability of gas detection.
- Rain Recognition: Integrating advanced rain sensors and cloud-based solutions ensures real-time and accurate monitoring.

9. Key features of systems
   - Gas detection control systems.

     The system includes advanced air detection sensors strategically placed in the indoor environment. These sensors can detect a variety of gases, including potentially harmful ones such as natural gas or propane. In the event of a gas leak, the system initiates an immediate response, such as shutting off the gas supply, sending warnings to homeowners, and activating ventilation systems. User-friendly interface allows remote monitoring and control of gas appliances, ensuring safety.

- Rain detection system.

  The rain detection system uses high-precision rain sensors to monitor real-time weather conditions. When precipitation is detected, the system can trigger automatic responses such as closing windows or adjusting outdoor fixtures. This feature prevents water damage, improves property conservation, and contributes to energy efficiency by optimizing resource use based on weather patterns.

- Auto door controlling system.

  The system includes smart door sensors that detect door conditions, providing insight into home security and access points. Increasing the security of the home, when any person comes to the front door, the user is informed by a message and the door is closed based on the user's authenticity.

  And the user can operate the door by auto door controlling system in normal situations.

- Manual door controlling system.

  Here the application can operate the door normally through the android system. There the door is operated according to the customer's decision.

- Lighting control systems.

  Lighting control systems allow users to remotely manage and customize the lighting environment of different rooms. Through the user-friendly interface, homeowners can set lighting schedules, adjust brightness levels and create personalized light scenes. This feature not only saves energy, but also improves the comfort and aesthetics of the living environment.

Advantages of proposed system

Table 1.5 Advantages of proposed systems

Enhanced Safety	Gas recognition and door open recognition systems contribute to a safer home environment by detecting potential hazards and security breaches.
Property Preservation	The rain detection system prevents water damage by initiating automated responses, safeguarding the property and its value.
Energy Efficiency	Auto lighting systems and light controlling systems optimize energy usage by adapting to occupancy and natural light conditions.
Convenience	Remote monitoring and control capabilities provide homeowners with convenience, allowing them to manage various aspects of their home regardless of their physical location.
Adaptability	The system is designed to adapt to local weather patterns, gas usage norms, and user preferences, ensuring relevance and effectiveness.
User-Friendly Interface	The intuitive user interface simplifies interaction with the system, making it easy for homeowners to monitor, control, and customize settings according to their preferences.

1.5. Functionality & Non Functionality of the system.

1.5.1. Functionalities

- Login – A registered user can provide the email and password to login the system. When the user clicks the login button the app will compare the given data with the firebase database if the data match with the firebase data user will be directed to the dashboard. Else the data does not match, the app will show a error message.

- Register – When a new user register, he/she will have to provide the serial number in the esp32 module, first name, last name, birthday, phone, address, email, and password and confirm password. Then the application will perform a data validation process to confirm if the given data is correct. If it is validated, the user will be registered and will be able to login using the given email address and password.

- Gas detection system – when the gas detection sensor (MQ2 module) detects LP gas, Alcohol, Propane, Hydrogen, CO, or Methane. The module will send a signal to the esp32 module. Then the ESP 32 module will upload the detected data to the firebase storage. If user provided conditions are satisfied, the user will be alerted with a system notification on the app.

- Rain detection system – When the rain detection system (YL-83 module) detects water on the sensor’s surface it will send a signal to the ESP32 module. Then the ESP32 will upload the detected data to the firebase.

- Control Lights remotely with the application – If the user needs to control light manually .user can controls specific light in their home .when the user click the application interface button, the button send signal to the firebase console and firebase send to the signal , the LDR will send the fetched data to the ESP32 module. If the given condition by the user is satisfied, the ESP32 module will turn on the lights.

- Auto Door controlling system – There are two methods in the auto door system. User can set the system to auto open door when the system detects a person in the door. Or user can set the system to send a notification to the user’s phone when the system detects a person in the door. If the user gives the approval to open the door the system will open the door.

- Manual door controlling system – Here the application can operate the door normally through the android system. There the door is operated according to the customer's decision.

- Update profile - Registered users can have the ability to update their profile information. In the mobile app, provide a dedicated section where users can modify details such as phone number, address, or other personal information. Then the data will be validated and uploaded to the firebase.

- Add home user- A registered user (customer) can add home users to the android system under the serial number where only 5 users can be added. Also registered user can remove home users based on their needs.

- Password reset - Registered users can have the ability to update their profile information. In the mobile app, provide a dedicated section where users can modify details such as phone number, address, or other personal information. Ensure that changes made to the profile are reflected in the Firebase database.

- Logout – Enable users to log out of the system securely. Include a logout button or option in the app's dashboard or settings. When a user logs out, clear any locally stored session data and ensure the app requires Re authentication for access.

- Admin interface- • Admin Interface-Registration Admin Interface Admin can login to admin panel where username and password add new serial number and go to admin interface. Full admin interface has admin panel features like add new admin, show all added serial number, and show all users and admin panel logout. Here the data is accessed and updated in the Firebase console. Also, if admins forget the password, they can change the password through the Firebase console by using email for admin usernames.

1.5.2. Non functionalities.

Non-functional requirements are constraints imposed on a system that define its quality attributes. They refer to general properties that provide a good user experience and improve performance, accuracy, maintainability, auditing, security, error handling, reliability, scalability, usability, and quality of capacity. Functional requirements mentioned by researchers in the context of a home automation system:

- Security→ The safety non-functional requirement emphasizes protecting the privacy of the home automation system and the user. This includes implementing strong encryption protocols, secure user authentication mechanisms, and protection against unauthorized access. The system is expected to comply with industry standards for cyber security, ensuring that user data, device communications and sensitive information are protected from potential threats.
- Reliability→ Reliability is crucial for a home automation system to run smoothly without errors or interruptions. The system must continuously perform its intended functions without unexpected shutdowns or failures. This includes thorough testing during development, incorporating failure mechanisms, and proactive monitoring to identify problems and fix them quickly. This is expected to instill confidence in the users about the stability and reliability of the system.
- Use→ Usability focuses on the user experience, emphasizing that the home automation system should be easy to use and understand. This includes an intuitive interface, clear

navigation and simple controls. User documentation, tutorials and customer support help users easily set up and manage the system.

- Scale→Scalability ensures that the home automation system can accommodate future growth and expansion. Architecture and infrastructure must be designed to handle increased devices, users, or functionality without significant degradation in performance. Expect the system to evolve with user needs and technological advances without requiring a complete overhaul.
- Maintainability→ Maintainability focuses on the ease with which the home automation system can be maintained, repaired or upgraded. Troubleshooting includes clear documentation, regular software updates, and accessible hardware components. Designing the system with modularity in mind allows seamless replacement or addition of components and ensures that maintenance can be performed without disrupting overall functionality.

These non-functional requirements are essential in shaping the overall quality and effectiveness of a home automation system. They prioritize aspects such as user privacy, system stability, user-friendly interaction, adaptability to future needs, and ease of maintenance. Addressing these needs ensures a secure, reliable and user-centric smart home experience.

1.6. Software development methodology

The software development life cycle is the procedures involved in designing, developing, modifying and maintaining software (SDLC). Developers use this technology to design and create sophisticated software for platforms such as video games, computers, cloud deployments, and mobile devices. Observing the SDLC procedure helps in output optimization. The term "life cycle" was first used in the field of information technology in the 1950s and 1960s to describe the stages of development of a new computer system, but is now more commonly used to describe the entire software production process.

Software Development Life Cycle (SDLC) is very important because it ensures that the right people are deployed for the right tasks at the right time. A systematic approach to software development increases the probability of success of the user project. Among the advantages of SDLC are:

- Awareness of user needs and purpose of the software
- Identify risks at an early stage
- Establish the procedures the user will follow to deliver their solution, such as developing functional specifications or prototypes.
- Check that everything is on track by measuring the user's progress against goals.

SDLC generally follows the seven phases outlined below. Written by Coursera Staff • (Updated on Nov 29, 2023).

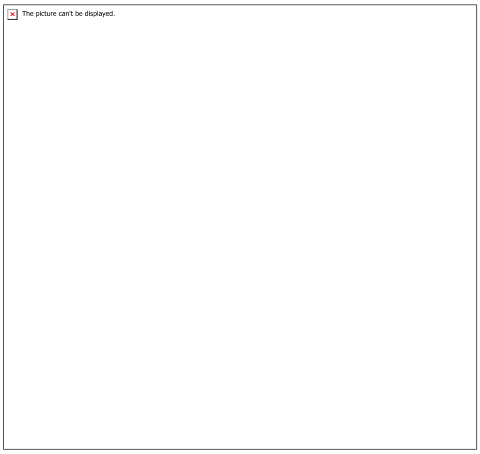


Figure 1.11 software development life cycle.

Software development patterns are systematic approaches or frameworks used in designing, testing, implementing, and maintaining software. Software Development Life Cycle (SDLC) can be managed in an orderly and structured manner with the help of these models. Different models handle different aspects of software development in different ways. These are some popular models for software development.

- Waterfall Model
  This paradigm takes a sequential, linear approach, requiring each step to be completed before moving on to the next. Planning, requirements, design, implementation, testing, deployment and maintenance are the steps that go through it.
- Agile Mode
  Agile is a systematic, iterative methodology that prioritizes adaptability and flexibility. It breaks the project into manageable chunks with little advance planning, enabling changes as the project develops.
- Repetitive format
  The development process is done in repeated cycles according to the iterative model. Each iteration expands on the knowledge of the one before it, enabling adjustments and improvements in the iterations that follow.
- Spiral Form
  Waterfall and iteration models are combined in the Spiral model. Design, risk analysis, engineering, and evaluation are all done in cycles, with each cycle representing a different stage of development.
- V-Form (Verification and Validation Form)

V-Form is an extension of the waterfall paradigm that emphasizes the interaction between the development and testing phases. These are tests for each stage of development.

- Incremental Model

  This approach breaks the system down into more manageable, smaller components. Every component has been expanded and improved with each release bringing further capabilities.

- RAD Model (Rapid Application Development):

RAD is an agile, adaptive approach that focuses on rapid development and iteration. It involves user feedback and iteration throughout the development process.

Agile is considered the best SDLC methodology for a home automation system because it is a flexible software development process that emphasizes customer collaboration and efficient collaboration between development and operations teams. , 2024). It works particularly well in settings where automation, continuous integration, and continuous delivery (CI/CD) provide an efficient and responsive software development lifecycle. Agile methodology enables the many components of a home automation system to work together effectively, at scale, and flexibly. Agile style puts the customer first, which is critical for a home automation system that seeks to increase end-user convenience, safety, and energy efficiency. By Somosree Roy (November 11, 2022) is a Community Contributor.

The choice of **agile methodology** for home automation research is primarily driven by the characteristics of the project identified as a short-term research effort. Due to the nature of the project, which is characterized by a relatively short duration, researchers have opted for a fast-track methodology in conducting home automation research. Agile methodologies are well-suited to projects with evolving requirements, quick iterations, and flexible requirements. In the context of this short-term research initiative, the agile iterative and incremental approach allows for continuous adaptation of research goals, quick feedback loops, and efficient collaboration between team members. An agile emphasis on customer collaboration and responsiveness to changing needs aligns with the dynamic nature of home automation research, where technology and user needs can evolve rapidly. By adopting agile practices, the research team can effectively manage the complexity of the project, respond quickly to emerging insights, and deliver valuable results within the prescribed time frame. Furthermore, agile methodologies promote close communication and collaboration within the research team, fostering a responsive and adaptive work environment. This collaborative aspect is particularly useful in conducting research as it facilitates knowledge sharing, quick decision-making and the ability to pivot research directions based on real-time findings.

In the proposed home automation system, the main component would be an ESP32 micro controller. Researcher's methodology revolves around a modular design approach, allowing for enhanced flexibility and customization. The system is designed to accommodate various sensors, including gas sensors, rain sensors, and door sensors, providing real-time feedback to enhance safety and convenience. These sensors are seamlessly integrated into modular units, each responsible for controlling specific devices such as lights, fans, and appliances.

The central hub, powered by the ESP32 microcontroller, acts as a communication center. It receives user commands from smartphones which are upload to the firebase database to respective modules, ensuring uninterrupted interaction with the home automation system. This modular and distributed approach not only streamlines the system but also allows users to tailor the configuration to their specific needs. Below are methodologies that will be used to finalize the proposed system.

1. Requirements gathering - This stage will involve identifying the project's objectives, scope, and deliverables. It will also involve understanding the stakeholders' needs and expectations.

2. Design - Based on the requirements gathered, the project team will develop a detailed design for the solution. This stage will involve creating wireframes, UI designs, and functional specifications using Android Studio's design tools.

3. Development: The development stage will involve implementing the design using Java Language and compulsory Arduino components such as breadboards, resistors, capacitors, LEDs, buttons, etc. The project team will use Android Studio as the primary Integrated Development Environment (IDE) for Android Studio and Arduino IDE for programming the Arduino components. The data collected from these components will be stored in Firebase Database using ESP32 Module's built-in Wi-Fi capabilities or an external

Wi-Fi module connected to ESP32 through Arduino components such as Ethernet Shield or W5100 Ethernet Module.

4. Testing - The project team will perform thorough testing of the solution to ensure its functionality, performance, and reliability. This stage will involve unit testing, integration testing, system testing, and acceptance testing using Android Studio's built-in testing tools and an Android based phone will be used as the testing subject.

5. Deployment - Once the solution is tested and approved, it will be deployed to the production environment using the Firebase database. This stage will involve configuring the servers, databases, and network infrastructure to support the solution using GCP's console or command-line tools.

6. Maintenance - After deployment, the project team will provide ongoing maintenance and support for the solution. This stage will involve monitoring system performance, addressing any issues that arise, and making necessary updates or upgrades as required using Android Studio's debugging tools or Firebase’s monitoring tools

The System development Map with agile methodology

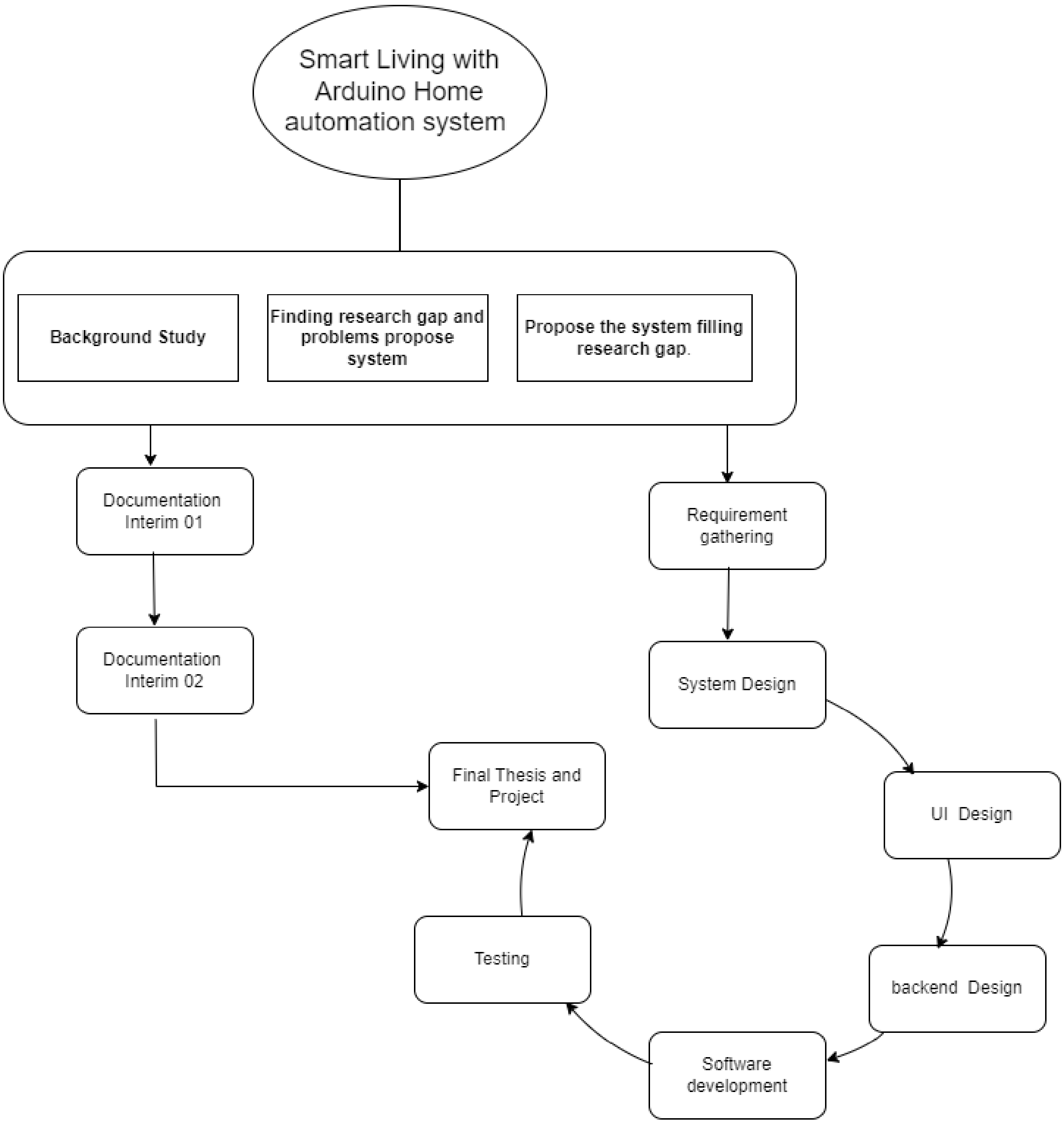


Figure 1.12 System map with agile methodology

2. Chapter 2

2.1. Feasibility study report.

According to Julia Martin in 2023 (Asana, June 27, 2023) A feasibility study, sometimes called a feasibility analysis or feasibility report, is a way to evaluate whether or not a project plan is likely to succeed. A feasibility study evaluates the feasibility of the project plan to judge whether or not the project can go ahead with it. A feasibility study should be conducted after the initiation of the project, but before any work actually begins. The study is part of the project planning process. In fact, it is often done in conjunction with a SWOT analysis or project risk assessment, depending on the particular project.

Feasibility study help to:

- Narrow business alternatives.
- Create documentation about the benefits and detriments of proposed initiative.

Technical feasibility, financial feasibility, market feasibility and operational feasibility are the four basic components of a feasibility study. Although most feasibility studies actually include a review of the four elements, these can also be seen as four types of feasibility studies.

1. Technical Feasibilities.
2. Financial feasibilities.
3. Marketing feasibilities.
4. Legal and Regulatory feasibilities.
5. Social Feasibilities.

Feasibility studies have been conducted for home automation systems to assess various aspects of implementing such systems. Lin (2019) presented a new smart home system architecture that facilitates demand-side management with distributed and embedded flexible edge analytics, demonstrating the feasibility and efficiency of the proposed architecture (Lin, 2019).

Additionally, Choi et al. (2020) conducted a pilot feasibility study on the use of an Internet-of-things smart home system for healthy aging in older adults, highlighting the practicality and potential benefits of such a system in residential settings (Choi et al., 2020). Furthermore, Jabber et al. (2019) designed and developed a cost-effective and hybrid IoT-based home automation system with a user-friendly interface emphasizing technical feasibility and user acceptance of the system (Jabber et al., 2019; . Reda et al., 2022) standardized and supporting smart home scenarios using OWL and SWRL rules, demonstrating the feasibility of the proposed approach in validated contexts (Reda et al., 2022). Moreover, OO et al. (2022) developed an IOT-based home automation system using a REST API architecture aimed at controlling electronic devices from a distance, demonstrating the feasibility of remote control and automation (OO et al., 2022).

2.1.1. Technical Feasibilities of developing system.

Hardware integrations

In the area of hardware integration for a home automation system, the focus is on anticipating and addressing challenges that may arise in the future. As the technology landscape evolves, it is critical to consider not only the current compatibility and connectivity of devices, but also their ability to adapt to emerging standards and advancements. When considering the integration of hardware devices such as smart lights, thermostats, Gas, rain and sensors, choosing a platform or standard is key. Choosing a platform that not only meets current needs but also aligns with future developments ensures a sustainable and future-proof solution. Furthermore, Wi-Fi, a widely used and versatile standard, offers high data transfer rates and wide coverage. However, it is essential to consider possible advances in Wi-Fi technology and standards to ensure that selected devices can seamlessly integrate with future Wi-Fi iterations. To integrate future-proof hardware, staying abreast of industry developments and participating is essential.

Communication protocols

In the field of communication protocols for future home automation systems, the selection process becomes more critical as the technology landscape evolves. Foresight in selecting appropriate communication protocols is essential to ensure seamless operation of the system in the face of emerging devices and standards. Emphasis on interoperability is paramount, recognizing that different devices may adopt different communication protocols. Future proofing the home automation system requires not only compatibility with existing protocols but also the ability to adapt to new and emerging standards that may take precedence. This includes an ongoing commitment to monitoring industry developments and a proactive approach to integrating support for new communication protocols that align with the evolving needs of the smart home ecosystem. Security considerations play a major role in the selection of communication protocols for future systems. With cyber threats on the rise, it is critical to ensure that the protocols chosen provide robust and up-to-date security features. This includes encryption methods, authentication mechanisms and secure data transmission practices. Anticipating potential security challenges and adopting protocols with a focus on resilience to emerging threats is essential to protecting the integrity and privacy of the home automation system. Future home automation systems must be designed with a holistic view of interoperability, not just between devices within. Not just the system but with external ecosystems. Integration with emerging Internet of Things (IOT) platforms and standards can improve overall system connectivity and interoperability, paving the way for a more interconnected and intelligent living environment. Considering the potential convergence of communication technologies such as 5G network integration. With home automation, this can be useful in preparing the system for future connectivity requests.

User friendly interface design:

When envisioning the future of home automation system user interface design, a proactive and user-centric approach is critical. As technological advancements shape the way users interact with their smart homes, developing an intuitive and user-friendly interface emerges as a critical component in ensuring widespread acceptance and adoption.

Future user interfaces must go beyond current standards and embrace a multifaceted approach that caters to different user preferences and technical expertise. A mobile app, a key component of contemporary smart home ecosystems, will remain a central control center. However, anticipating changes in user behavior and technology trends suggest that the future may see a proliferation of interaction modes beyond traditional touch-based interfaces. Voice control in particular is likely to become an integral part of future home automation systems, gaining prominence. . As natural language processing and voice recognition technologies advance, integrating robust voice control capabilities into the user interface gives users a hands-free and convenient way to manage their smart home devices. Moreover, considering the potential rise of augmented reality (AR) and virtual reality (VR) technologies, exploring interfaces that leverage immersive and spatial computing experiences may be a promising avenue for research. Accessibility for users of varying levels of technical familiarity. As the user base expands, considerations for inclusion, such as accommodating people with disabilities or older users, become increasingly important in shaping the future user interface landscape. The researcher's research, it is recommended to explore design principles that prioritize personalization and customization that allow users. To tailor the interface to suit their particular needs and preferences. Additionally, a focus on data visualization and contextual awareness can enhance the user experience by providing meaningful insights into the status and interactions of smart home devices. Conducting user experience (UX) studies and gathering feedback from potential users can help refine design and functionality. Interface to meet the evolving expectations of smart home users in the future.

Energy Efficiency:

Explore ways to make the home automation system energy-efficient. This could involve optimizing the power consumption of connected devices, implementing scheduling algorithms, and integrating energy monitoring features. Consider the environmental impact and cost savings associated with energy-efficient solutions.

Reliability and Redundancy:

Build redundancy and reliability into the system to prevent single points of failure. Consider backup mechanisms, failover strategies, and recovery procedures to ensure continuous operation even in the event of device failures or network issues.

2.1.2. Financial feasibilities for developing systems.

2.1.2.1. Initial investments

c. Mitchell says (smart capital mind, January 01, 2024) an initial investment is the initial amount required to open an account or establish a buying relationship.

When developing a financial feasibility study for home automation system research, it is essential to assess the project's potential costs, revenue streams, and overall financial viability. One key aspect to consider is the initial investment required to develop and deploy the home automation system. This includes costs related to hardware components, software development, infrastructure setup, and any research and development costs.

Some examples of initial investment costs for a home automation system:

- Buying smart devices like smart thermostats, lighting systems, security cameras and a central hub.
- Installation charges for setting up devices and infrastructure.
- Additional equipment required for integration such as gateways, routers, and controllers.

Depending on the size and complexity of the home automation system, these costs can vary. For example, a basic setup for a small home can cost thousands of dollars, while a comprehensive offering with high-end tools and advanced features can cost more than $50,000.To ensure a detailed financial feasibility study, it is critical to research and analyze the costs associated with each aspect of the home automation system. This includes understanding market demand, pricing strategies and potential revenue streams to determine the overall financial viability of the project.

2.1.2.2. Operating cost

Operating costs of a home automation system can include monthly subscription fees for cloud services, data charges, energy consumption of connected devices, and ongoing maintenance costs. Here are some references and additional information about these factors.

The researcher's propose software cost:

Table 2.1 Cost estimation

Materials	Cost
ESP 32 Module	5.9$
MQ2 Gas Sensor	1.86$
Relay Module	0.76$
Ultrasonic sensor	0.88$
Servo Motor	1.20$
DHT11 Temperature and Humidity Sensor	1.23$
Wires and Led bulbs	0.94$

The researchers suggest that the total cost of materials for the system is less than $15. And considering the cost of development and maintenance, researchers can bring the system to market for less than $20.

- Monthly charges and energy consumption

Monthly fees, data charges and maintenance costs for cloud services are part of ongoing operational costs. Energy consumption of connected devices is a significant factor in home automation system operating costs.

- Research and Development Expenses

Research and development of technology solutions in the smart home automation business can cost anywhere from $500,000 to $2 million, including ongoing research and development activities.

- Smart Home Automation Application Development

Research costs for home automation software range from $50 to $350, and ongoing UX design and UI design costs are also part of development costs. Harni oza (hyperlink information system, 23 June 23) says.

- Installation and Maintenance Cost

Installation fees for setting up devices and infrastructure are part of the initial investment cost ongoing maintenance costs include the cost of repairing or replacing devices, updating software, and fixing any problems. By HomeAdvisor (HomeAdvisor, Dec 14, 2022).These references provide a detailed understanding of the various operating costs and development costs associated with home automation systems.

2.1.2.3. Energy saving

Smart thermostats are known for optimizing heating and cooling based on occupancy and preferences, leading to potential energy savings. According to Consumer Reports, smart thermostats can help many users save money, and with real-world data collected by the Environmental Protection Agency, smart thermostats that meet Energy Star criteria save users an average of 8 percent on their utility bills. Posted by Liam McCabe on August 17, 2022 (cr Consumer Reports, May 5, 2023).

The Energy star program states that on average, savings from smart thermostats are approximately 8% of heating and cooling bills, or $50 per year, with the potential for greater savings based on climate and personal comfort preferences.

Well-known HVAC Company Trane emphasizes that smart thermostats save money through precise temperature control, adaptive learning and reduced energy waste. They note that smart thermostats make it easier to monitor and manage energy costs, and that savings vary based on factors such as climate and energy rates. (HVAC TIPS & TRICKS, August 8, 2023)

The ENERGY STAR program emphasizes that smart thermostats bearing the ENERGY STAR logo have undergone an independent certification process based on real-world field data to demonstrate energy-saving capabilities. Common features of smart thermostats include geo-insulation, remote control, and low-power standby mode.

Discussions on platforms like Reddit generally support the idea that smart thermostats can save money on heating bills, with users sharing their experiences of minimal savings compared to traditional programmable thermostats but emphasizing the convenience and extra features that smart thermostats offer.

In summary, smart thermostats can save energy and lower utility bills, with average savings of approximately 8%. However, actual savings may vary based on factors such as climate, personal preferences, and the specific features and capabilities of a smart thermostat.

What the society is expected to provide in terms of financial capacity?

The financial feasibility study conducted for the home automation system plays a key role in ensuring its value and usability to users. By thoroughly assessing the initial investment required for hardware components, software development, infrastructure setup and additional integration equipment, the system is positioned to deliver not only state-of-the-art technology but also financial viability. Mitchell's definition of initial investment as the amount required to open an account or establish a purchasing relationship resonates with the initial costs associated with developing and deploying a home automation system. Accepts variation in cost taking into account factors such as scale and complexity of the system. From basic setups for small homes to advanced offerings with high-end tools and advanced features, the system caters to a variety of needs and budgets. The financial feasibility study provides a better understanding of market demand, pricing strategies and potential revenue streams, the overall financial viability of the system. By doing so, it not only benefits its users from the convenience and efficiency of home automation, but also ensures that they experience financial prudence on their investment. The financial feasibility study serves as a guiding framework, allowing the offering of a home automation system that not only meets technical expectations, but aligns with the financial considerations of its users. This user-centric approach not only improves system adoption, but also establishes it as a financially beneficial solution that contributes to the overall satisfaction and success of its users.

2.1.3. Legal and Regulatory feasibilities developing system.

Legal and regulatory feasibilities are critical aspects to consider when developing a home automation system. Ensuring compliance with relevant laws and regulations helps to mitigate risks, build trust with users, and avoid potential legal issues.

The potential consequences of non-compliance with data protection laws for a home automation system can be significant and may include:

1. Privacy Breaches and Misuse of Data

Failure to comply with data protection laws may lead to privacy violations and data misuse, and may result in unauthorized access to personal information and sensitive data.

2. Legal and Financial Consequences

- Non-compliance with data privacy laws may result in fines, prosecution and legal restrictions on use of the system in certain jurisdictions. By (Osano Staff

December 14, 2022).

3. Security vulnerabilities

- Misconfiguring or customizing privacy automation tools can lead to significant privacy issues, unauthorized access and data breaches, creating cybersecurity vulnerabilities.by Danie Strachan (Vera safe, 18 October 2023)

4. Loss of trust and reputation

- Privacy breaches and data misuse can erode user trust and damage the home automation system's reputation, leading to a loss of consumer and market credibility.

5. Operating costs and user experience

- Non-compliance can lead to increased operational costs such as fines and legal fees, and negatively impact the user experience of the home automation system.

What society is expected to deliver in terms of legal and regulatory capacity?

The meticulous attention paid to legal and regulatory feasibility in developing the home automation system underscores its commitment to user well-being and ethical standards. By ensuring compliance with applicable laws, especially data protection regulations, the system not only mitigates risks but also establishes a foundation of trust with users. The potential consequences of non-compliance with data protection laws, such as privacy breaches, legal and financial consequences, security risks, loss of trust and increased operational costs, underline the critical importance of compliance with regulatory frameworks. The legal best practices described prioritize protecting user data, preventing privacy breaches, and mitigating the risk of unauthorized access.

As stated in Compliance with Legal and Regulatory Norms, “Aims to provide a home automation system that not only meets technical expectations but also operates within ethical and legal boundaries. This commitment not only protects users' privacy and security, but also contributes to the system's sustainable trust. And positive reputation. By doing so, the system not only complies with legal obligations, but also actively promotes a safe, reliable and user-friendly environment, ultimately ensuring a positive and beneficial experience for its users.

2.1.4. Social Feasibilities developing system.

Social feasibility in the context of a home automation system, such as involves assessing whether the system is acceptable and beneficial to the people who will use it. This evaluation considers various social factors to ensure that the technology aligns with the values, preferences, and needs of the users and the broader community.

- User Acceptance

Examples: Conducting surveys and interviews to understand how potential users perceive the home automation system.

Factors: Assessing user attitudes, expectations and comfort levels with technology. Ensuring that the system is simple and intuitive to use.

- Cultural sensitivity

Example: Consideration of cultural differences in design and operation.

Factors: Some cultures may have specific preferences or taboos related to technology use. Ensuring that the system respects cultural norms and values.

- Privacy and Security

Examples: Implementing strong security measures to protect user data and privacy.

Factors: Users need assurance that their personal information is secure. Clear privacy policies and encryption mechanisms should be in place to address these issues.

- Access

Example: Designing the system to be accessible to users with disabilities.

Factors: Consider features such as voice commands, large text options, or compatibility with assistive technologies to ensure inclusion.

- Community Impact

Example: Evaluating how the system affects the neighborhood or community.

Factors: Consideration of noise levels, visual impact, and other external factors that may influence community perceptions of the technology.

- Social Justice

Example: Ensuring that the benefits of home automation system are accessible to all socioeconomic groups.

Factors: Avoiding creating a technological divide and ensuring that the cost and accessibility of the system does not exclude certain demographic groups.

- Ethical considerations

Example: Establishing ethical guidelines for the use of the system.

Factors: Defining rules for ethical dilemmas that may arise from data collection, use, and system capabilities. For example, clear guidelines on data sharing and informed consent.

- Community Engagement

Example: Involving the community in the development and implementation process.

Factors: Solicit feedback, conduct focus groups, and involve potential users in decision-making to create a system that aligns with their needs and preferences. Reference by Mohammed A. Al-Sharafi (smart homes adoption factors, 2023 Oct 20).

These references provide a comprehensive understanding of various social feasibility considerations for a home automation system, including user acceptance, cultural sensitivity, privacy and security, accessibility, community impact, social justice, ethical considerations, and community participation.

What is expected to be given to the society according to the social possibilities?

Home automation system implementation reflects a socially conscientious approach, addressing a range of factors critical to user acceptance and community well-being. Through user-centered methodologies such as surveys and interviews, the system ensures that it aligns with users' attitudes, expectations, and comfort levels with technology, emphasizing intuitive and user-friendly design. Cultural sensitivity of the system recognizes and respects diverse norms and values, fostering inclusion across diverse communities.

Prioritizes privacy and security, including robust measures to protect user data and privacy concerns. Its commitment to accessibility, features such as voice commands and compatibility with assistive technologies, promotes inclusion for users with disabilities, and reflects a commitment to universal use. The assessment of the system's community impact includes considerations of noise levels, visual aesthetics and external factors. Commitment to align technology with wider environment. Social equity is a core principle, ensuring that the benefits of home automation are accessible to all socioeconomic groups and minimizing the risk of creating technological divides. Stands as a socially beneficial home automation system, deeply embedded in the principles of prioritizing user satisfaction. Sensitivity, privacy, accessibility, community well-being, social justice, ethical considerations and meaningful community participation. Through these considerations, the system emerges not just as a technological innovation but as a facilitator of positive social impact in the realms of home automation.

2.2. Requirement Gathering.

The process of determining and recording the specific requirements of a project from start to finish is called requirements gathering. It typically occurs during the project initiation phase but continues throughout the project timeline. This process involves determining what the project needs to achieve and what must be created to make that happen. It is essential for understanding the project's goals and ensuring that all stakeholders have a shared understanding of the requirements. The primary sources for gathering requirements are stakeholders, such as customers, users, experts, and analysts. The process consists of six steps, including requirements elicitation, documentation, and understanding. Some common challenges in requirements gathering include scope creep and loss of focus on the project goal. To address these challenges, it is important to reinforce the project goal, document and confirm understanding of the requirements, and have a plan for dealing with changes that may arise during the process.

Gathering requirements for a home automation system involves various methods to ensure a comprehensive understanding of user needs and system functionality. There are several ways to gather requirements for a project.

1. User interviews.

   User interviews are an essential part of designing and implementing home automation solutions, providing valuable insights into users' preferences, expectations and specific needs. These one-to-one interactions provide a closer understanding of people's lifestyles, enabling the integration of more personalized smart technologies into their homes. They uncover latent needs and desires, delve into daily routines and challenges, and allow users to express their visions of the perfect smart home environment. In addition, interviews can include practical demonstrations, explore the emotional dimensions of smart home adoption, and foster a collaborative and user-centered approach to home automation development. Overall, user interviews for home automation contribute significantly to the development of a thoughtful, user-centered smart home solution.

2. Questionnaires.

   Questionnaires represent a scalable and efficient method for gathering insights from a larger group of stakeholders, offering a unique set of advantages in the context of home automation development. Beyond their ability to collect a broad range of opinions and ideas, these tools enable the incorporation of diverse perspectives, ensuring a holistic understanding of user needs and expectations.

One distinctive aspect of questionnaires lies in their potential to reach a geographically dispersed audience. This allows for the inclusion of individuals with varied cultural backgrounds, lifestyles, and environmental considerations, ensuring that the developed home automation solutions cater to a diverse user base. By designing survey questions that account for regional nuances and cultural preferences, developers can create more inclusive and globally relevant smart home technologies.

Questionnaires serve as dynamic tools for engaging a large and diverse group of stakeholders in the home automation development process. Their adaptability, scalability, and potential for quantitative insights make them valuable instruments for shaping user-centric solutions that resonate with a wide spectrum of preferences and needs.

3. Observations

Observational research, particularly the act of directly observing users as they interact with home automation products or comparable technologies, provides a nuanced and in-depth understanding of their needs and pain points. Beyond traditional methods such as interviews or surveys, monitoring provides a real-time, contextual view of users' behaviors, preferences and challenges, providing unique insights that can significantly inform the design and improvement of home automation solutions.

One unique aspect of observational research is its ability to capture nonverbal cues and subtle nuances that users may not clearly communicate. By immersing researchers in users' natural environments, be it their homes or simulated settings, they are able to witness unfiltered reactions, frustrations, and moments of joy. These observations provide a more holistic understanding of the user experience, and help identify aspects of the interaction that go unnoticed through other research methods.

Furthermore, observational studies can uncover patterns of behavior that users may not be fully aware of or express during interviews. This includes habitual actions, decision-making processes, and even moments of hesitation or uncertainty. By documenting these patterns, designers gain valuable insight into the underlying motivational and cognitive processes that shape user interactions, allowing for more informed and deliberate design of home automation systems.

Observational research offers a comprehensive and authentic perspective on user interactions with home automation products. By delving into the complexities of user behavior in their natural environment, designers can uncover valuable insights that go beyond obvious feedback, ultimately leading to more refined and user-centric smart home solutions.

4. Use case scenarios.

Formulating use cases for home automation products involves a careful exploration of user interactions, preferences and objectives. One of the unique aspects of this process is its focus on emotional storytelling from the user's perspective, providing a vivid narrative that extends beyond mere technical functionality. By immersing developers in the user's perspective, use cases bring to light not only the obvious tasks users are expected to perform, but also the underlying motivations, challenges, and emotional aspects that influence their interactions with the product.

Each use case scenario acts as a mini-drama, unfolding a story that outlines the journey of a specific user persona as they engage with the home automation system. This narrative framework not only depicts the steps the user takes to achieve their goal, but also looks at the contextual factors that shape their decisions. For example, a use case might explore how a busy working parent can use smart home features to streamline morning routines, emphasizing not only the technical steps involved but also the time-saving benefits and enhanced sense of control over their daily life. By incorporating these contextual details, they become powerful tools for developers to envision the perfect user experience, fostering a more comprehensive and user-centric design approach.

Researchers choose **Questionnaire** method for the interest gathering part of published research.

Why do researchers use questionnaires for research?

The choice of questionnaires as the requirements gathering method for system development is driven by the need for a fast and efficient data collection process, especially when time constraints are a critical consideration. The structured nature of questionnaires allows researchers to rapidly collect information from large numbers of participants in a relatively short time frame. Given the limited time available for research, it is important for researchers to choose these questionnaires to quickly gain insight into user needs and preferences.

Another thing is, that choosing surveys and questionnaires as the preferred method for conducting research often affects their ease of implementation. These methods offer a simple and user-friendly approach that simplifies the flow of data collection. Researchers can easily design, distribute, and collect responses from participants without complex logistical arrangements or specialized training. The ease of implementation associated with questionnaires makes them a practical and efficient choice for researchers, especially when time is limited. Simple design, accessibility for participants, and simplified data analysis contribute to the overall efficiency of the research process in gathering requirements for system development.

Lastly the researchers choose the questionnaires easy to the decision to select questionnaires for interest gathering is often influenced by the ease of managing and organizing the data collected. Questionnaires provide a structured format for responses, facilitating straightforward organization of information. The standardized nature of the data makes it easier for researchers to create coding schemes, categorize responses, and conduct efficient analysis. Furthermore, questionnaires often generate quantitative data suitable for statistical analysis. This facilitates the application of various analytical techniques to uncover patterns, correlations and trends in the data. The structured nature of the responses simplifies the generation of summary statistics, charts and graphs, helping researcher's present findings in a clear and concise manner.

Ultimately researchers decide to choose questionnaires based on ease of use, often influenced by the ease of managing and organizing the data collected. Questionnaires provide a structured format for responses, facilitating straightforward organization of information. The standardized nature of the data makes it easier for researchers to create coding schemes, categorize responses, and conduct efficient analysis. Furthermore, Questionnaires often generate quantitative data suitable for statistical analysis. This facilitates the application of various analytical techniques to uncover patterns, correlations and trends in the data. The structured nature of responses simplifies the generation of summary statistics, charts and graphs, helping researcher's present findings in a clear and concise manner.

In the proposed research, the use of a **convenience sampling process** is a strategic choice aimed at ensuring practicality and efficiency in data collection. This method selects participants based on their accessibility and willingness to participate, making it an easy approach for researchers. Unlike random sampling, convenience sampling allows researchers to contact people who are readily available and willing to contribute, often nearby or with easy access.

By using convenience sampling, the research team acknowledges the trade-off between representativeness and ease of recruiting participants. The focus was on easily accessible individuals, and although this may introduce some bias due to non-random selection, it coincides with the practical constraints of the study. This method is especially useful when time, budget and resource constraints play an important role in the research process.

In the context of the research, the decision to collect needs from a sample size of **170 individuals** through convenience sampling underscores the pragmatic approach taken. The selected individuals are those who are readily available or approachable, and the sampling process prioritizes practicality over strict randomness. Although the selected sample may not be fully representative of the entire population, it allows valuable insights to be efficiently gathered within the constraints of the research project.

This approach recognizes the inherent limitations of convenience sampling but exploits its advantages in terms of feasibility and resource management. By choosing this method, the research team aims to strike a balance between obtaining meaningful data and navigating obstacles posed by time, budget, and logistical considerations.

Table 2.2 Requirement gathering Questionnaires

Objective no	Description	No of questionnaires and surveys
Objective no-1	To identify the problems with IoT based home automation systems.	QE 01 QE 02 QE 03 QE 04 QE 05
Objective no-2	To analyze the needs of the customers of using home automation systems.	QE 06 QE 07

		QE 08 QE 09 QE 10
Objective no-3	To implement a cost-effective mobile app with a user-friendly UI to control and monitor the home.	QE 11 QE 12 QE 13 QE 14 QE 15
Objective no-4	To evaluate the effectiveness of Arduino based home automation system	QE 16 QE 17 QE 18 QE 19 QE 20

2.2.1. Data analysis.

Objective 01

Question No: QE 01

Aim: The purpose of the question is to seek information on common challenges associated with existing IoT-based home automation systems.

Result:

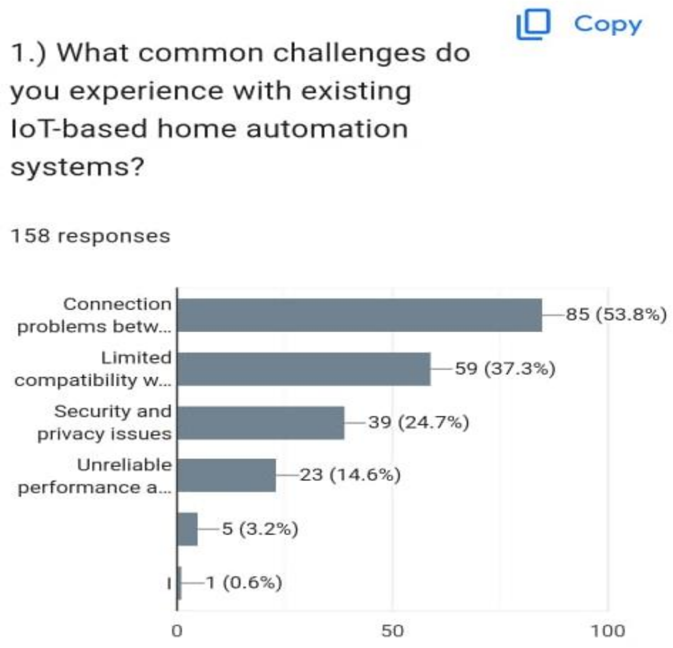


Figure 2.1 Summary of the common challenges in IOT base home automation system.

Problems	Responses
Connection problem between devices	53.8%
Limited compatibility with various devices	37.3%
Security and privacy issues	24.7%
Unreliable performances and frequents interruptions.	14.6%
other	0.6%

Conclusion.

The investigation reveals frequent problems with current IOT-based home automation systems. These difficulties include poor device connectivity, limited interoperability with different devices, privacy and security concerns, and inconsistent performance that frequently crashes. These results highlight how critical addressing these issues is to improving the overall usability, interoperability, security, and reliability of IOT-based home automation systems.

Objective 01

Question No: QE 02

Aim: The aim here is to gather anecdotal evidence or personal experience of cases where IoT home automation systems failed to meet expectations or were inconvenient.

Result:

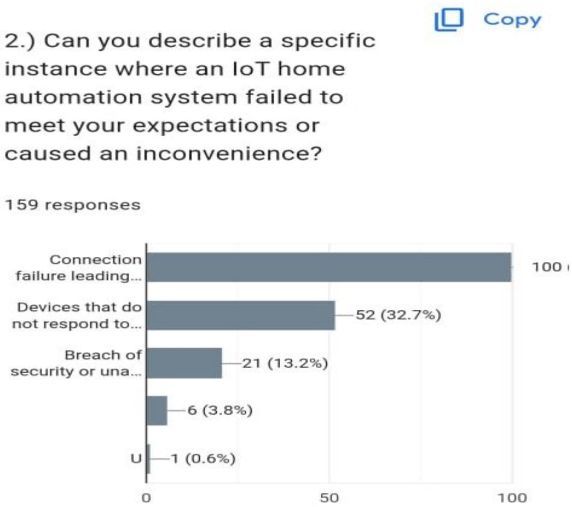


Figure 2.2 Summary of cases where an IoT home automation system failed to meet expectations.

Problems	Responses
Connection failure leading to loss of control	62.9%
Devices that do not respond to commands	32.7%
Breach of security or unauthorized access	13.8%
other	0.6%

Conclusion

The most frequent problems include lost control, broken connections, and unresponsive equipment. Furthermore, a significant portion of respondents expressed concerns about security flaws or illegal access. These results highlight how critical solving connectivity issues, improving device responsiveness, and strengthening security protocols are to enhance the reliability and user experience of Internet of Things home automation systems.

Objective 01

Question No: QE 03

Aim: The focus of this question is to assess the overall reliability of IoT home automation systems from the perspective of users or stakeholders.

Result:

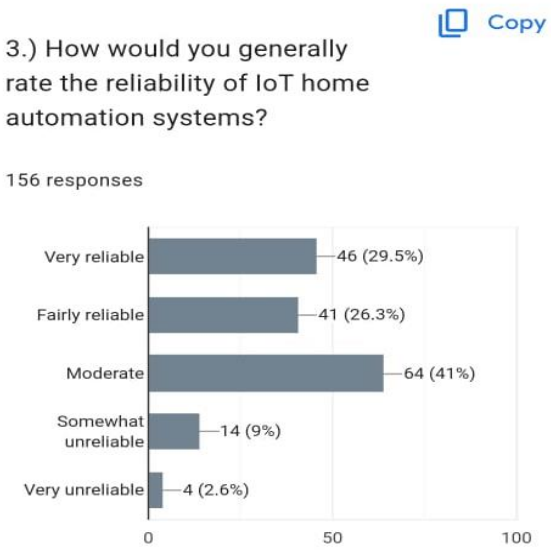


Figure 2.3summary of reliability of home automation system

	Responses
Very reliable	29.5%
Fairly reliable	26.3%
Moderate	41%
Somewhat unreliable	9%
Very unreliable	2.6%

Conclusion

Response analysis on the reliability of IoT home automation systems reveals mixed perceptions among users or stakeholders. A significant proportion of respondents consider these systems moderately reliable, while a significant number consider them very or somewhat reliable. However, a significant proportion also indicated varying degrees of distrust, with a smaller proportion reporting them as somewhat or very unreliable. These findings suggest that while most users consider IoT home automation systems reliable, there are still areas for improvement to improve overall reliability and user satisfaction.

Objective 01

Question No: QE 04

Aim: The purpose of this question is to understand the security issues associated with IoT home automation systems from the perspective of users or stakeholders.

Result:

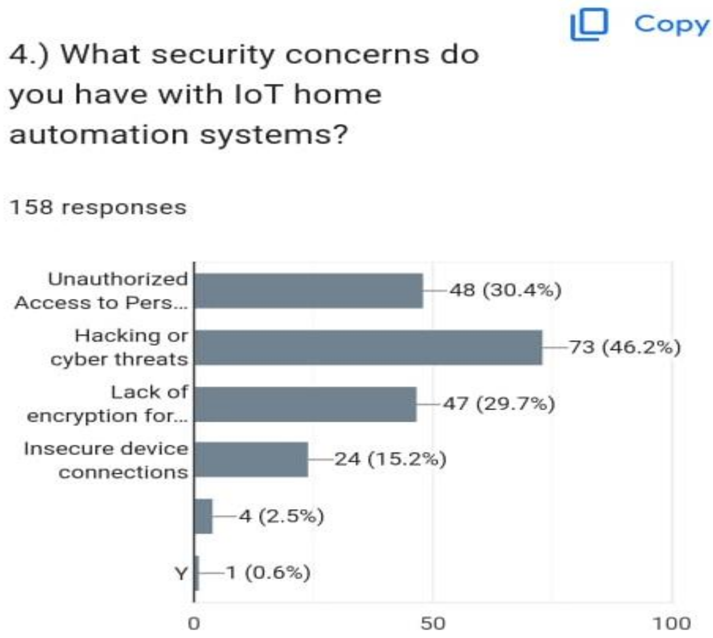


Figure 2.4summery of security concerns iot systems.

	Response
Unauthorized Access to Personal Data	31%
Hacking or cyber threats	27.2%
Lack of encryption for communication	52.5%
Insecure device connections	22.2%
Other	1.9%

Conclusion

Analysis of security issues related to IoT home automation systems highlights several key areas of apprehension among users or stakeholders. A significant percentage of respondents expressed concern about unauthorized access to personal data and hacking or cyber threats, indicating concerns about privacy violations and malicious attacks. Additionally, a significant portion cites lack of encryption for communications and insecure device connections as significant security concerns. The findings underscore the importance of addressing these vulnerabilities and implementing robust security measures, such as encrypted protocols and secure device connections, to mitigate risks and improve overall security of IoT home automation systems.

Objective 01

Question No: QE 05

Aim: The purpose of this question is to gain insight into potential areas for improvement of IoT home automation systems from the perspective of users or stakeholders.

Result:

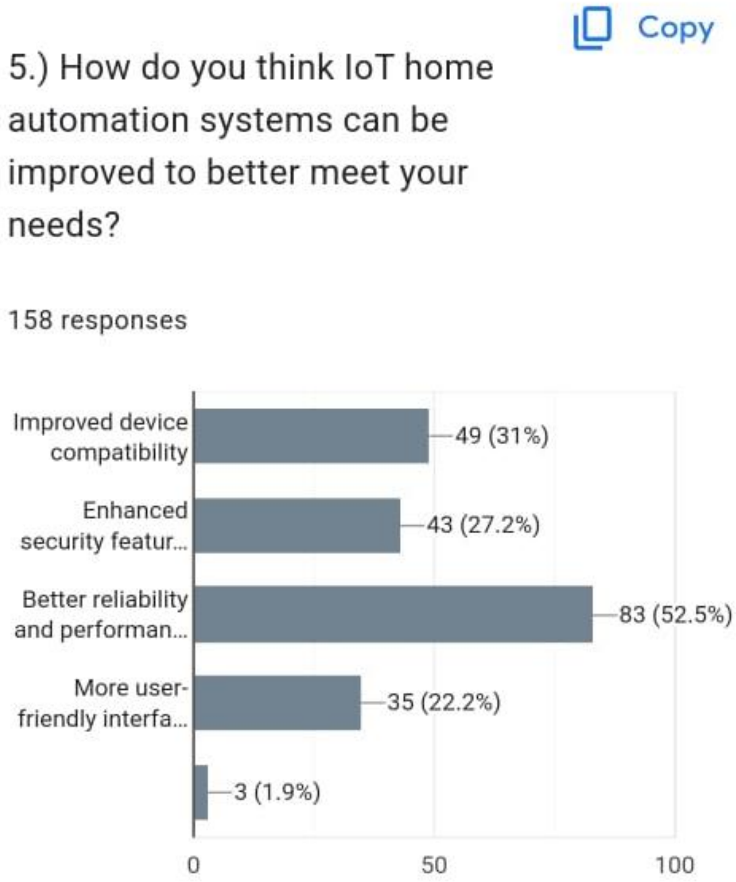


Figure 2.5 Summary of ways IoT can improve proposed home automation systems.

	Responses
Improved device compatibility	31%
Enhanced security features	27.2%
Better reliability and performance	52.5%
More user-friendly interfaces and controls	22.2%
Other	1.9%

Conclusion

Analyzing responses regarding potential areas for improvement of IoT home automation systems provides valuable insight into the preferences and priorities of users or stakeholders. A significant percentage of respondents indicated a need for better reliability and performance, and a strong desire for more reliable and stable systems in operation. Additionally, there is a notable demand for enhanced security features in these systems, suggesting a growing awareness and concern for protecting personal data and privacy within these systems.

Furthermore, respondents are interested in improved device compatibility and more user-friendly interfaces and controls, stressing the importance of ease of use and seamless integration with existing devices and interfaces. These findings underscore the importance of addressing these areas for improvement to meet users' evolving needs and expectations, ultimately improving functionality, usability, and overall satisfaction with IoT home automation systems.

Objective 02

Question No: QE 06

Aim: The purpose of this question is to understand the motivations or factors that influence people's decisions to adopt home automation systems.

Result:

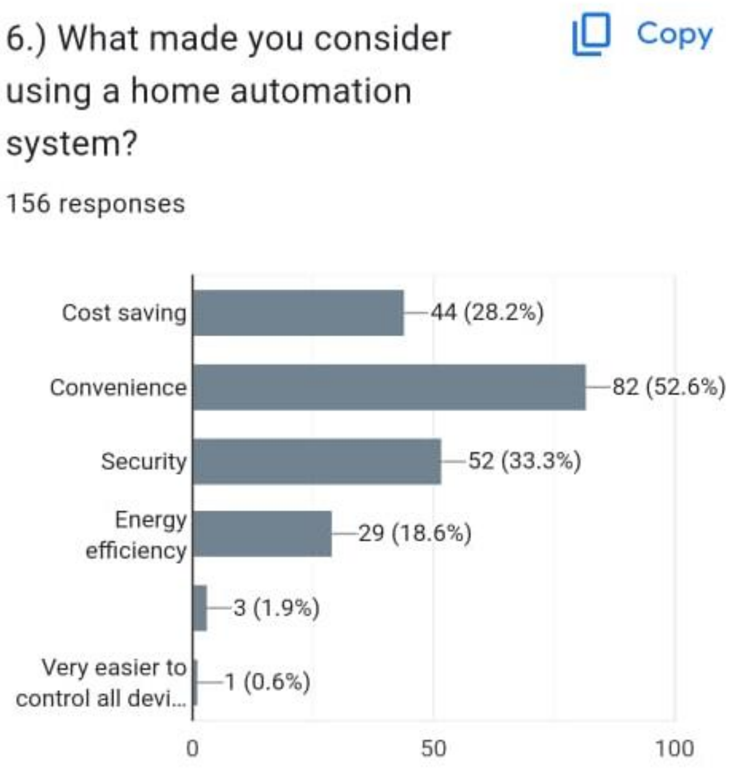


Figure 2.6 summery of consider using home automation.

	Responses

Cost saving	28.2%
Convenience	52.6%
Security	33.3%
Energy efficiency	18.6%
Other	1.9%

Conclusion

Analyzing the responses regarding the motivations or factors influencing the use of home automation systems reveals several key drivers. The majority of respondents cited convenience as a primary motivation, indicating a desire for streamlined and automated processes in managing household tasks and activities. Additionally, a significant portion cited security concerns as a factor influencing their decision, highlighting the importance of home automation systems in improving safety and peace of mind. Cost savings emerged as another prominent motivation, reflecting the potential financial benefits associated with efficiency and optimization of energy use. Although energy efficiency was cited by a small percentage of respondents, it is still a significant concern for some users. These findings underscore the multifaceted appeal of home automation systems that offer a combination of convenience, security, cost savings, and energy efficiency to users looking to improve their living environments.

Objective 02

Question No: QE 07

Aim: The purpose of this question is to understand the motivations or factors that influence people's decisions to adopt home automation systems.

Result:

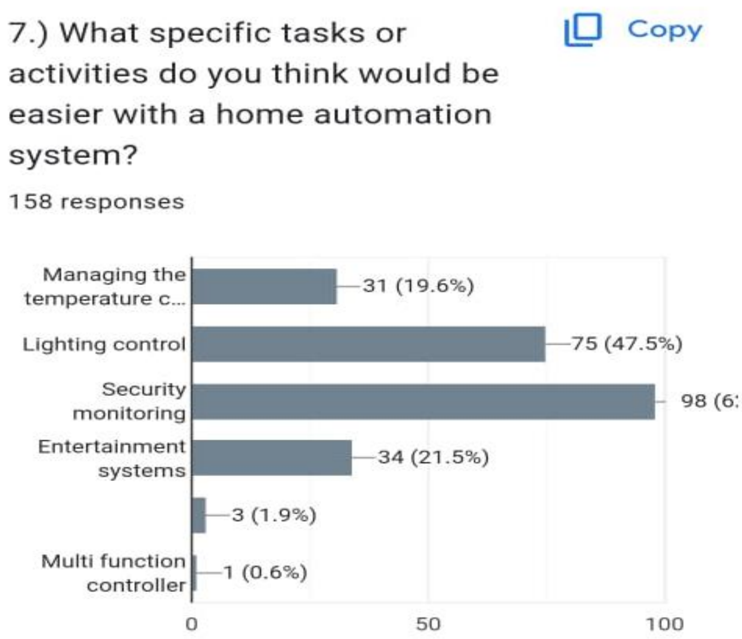


Figure 2.7 Summery of specific task easier with home automation

	Responses
Managing the temperature controller	19.6%
Lighting control	47.5%
Security monitoring	62%
Entertainment systems	21.5%
Other	1.9%

Conclusion

Analysis of responses regarding factors influencing the use of home automation systems highlights several key motivations among users. The majority of respondents cited security monitoring as a primary factor, indicating a strong desire for improved security and surveillance capabilities in their homes. Lighting control emerged as another consideration, reflecting the appeal of automated lighting solutions for convenience, environment and energy efficiency. Additionally, managing thermostats and entertainment systems was mentioned by a significant percentage of respondents, suggesting a growing interest in optimizing comfort and entertainment experiences through automation. These findings underscore the diverse range of needs and preferences influencing the adoption of home automation systems, which provide a variety of functionalities to enhance convenience, security, comfort and entertainment in households.

Objective 02

Question No: QE 08

Aim: The purpose of this question is to measure the importance of energy efficiency as a factor influencing people's considerations when evaluating home automation systems.

Result:

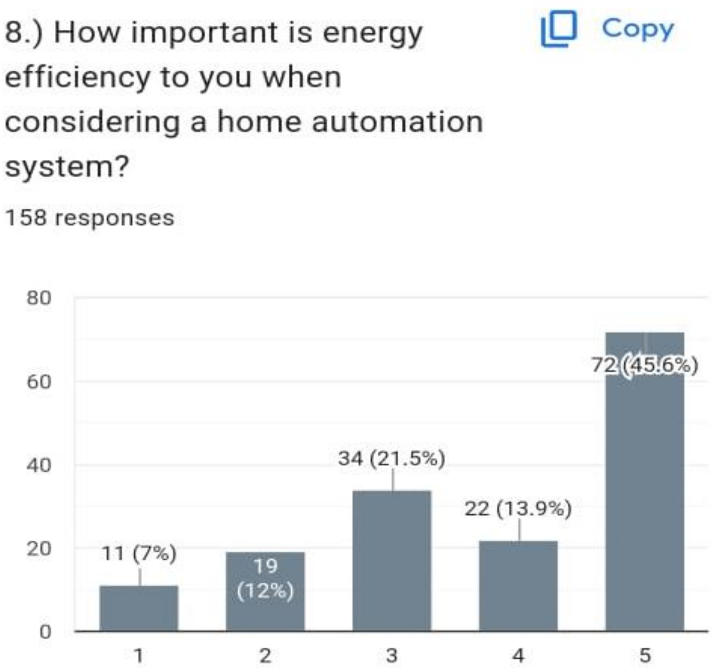


Figure 2.8 summery of energy efficiency consideration home automation system

	Response
Not Important<20%	7%
20% < 40%	12%

40% < 60%	21.5%
60% < 80%	13.9%
80% < very Important	45.6%

Conclusion

When considering energy efficiency as a deciding factor to consider when evaluating home automation systems, a significant majority of respondents believe it to be very important. This suggests that energy-efficient features and solutions should be given top priority when deciding whether to use home automation technology. Energy efficiency was given great weight by most respondents when evaluating home automation systems, while a smaller percentage considered it to be less important. These findings demonstrate how essential it is to incorporate energy-efficient features and solutions into home automation systems in order to meet user or stakeholder objectives and preferences.

Objective 02

Question No: QE 09

Aim: The purpose of this question appears to be to understand the expectations of individuals regarding the convenience of a home automation system.

Result:

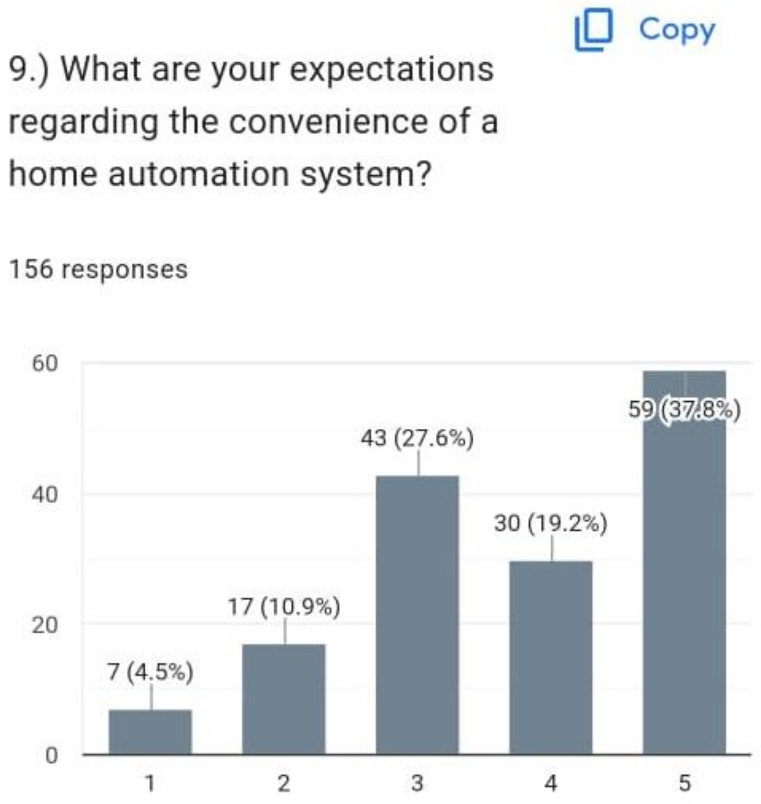


Figure 2.9 summery of expectations regarding convenience home automation system

	Response
Not Convenient at All<20%	4.5%
20% < 40%	10.9%
40% < 60%	27.6%
60% < 80%	19.2%
80% < Extremely Convenient	37.8%

Conclusion

The majority of people want a high level of convenience, according to an analysis of replies on what they expect from a home automation system. Home automation systems have a strong desire to simplify and streamline household routines and activities, as seen by the combined 57% of respondents who rated them as very convenient or highly convenient, and by almost 37.8% of respondents who rated them as extremely convenient. The majority of respondents thought home automation systems offered a considerable degree of convenience in organizing everyday routines, whereas a minority assessed them as less convenient. These results highlight the significance of creating and deploying home automation systems that successfully satisfy consumers' expectations for ease, enhancing their usability and elevating user satisfaction.

Objective 02

Question No: QE 10

Aim: The purpose of this question is to assess the level of concern individuals have regarding the privacy implications of IoT devices collecting and sharing sensitive data.

Result:

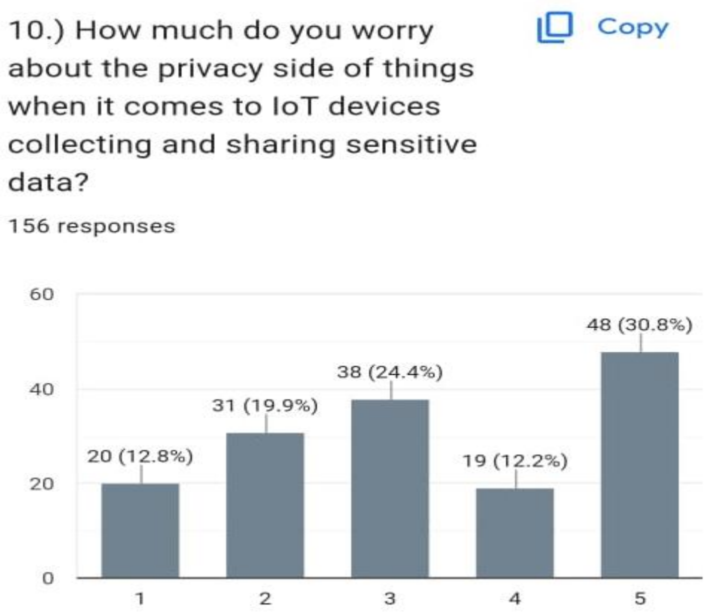


Figure 2.10

	Response
Really worried <20%	12.8%
20% < 40%	19.9%
40% < 60%	24.4%
60% < 80%	12.2%
80% < Not worried at all	30.8%

Conclusion

Analyzing responses to concerns about the privacy implications of IoT devices to the collection and sharing of sensitive data reveals different attitudes among individuals. A significant proportion of respondents expressed moderate to high levels of anxiety, while a significant percentage indicated that they were not at all anxious. These findings suggest that while privacy concerns are prevalent among some individuals, a significant proportion may perceive the risks associated with data collection and sharing differently or may not prioritize privacy as a significant issue. However, addressing the concerns of those concerned is essential to ensure transparency, trust and ethical use of data in IoT ecosystems.

Objective 03

Question No: QE 11

Aim: The purpose of this question appears to be to understand the essential features that individuals consider necessary in a mobile application designed to control and monitor their homes.

Result:

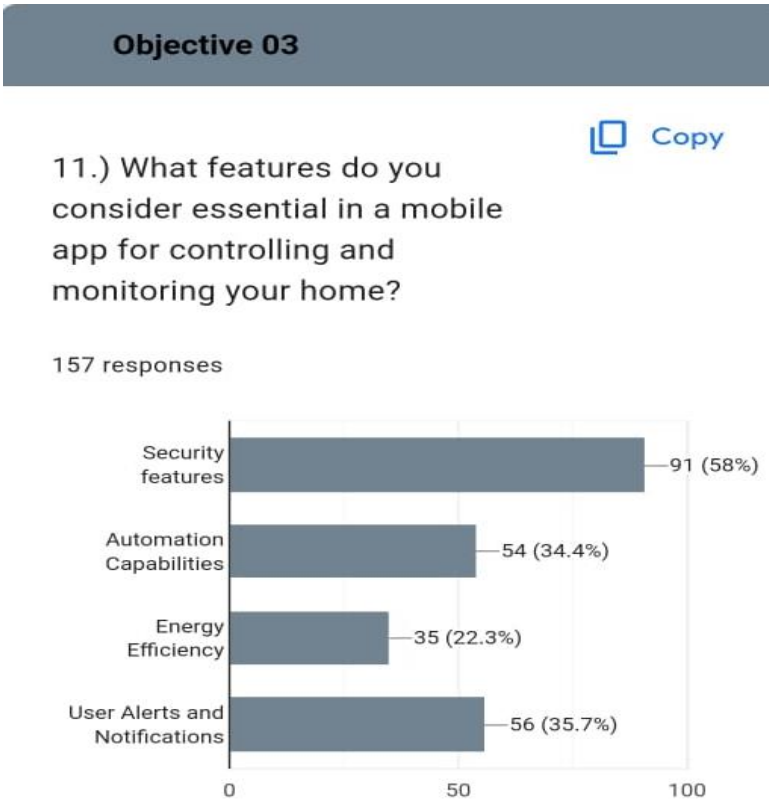


Figure 2.11 summery of features consider essential mobile app

	Responses
Security features	58%
Automation Capabilities	34.4%
Energy Efficiency	22.3%
User Alerts and Notifications	35.7%

Conclusion

The analysis of responses regarding essential features in a mobile application designed to control and monitor homes reveals several key priorities among individuals. The majority of respondents consider security features to be the most crucial aspect, highlighting the paramount importance of safeguarding their homes and personal data. Additionally, there is considerable interest in automation capabilities and user alerts/notifications, reflecting a desire for convenience and real-time awareness of events within the home environment. However, fewer respondents prioritize energy efficiency features, suggesting that while important, it may not be as critical as security and convenience for some users. These findings underscore the importance of incorporating robust security features, automation capabilities, and user-friendly alerts/notification systems into mobile apps for home automation to meet the diverse needs and preferences of users effectively.

Objective 03

Question No: QE 12

Aim: The purpose of this question is to assess the importance to individuals of the ease of use of a home control application's user interface.

Result:

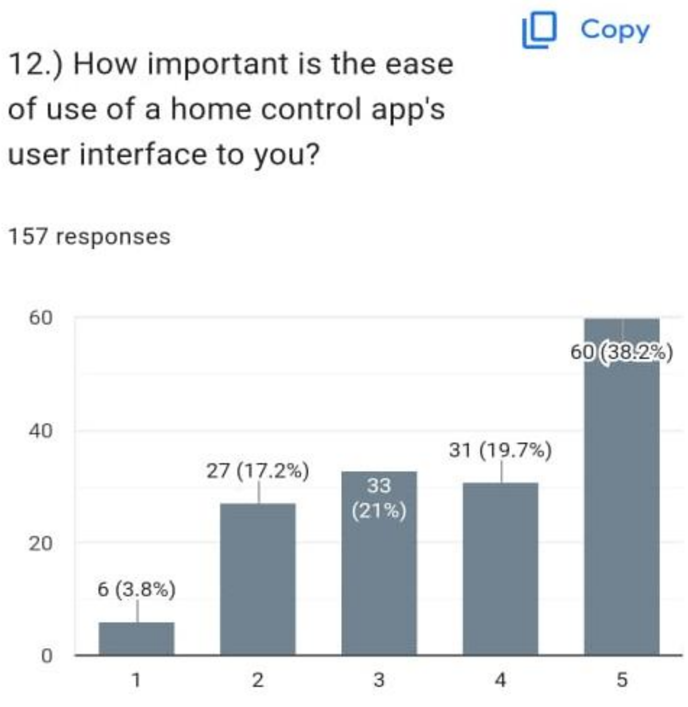


Figure 2.12 summary of important home automation

	Response
Not Important at All<20%	3.8%
20% < 40%	17.2%
40% < 60%	21%
60% < 80%	19.7%
80% < Extremely important	38.2%

Conclusion

Analysis of responses on the importance of ease of use of a home control application's user interface shows that a significant majority of people consider it extremely important. There is a strong emphasis on intuitive and user-friendly interfaces, with nearly 38.2% of respondents ranking ease of use as extremely important and a combined 57.9% ranking it as highly or very important. A minority of respondents rated ease of use as less important, while the majority considered it a critical factor affecting their satisfaction and usability of home control applications. These findings underscore the importance of prioritizing UI design considerations to ensure home control apps are accessible and user-friendly, thereby improving user experience and adoption rates.

Objective 03

Question No: QE 13

Aim: The purpose of this question is to understand people's preferences regarding the design and layout of a home control application.

Result:

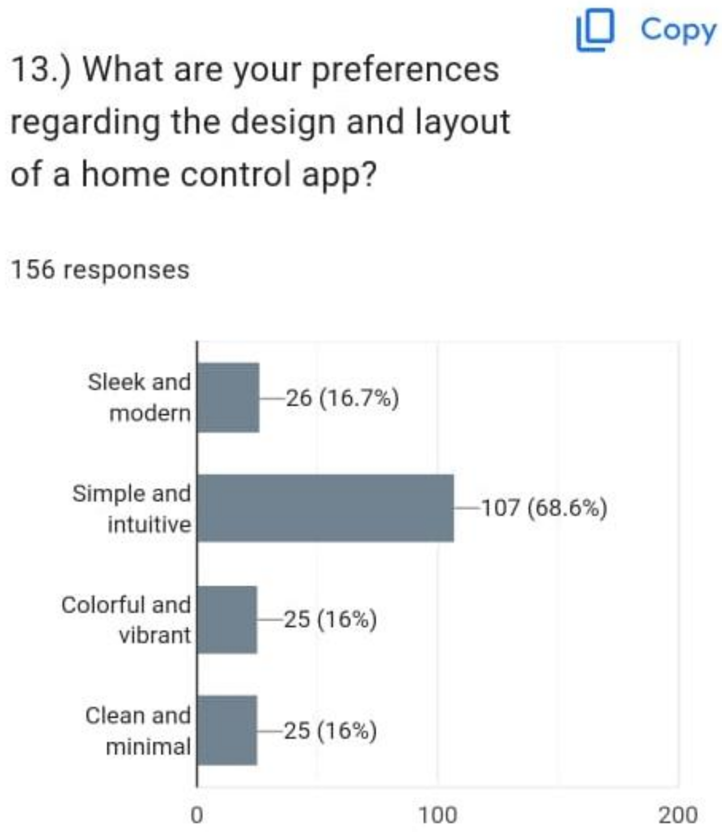


Figure 2.13 summery of preferences of regarrding home automation system application

	Responses
Sleek and modern	16.7%
Simple and intuitive	68.6%
Colorful and vibrant	16%
Clean and minimal	16%

Conclusion

The analysis of responses regarding preferences regarding the design and layout of a home control application highlights a strong preference for simplicity and intuitiveness. The majority of respondents indicated a preference for simple and intuitive designs, emphasizing the importance of clear navigation and ease of use in home control apps. Additionally, while fewer respondents expressed preferences for sleek and modern, colorful and vibrant, or clean and minimal designs, these preferences still represent diverse aesthetic preferences among users. These findings underscore the importance of prioritizing simplicity and intuitiveness in the design of home control applications to ensure user-friendly interfaces and enhanced user experience.

Objective 03

Question No: QE 14

Aim: The purpose of this question is to identify challenges that individuals can expect when using a mobile application to control and monitor their homes.

Result:

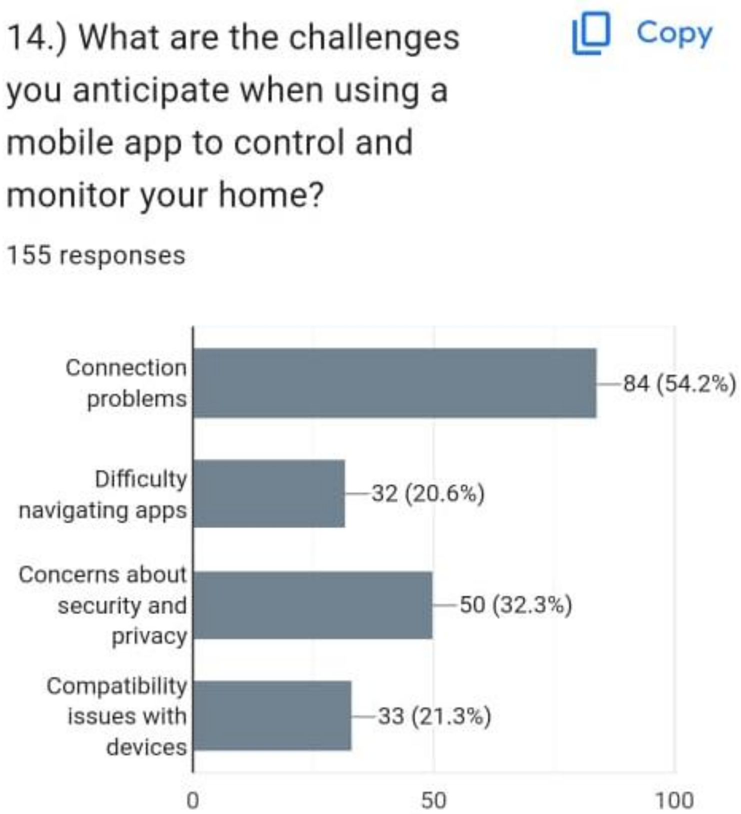


Figure 2.14 summary of challenges anticipate using mobile application.

	Responses

Connection problems	54.2%
Difficulty navigation apps	20.6%
Concerns about security and privacy	32.3%
Compatibility issues with devices	21.3%

Conclusion

The analysis of responses regarding anticipated challenges when using a mobile application to control and monitor homes highlights several key concerns among individuals. The majority of respondents identified connection problems as a significant challenge, indicating potential issues with reliability and stability of connections between the app and smart home devices. Additionally, concerns about security and privacy emerged as another prevalent challenge, reflecting apprehensions regarding the protection of personal data and privacy within the home automation ecosystem. While fewer respondents cited difficulty navigating apps and compatibility issues with devices, these challenges still represent potential barriers to a seamless user experience. These findings underscore the importance of addressing connectivity issues, enhancing security measures, and improving user interface design and device compatibility to mitigate challenges and enhance the effectiveness and usability of mobile apps for home automation.

Objective 03

Question No: QE 15

Aim: The purpose of this question is to understand people's perception of a reasonable price for a home automation system that effectively controls and monitors their home.

Result:

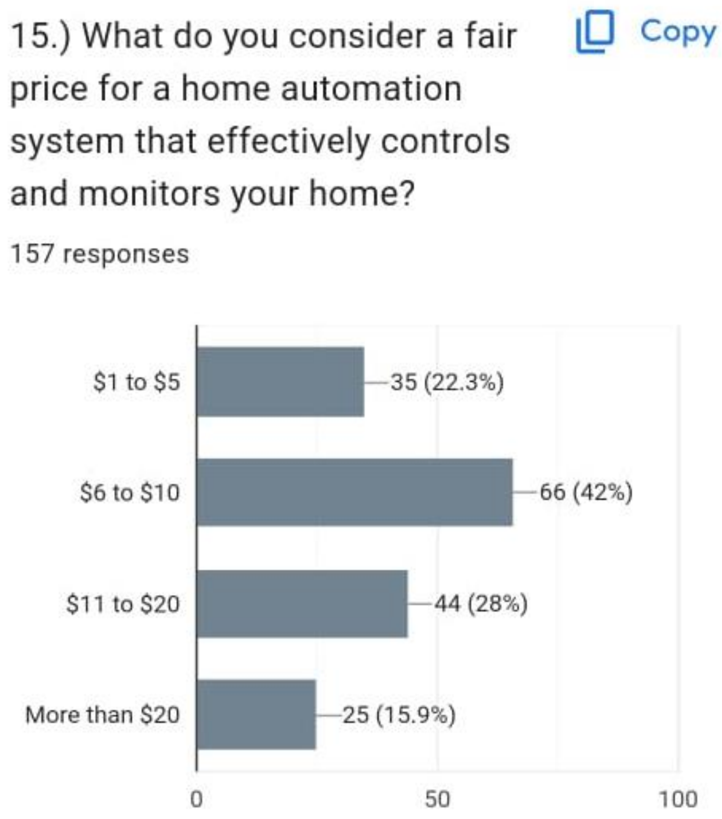


Figure 2.15 summery of fair prices home automation system.

	Responses
$1 to $5	22.3%
$6 to $10	42%
$11 to $20	28%
More than $20	15.9%

Conclusion

The analysis of responses regarding the perception of a reasonable price for a home automation system that effectively controls and monitors their home indicates varied expectations among individuals. The majority of respondents, approximately 70%, consider a price range between \$1 to \$10 to be reasonable, with the highest percentage favoring the \$6 to \$10 range. However, a significant portion, around 28%, perceive a higher price range between \$11 to \$20 as acceptable. A smaller percentage, approximately 15.9%, are open to considering a price point exceeding \$20. These findings suggest that while many individuals perceive a relatively low to moderate price range as fair, there is also a segment of the population willing to invest more for advanced features and functionalities in a home automation system. Therefore, pricing strategies should consider these diverse preferences to meet the varying needs and expectations of users effectively.

2.3. Resource identification.

2.3.1. Software components

Table 2.3 Software Components Word office package

Software tools- Microsoft Office package **Microsoft Office suite comprising Word, Excel, and PowerPoint**	 Figure 2.16 Image Office package
Advantages	Word for documentation and project reports. Excel for data analysis and organization. PowerPoint for presentations.
Disadvantages	Proprietary software with licensing costs. Limited collaboration features in offline mode.
How It's Helpful for Home Automation Research	Efficiently manage project documentation, analyze collected data, and present research findings effectively.
History	Microsoft Office has been a standard office suite since its initial release in 1989, evolving over the years to become a ubiquitous productivity tool in various industries.

Table 2.4 software Components Android studio

Software tools- Android Studio **Integrated Development Environment (IDE) for Android app development**	 Figure 2.17 Image Android studio IDE.
Advantages	Specialized for creating Android applications. Supports Java and Kotlin programming languages. Emulator for testing apps on various devices
Disadvantages	An be resource-intensive on older hardware Steeper learning curve for beginners
How It's Helpful for Home Automation Research	Enables the development and testing of Android applications tailored for home automation control and monitoring.
History	Google introduced Android Studio in 2013, providing developers with a powerful and dedicated IDE for building Android applications.

Table 2.5 Software components Arduino IDE

Software tools- Arduino IDE **Open-source software for programming Arduino microcontrollers.**	*Figure 2.18 Arduino IDE*
Advantages	• Simple interface for programming Arduino boards. • Large community support and vast library of pre-built functions.
Disadvantages	• Limited debugging features. • Single-threaded programming model.
How It's Helpful for Home Automation Research	Facilitates the programming of Arduino-based devices for home automation, allowing for custom control and sensor integration.
History	Arduino IDE was first introduced in 2005 as part of the Arduino open-source electronics platform, making it accessible for hobbyists and professionals alike.

Table 2.6 Software components Firebase cloud service

Software tools- Firebase Cloud Service **Mobile and web application development platform.**	 *Figure 2.19 Firebase Cloud service.*
Advantages	• Real-time database for storing and syncing data. • Authentication and hosting services.
Disadvantages	• Limited to Google Cloud Platform. • Potential privacy concerns due to centralized data storage.
How It's Helpful for Home Automation Research	Provides a scalable and secure cloud backend for storing and managing data, supporting real-time updates crucial for home automation systems.
History	Firebase was initially an independent company and was later acquired by Google in 2014, becoming a part of the Google Cloud Platform.

Software tools- Google cloud forms	Table 2.7Google forms
Advantages	Form creation and data collection Google Cloud Forms provides a versatile platform for creating forms and collecting data from both mobile and web applications. Integration with Google Workspace Seamless integration with other Google Workspace tools like Google Sheets for efficient data organization and analysis
Disadvantages	Dependency on Google services: As a part of the Google Cloud Platform, Google Cloud Forms is tightly integrated with Google's ecosystem, which may limit flexibility for users preferring alternative services. Learning curve

	Users unfamiliar with Google Cloud Platform services may face a learning curve while working with Google Cloud Forms.
How It's Helpful for Home Automation Research	Google Cloud Forms serves as a valuable tool for creating customizable forms, facilitating data collection in the realm of home automation research. It allows researchers to efficiently gather information from various sources and integrate it into their analysis.
History	Google Cloud Forms is a part of the broader Google Cloud Platform and has evolved over the years. Its development aligns with Google's commitment to providing comprehensive cloud solutions for businesses, researchers, and developers. The integration of Google Cloud Forms with other Google Workspace tools enhances its usability and makes it a potent choice for data collection in various domains.

2.3.2. Hardware components

For the proposed system the following technologies will be used.

- ESP32 Module

Figure 2.20 ESP32 Module

According to Ravi (Teja, 2021) the ESP32, developed by Espressif Systems, is a cost-effective System on Chip (SoC) microcontroller and the successor to the well-known ESP8266 Soc Available in both single-core and dual-core configurations, it features Tensilica's 32-bit Xtensa LX6 microprocessor with integrated Wi-Fi and Bluetooth capabilities.

Like the ESP8266, one of the notable advantages of the ESP32 is its built-in RF components, including a Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters, and RF Balun. This integrated design simplifies the hardware development process around the ESP32, requiring minimal external components.

MQ2 Gas Sensor

Figure 2.21 MQ2 Gas Sensor

Debashis Das (Das, 2022) argues that the MQ-2 gas sensor necessitates a heating element to effectively detect combustible gases. However, placing a heating element in proximity to such gases poses a potential hazard. To address this, the sensor is designed with an anti-explosion network, comprising two thin layers of stainless-steel mesh. This mesh, depicted in the provided image, houses the heating element, serving as a protective barrier.

Additionally, the stainless-steel mesh structure acts as a safeguard against dust and suspended particles, allowing only gaseous elements from the atmosphere to pass through. Upon decamping the sensor, two primary components become evident. The first component is the heating element, which is made from nichrome wire, while the second is the sensing element, composed of a platinum wire coated with tin dioxide.

To prevent users from damaging the sensor during disassembly, they have performed this process themselves. The resulting image displays the sensor without the stainless-steel mesh, revealing the exposed sensing element. The star-shaped pins on the sensor are a result of the structure of both the sensing and heating elements, intricately connected to the six legs of the sensor. Furthermore, the sensor's black base, constructed from Bakelite, enhances thermal conductivity.

* Relay Module

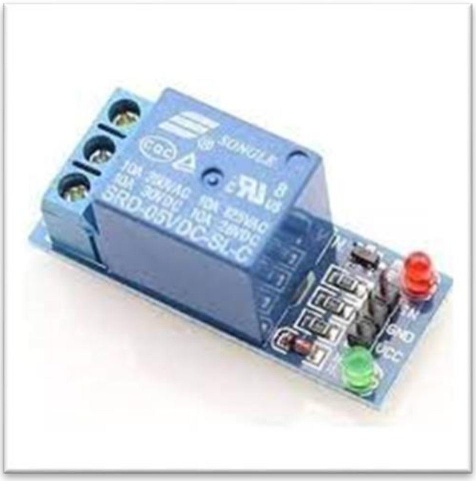


Figure 2.22Relay Module

Prathama’s Barik (Barik, 2023) says that the relays serve the purpose of toggling high power loads by utilizing a low-power control signal, thereby establishing electrical isolation between the control circuit and the load. Commonly employed for managing lights, motors, and other high-powered devices, relays can be activated by diverse signals including switches, sensors, or microcontrollers. Their functionality extends to independently switching various loads and safeguarding delicate electronic components from elevated voltages and currents.

* Ultrasonic sensor

Figure 2.23Ultrasonic Sensor

According to Danny Jost (Jost, 2019), the ultrasonic sensor here measures the distance to a target item by producing and converting ultrasonic sound waves Reflected sound into an electrical signal. Notably, ultrasonic waves travel faster than audible sound perceivable by humans. The essential components of ultrasonic sensors encompass the transmitter, responsible for emitting sound through piezoelectric crystals, and the receiver, which detects the sound after it has traveled to and from the target.

To determine the distance between the sensor and the object, the sensor calculates the time taken from the emission of sound by the transmitter to its reception by the receiver. This calculation is expressed by the formula D = ½ T x C, where D represents the distance, T denotes the time, and C signifies the speed of sound (approximately 343 meters/second). For instance, if an ultrasonic sensor is directed at a box and it takes 0.025 seconds for the sound to rebound, the distance between the ultrasonic sensor and the box can be calculated using the formula D = 0.5 x 0.025 x 343, yielding an approximate distance of 4.2875 meters.

- Servo Motor

Figure 2.24Servo Motor

Apoorve (Apoorve, 2015) argues that a servo comprises essential components, including a motor (DC or AC), a potentiometer, gear assembly, and a controlling circuit. The gear assembly serves the purpose of reducing the motor's revolutions per minute (RPM) while increasing its torque. Initially, at the servo motor's starting position, the potentiometer knob aligns in a way that no electrical signal is generated at the potentiometer's output port.

When an electrical signal is applied to another input terminal of the error detector amplifier, the difference between this signal and the one from the potentiometer is processed within a feedback mechanism. The outcome is an error signal, which then acts as the input for the motor, initiating its rotation. The motor's shaft is linked to the potentiometer, causing the potentiometer to rotate along with the motor. Consequently, the potentiometer generates a feedback signal that changes as its angular position evolves.

As the potentiometer's output feedback signal changes, the motor continues to rotate until a point is reached where the potentiometer's output matches the externally applied signal. In this state, there is no difference between the external signal and the signal generated by the potentiometer. Consequently, the amplifier produces no output signal to the motor input, resulting in the motor coming to a stop. This mechanism ensures that the servo maintains its position in response to external signals, demonstrating a closed-loop feedback system.

- DHT11 Temperature and Humidity Sensor

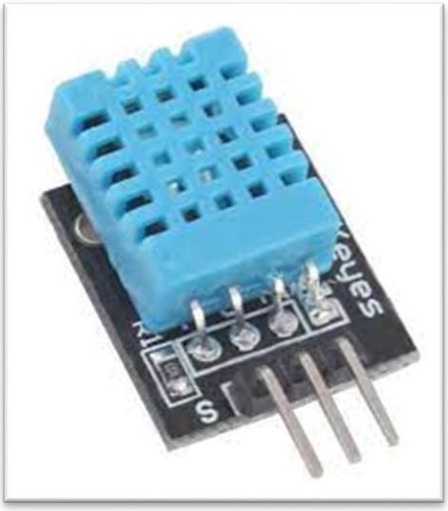


Figure 2.25 DHT11 Temperature

Jobith Joshep (Joseph, 2022) argues that the DHT11 incorporates both an NTC thermistor for temperature sensing and components for humidity measurement. The resistance of an NTC thermistor changes with changes in temperature, and this change is quantified to calculate the temperature. In earlier discussions, the researchers explored integrating an NTC thermistor with an Arduino to measure temperature.

Regarding the humidity sensing component, it encompasses a substrate capable of holding moisture, positioned between two electrodes. As the substrate absorbs water, the resistance between the electrodes diminishes. The alteration in resistance between the electrodes correlates directly with the relative humidity. A surge in relative humidity results in decreased resistance, while lower relative humidity amplifies the resistance between the electrodes. This variation in resistance is gauged using the onboard MCU's ADC (Analog-to-Digital Converter), ultimately allowing the calculation of relative humidity.

- And some wires, LED bulbs, etc. will be used.

2.3.3. Stakeholders Annalise by onion model

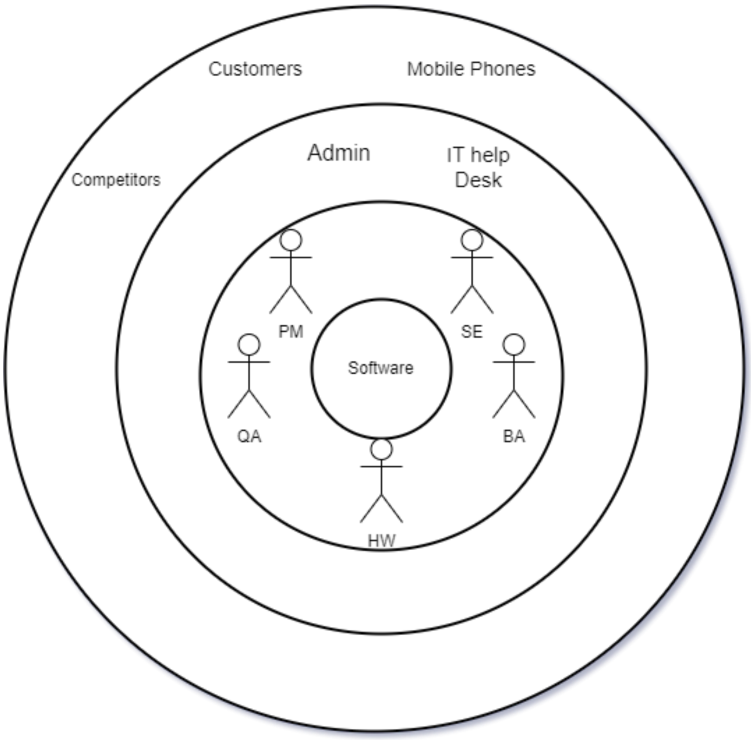


Figure 2.26 Onion Model

Table 2.8 Onion model components.

Software	SMART LIVING Arduino Home Automation System
Project Manager	Mr. R.M.D.T Ranathunga is the Project manager in the propose system. Develop and maintain the project plan, including timelines and milestones. Coordinate communication and collaboration among team members. Monitor progress and address any issues or interruptions. Ensure that the project stays within scope and meets the defined objectives etc.
Software engineer	Mr. I.D.N.S Kanrunarathna is the software developer in the propose system. Develop a user-friendly interface for remote control and monitoring. Collaborate with the Hardware Specialist to ensure hardware-software compatibility And Program the ESP32 microcontroller to handle various tasks and functionalities etc.
Hardware Developer	Mr. D.D.M.N. Disanayaka is the hardware developer in the propose system. Research and select appropriate hardware components, including sensors compatible with the ESP32. Assemble the hardware components together.

	Test and troubleshoot hardware issues. Collaborate with the Software Developer to ensure seamless integration between hardware and software components.
Business analysis	Mr. R.M.D.T Ranatunga, Mr. Mr. I.D.N.S Kanrunarathna and Mr. D.D.M.N Dissanayake are the business analysts of the proposed system. They analyze requirements, identify improvement opportunities, and contribute to making the system commercially viable.
Quality analysis	Mr. R.M.D.T Ranatunga is the project manager of the proposed system. Responsible for quality assurance of proposed home automation system. Tests systems, identifies bugs or issues, and works with the development team to troubleshoot and resolve any issues affecting system functionality.
Admin	Mr. I.D.N.S Kanrunarathna is the Admin in the propose system This role includes system administration tasks including user management, security configurations and overall system maintenance. Administrators ensure that the home automation system operates smoothly and safely.
It help desk	The IT help desk provides support to end users who may have problems or questions about the home automation system. They assist in troubleshooting and provide guidance for effective use of the system.
Competitors	This refers to other companies or systems in the market that offer similar home automation solutions. Analyzing competitors helps the user understand market trends, modify products, and identify potential areas for improvement.
Customers	End users or customers using the home automation system. Understanding user needs, preferences and feedback is critical to designing a system that meets user expectations.
Mobile phones	This often refers to the mobile device integration aspect of the home automation system. Many smart home systems can be controlled or monitored through mobile apps, allowing users to remotely manage their smart devices.

2.4. Work break down structure

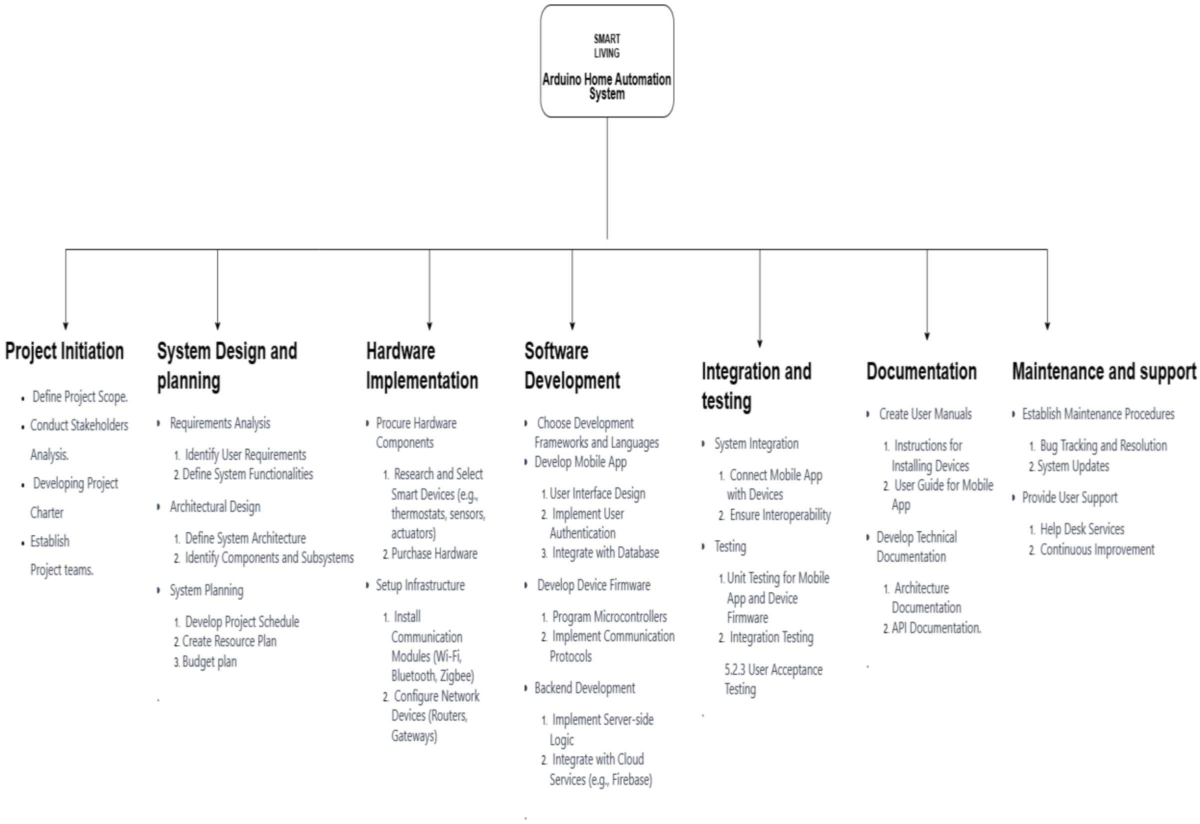


Figure 2.27 Work break down structure

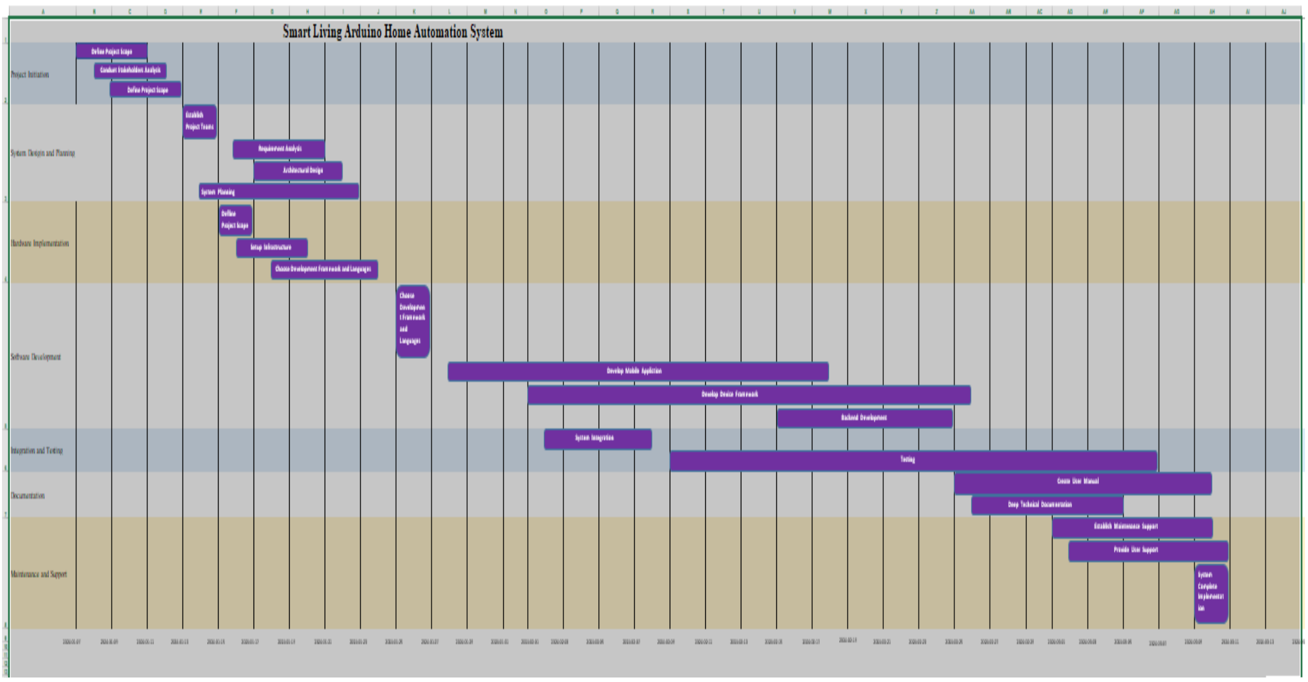


Figure 2.28 Gantt chart

2.5. Risk Analysis.

Home automation systems face four major challenges; these are poor management, inflexibility, difficulty in obtaining security and high cost of ownership, the main objectives of this research are to design and implement a home automation system using IoT that can control and automate many home appliances. Easy to manage web interface. The proposed system has great flexibility by using Wi-Fi technology to interconnect its distributed sensors to home automation servers. This will reduce deployment costs and increase upgradeability and system reconfiguration.

Identifying potential risks and developing mitigation strategies is crucial for the successful execution of the proposed project. Below are some anticipated risks and corresponding mitigation strategies.

- Limited research of Arduino base home Automation System
- Incorporation of Arduino for specific applications
- Limited budget or availability of materials.

Mitigation Explore cost-effective alternatives, seek potential collaborations, and prioritize essential tasks.

- Technical Challenges

Risk: Sensor inaccuracies, communication protocol issues.

Mitigations Collaborate with experts in sensor technology, conduct thorough testing, and have contingency plans for technical hurdles.

- User Acceptance

Risk: Users may find the system challenging or resist adopting new technology.

Mitigation Provide comprehensive user training, incorporate user feedback iteratively, and offer continuous support.

- Timeline Delays

Risk unforeseen circumstances causing delays in the proposed timeline.

Mitigation Build buffer time into the schedule, regularly review progress, and adapt the timeline as needed.

- Localization Challenges

Difficulty in tailoring the system to local preferences and needs.

Mitigation Involve local communities in the development process, conduct user surveys, and make iterative improvements based on feedback.

- Security Concerns

Vulnerabilities in IoT connectivity leading to security breaches.

Mitigation Implement robust security protocols, encryption, and regularly update system security measures.

- Unforeseen Technological Limitations

Technological limitations that were not apparent during the planning phase.

Mitigation Stay informed about the latest advancements, be ready to adapt the technology stack if necessary, and maintain flexibility in the development approach.

- Communication Risks:

Poor Team Collaboration: Ineffective communication between team members led to misunderstandings, delays and errors in the development process.

Stakeholder Misalignment: Misalignment between the development team and stakeholders led to deviations from the project's original goals.

- Very difficult to find people for the requirement gathering.

It posed a significant risk to the success of the research and the subsequent project. It posed a significant risk to the success of the research and the subsequent project.

Chapter 03

3.1. Design of the system.

3.1.1 Database

3.1.1.1. Entity Relationship Diagram(ER diagram)

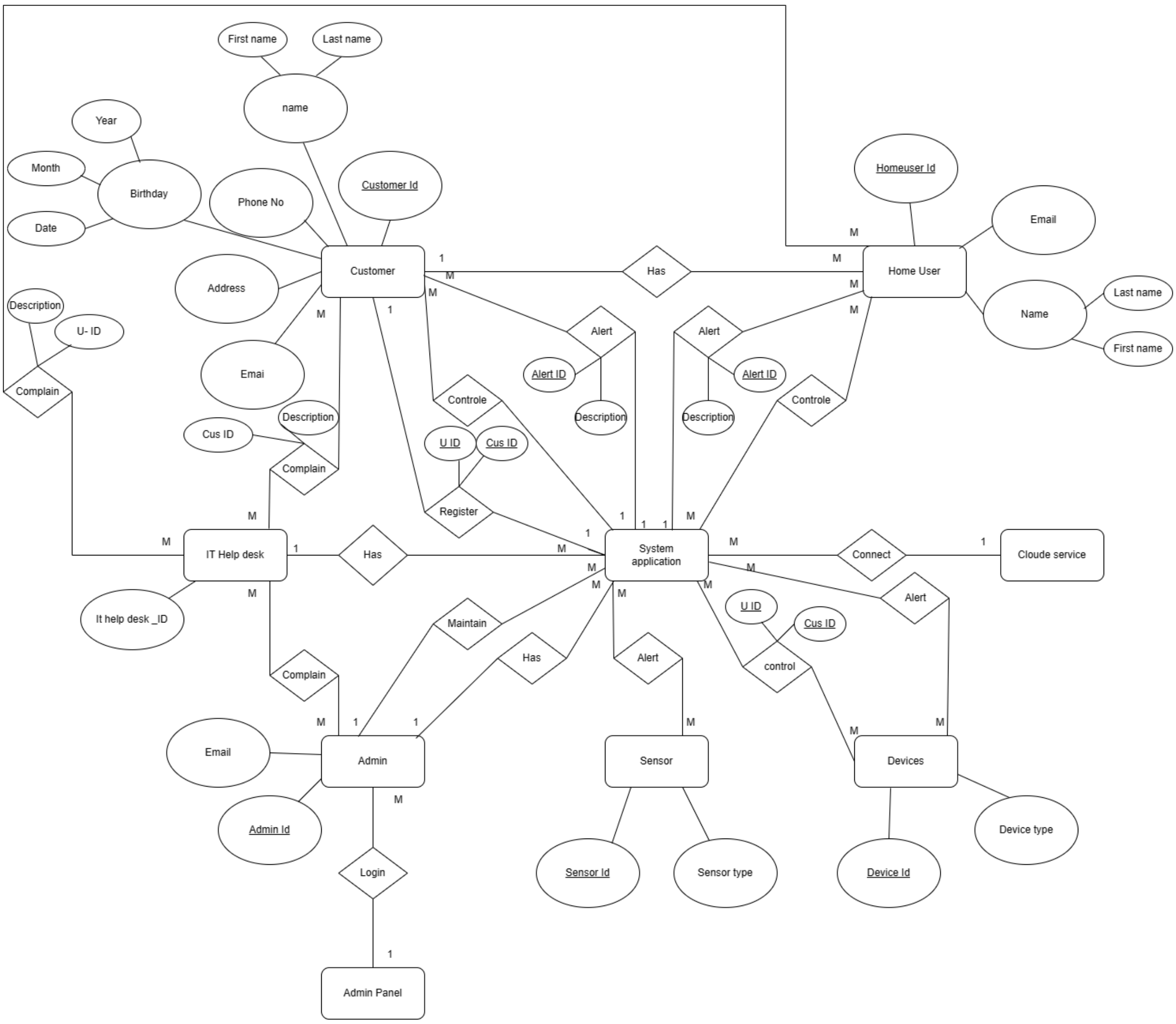


Figure 0.1Entity Relationship diagram

In conclusion

Here the diagram shows the home automation system organizational relationship diagram by the researchers. After registration the customer can register to the system and then the customer can login to the system. The customer can add users to the home automation system. Both customer registration and registered user can control the home automation system. The system is always connected to the cloud server. The system queries the user and customer control device controls and forwards the customer ID or device control device along with the user ID along with the authorization request.

A follow-up of the device's performance is again provided to the system by the device and an alert ID and description is provided to the customer registration and registered user.

Sensors perform the same function and provide alert ID and description related to customer registration and registered user. After the customer can complain with the ID help desk, send a complaint to the admin. Admin can fix errors in system application. An administrator has the admin panel and can control all the system requirements here.

Entities

- Customer
- User (customer can add users)
- Admin
- Sensor
- Device(for lights and door system)
- It help desk
- Cloud service(firebase)

Attributes

- Customer = Customer ID ,name, Birthday ,phone, Address, Email
- User (customer can add users)=User-id ,Email, name
- Admin=Email, Admin Id
- Sensor=Sensor-ID, sensor type
- Device (for lights and door system) = device-Id, device type.

3.1.1.2. Relationship

One to one relationships.

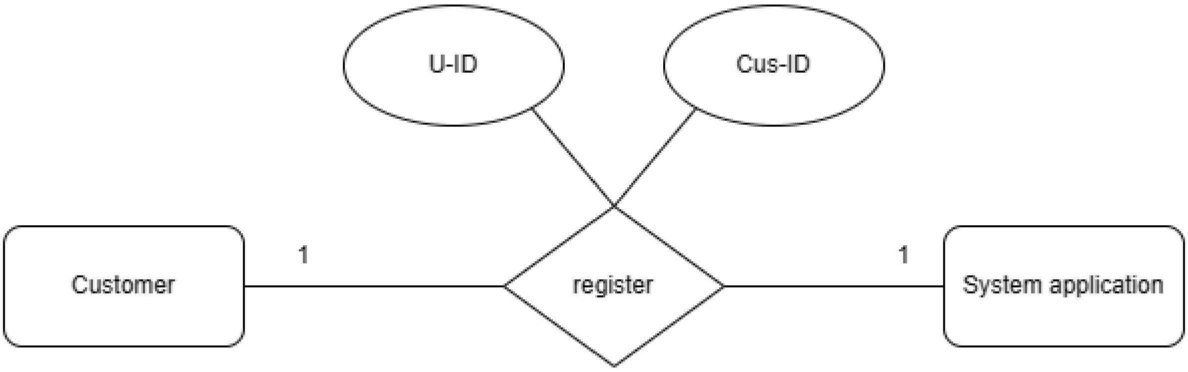


Figure 0.2one to one relationship Diagram

In this case customer have one home automation system application and system application have one customer.

One to many relationships

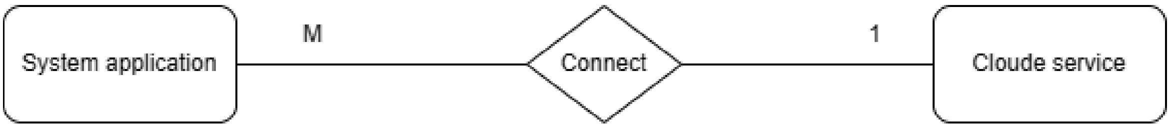


Figure 0.3one to many relationship Diagram

In this case the one system application have one cloud service and Cloud service have many different application.

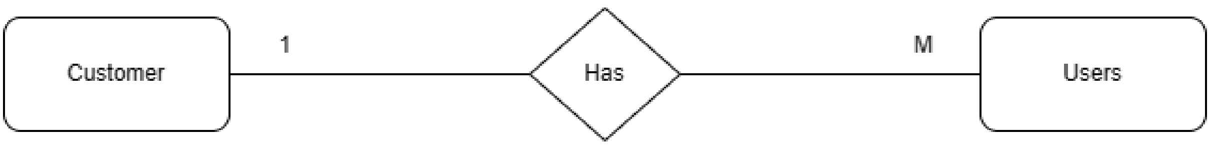


Figure 0.4 one to many relationship Diagram

In this case one customer has many users adding System and other case many users has one home automation system customer.

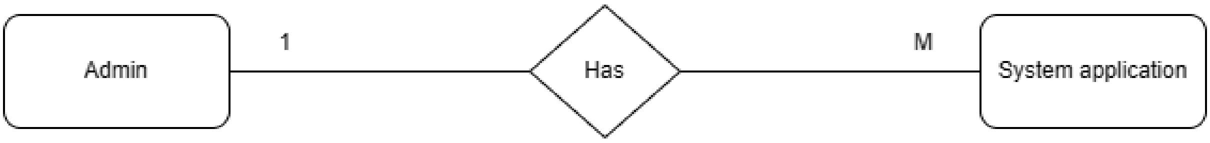


Figure 0.5 one to many relationship Diagram

In this case Admin have many different home automation system application but one home automation system has ne admin.

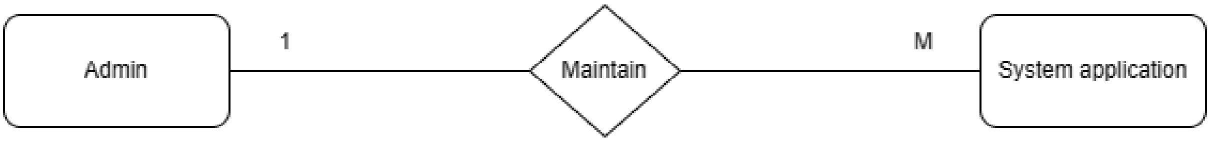


Figure 0.6 one to many relationship Diagram

In this case admin can maintain more home automation system application but one home automation system application can have one admin to maintain the system.

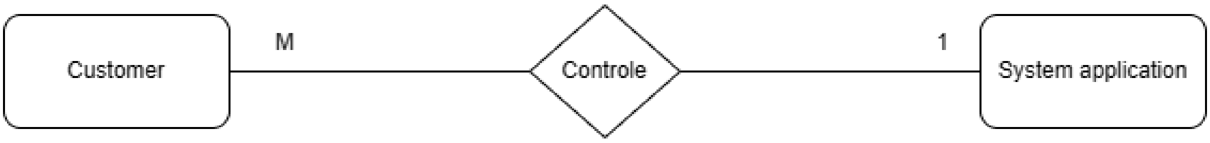


Figure 0.7 one to many relationship Diagram

In this case customer can control the system application many times System application have one customers to the control the system

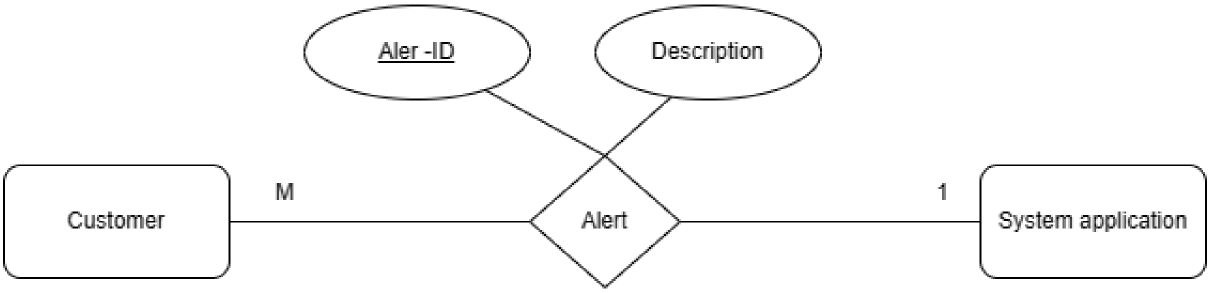


Figure 0.8 one to many relationship Diagram

In this case System send alert to the customer many times and the one system application have one customer   the send alert message.

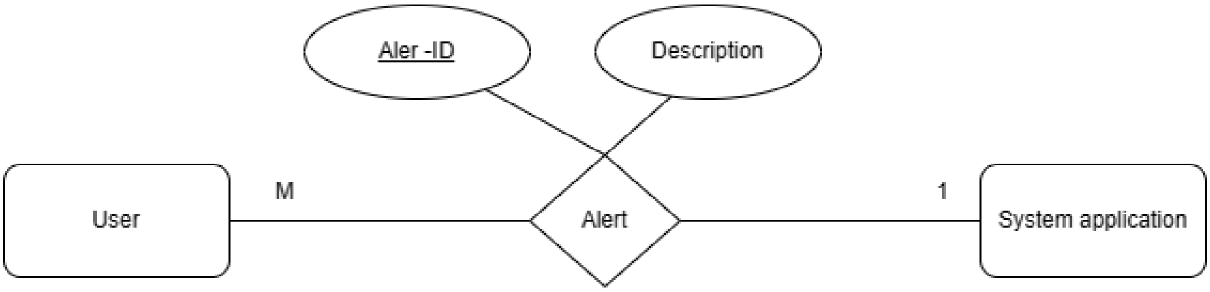


Figure 0.9 one to many relationship Diagram

In this case system application have many users to send alert message and many users have one application to get the message.

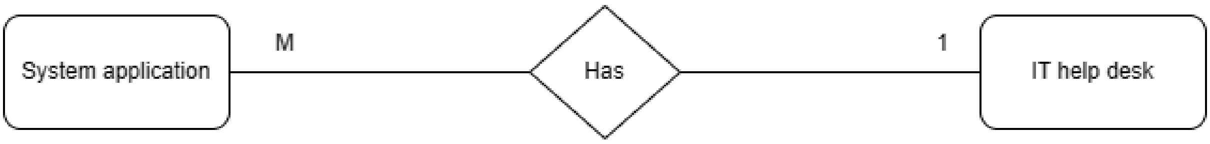


Figure 0.10 one to many relationship Diagram

In this case one system application has one IT help desk and IT help desk have more system application.

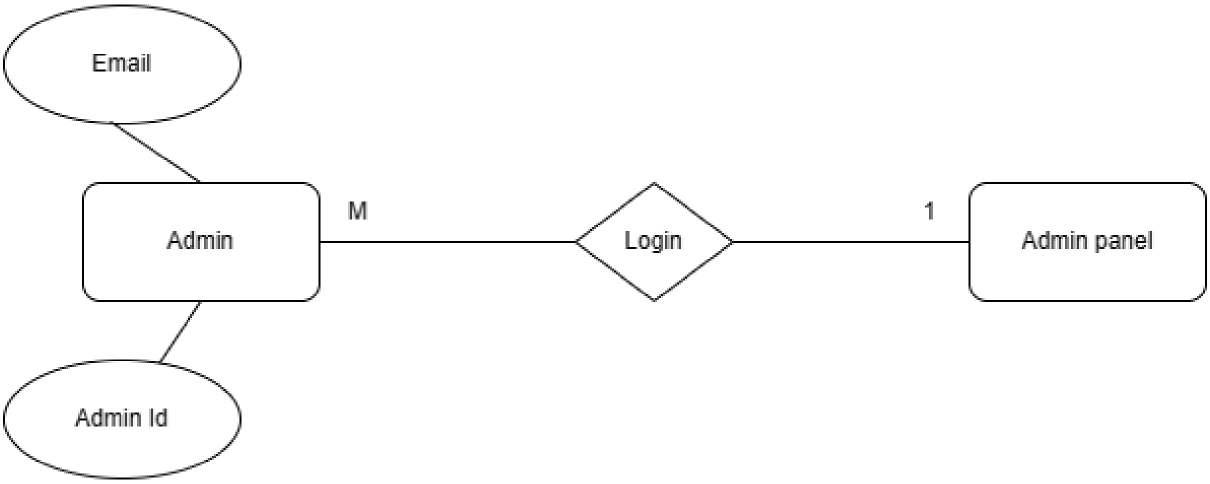


Figure 0.11 one to many relationship

In this case one admin has one admin panel and one admin panel has more admins.

Many to many relationship

In this case Customer complain system problem to IT help desk in here customers can complain many time to the help desk and one help desk have many customers.

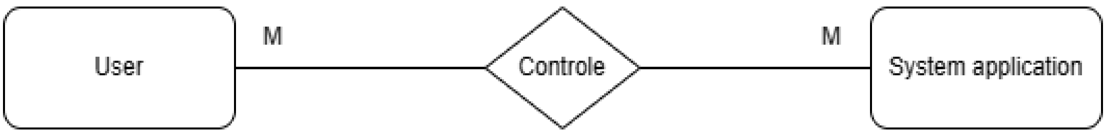


Figure 0.12 many to many relationship Diagram

In this case users can control man times the system application and the system application have many users to the control the system.

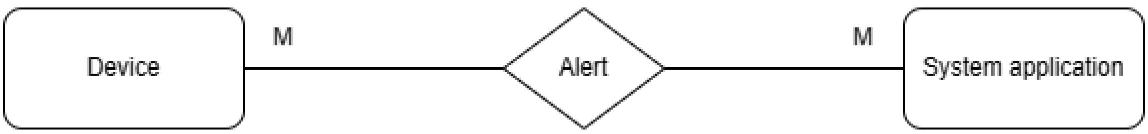


Figure 0.13 many to many relationship Diagram

In this case System have many devices to alert to the system application one system application have many alert devices inform the system.

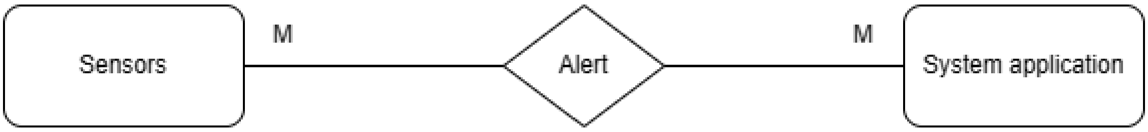


Figure 0.14 many to many relationship Diagram

In this case System have many sensors to recognize alert detection and sensors are send the alert many times to the systems.

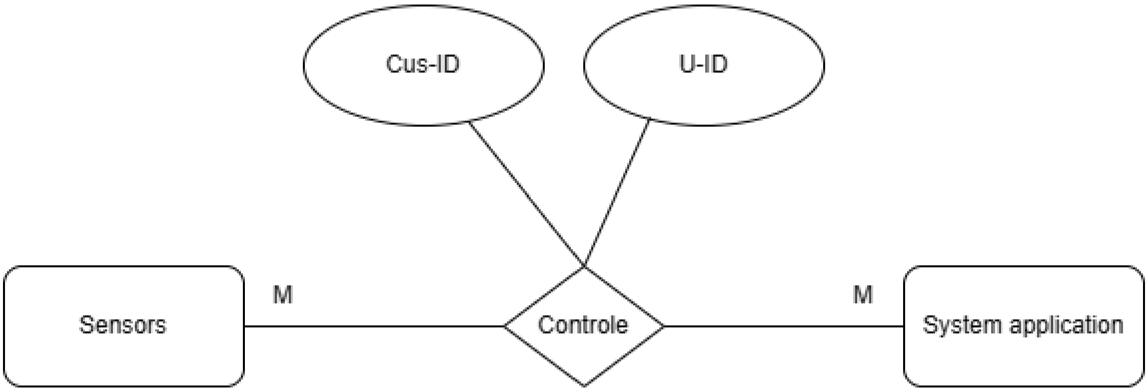


Figure 0.15 many to many relationship Diagram

In this case Sensor are control the system application many time and system application have many sensors to the control the system application.

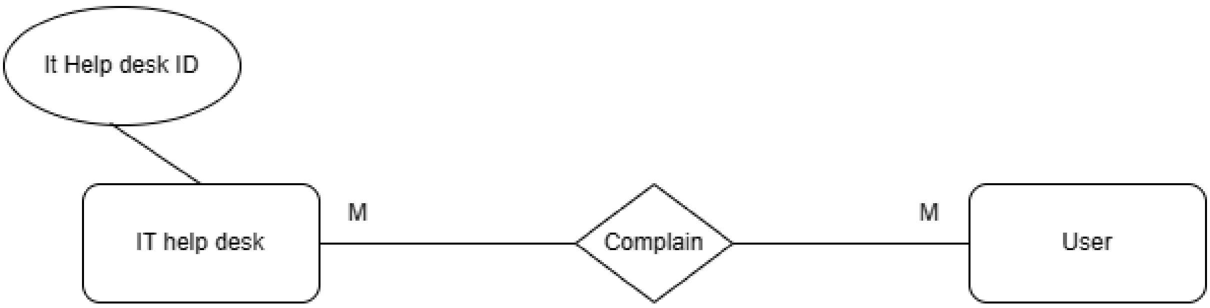


Figure 0.16 many to many relationship Diagram

In this case IT help desk complain many times to the admin and admin have many IT help desks.

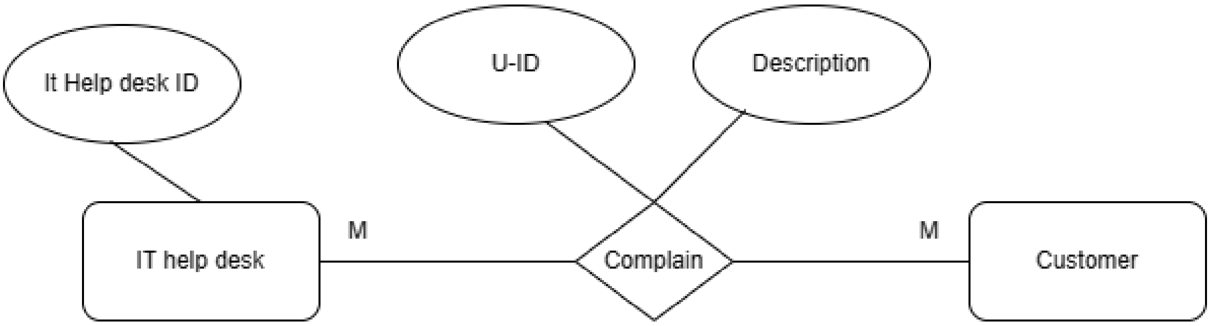


Figure 0.17 many to many relationship Diagram

In this case customers can complain the IT help desk and it helpdesk have more customer complains.

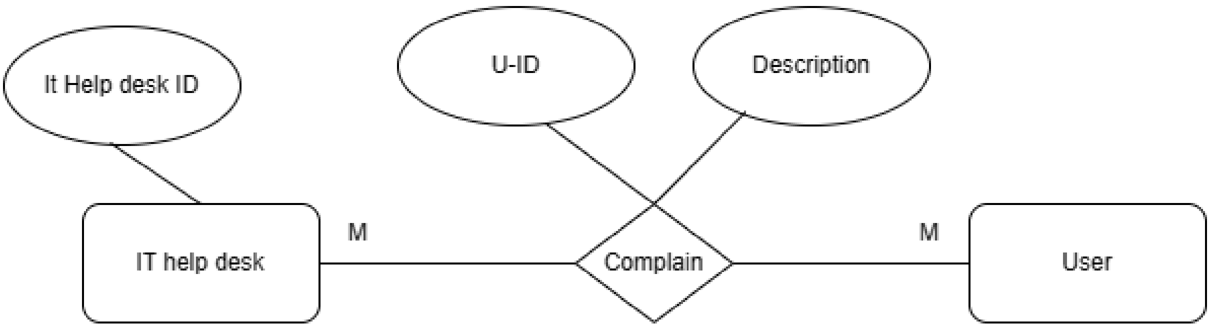


Figure 0.18 many to many relationship Diagram

In this case Users can complain the IT help desk and it helpdesk have more User complains.

3.1.2. Normalized relation schema

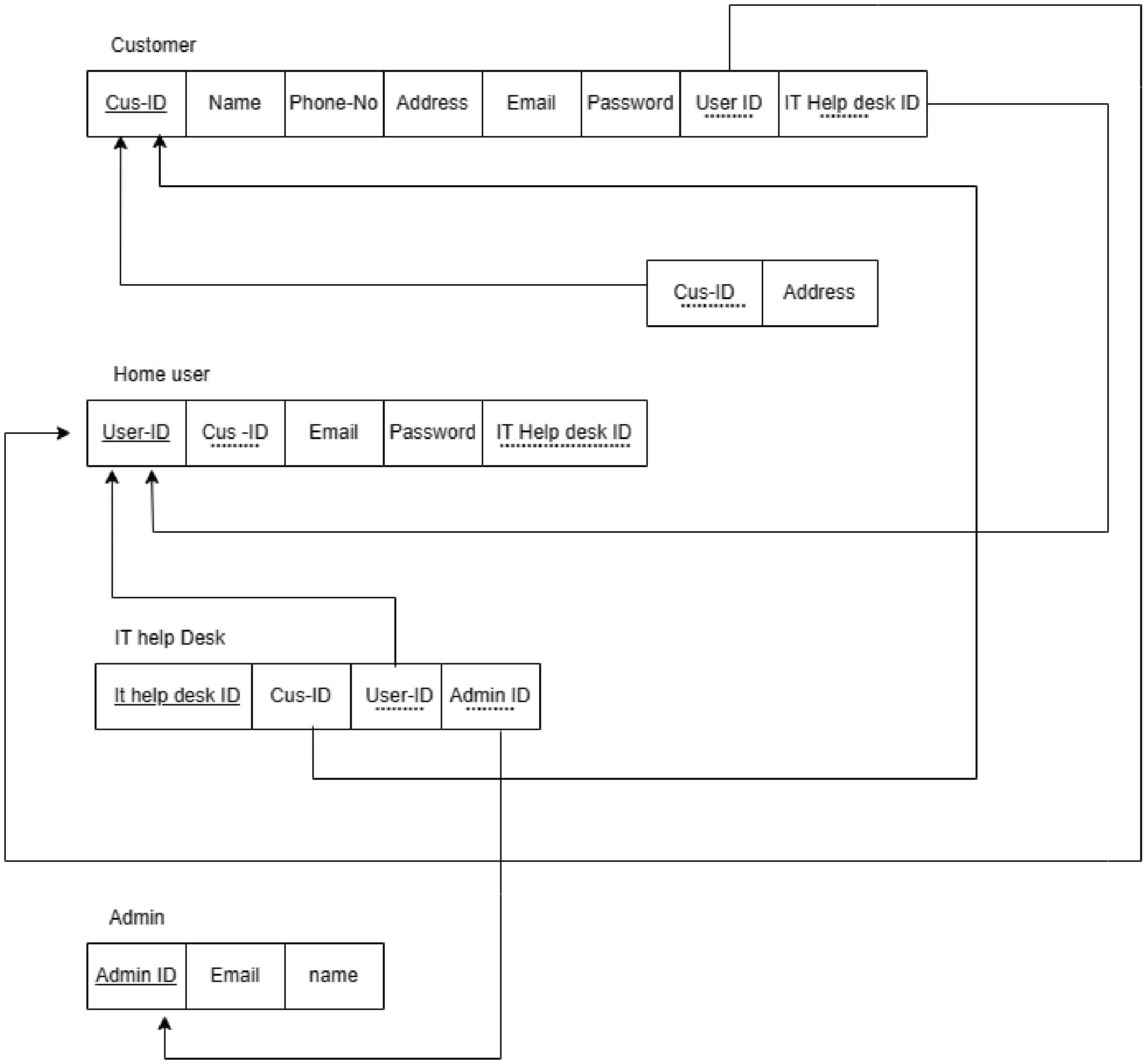


Figure 0.19 Normalization relational scheme.

3.2. System Design

3.2.1. Use case diagram.

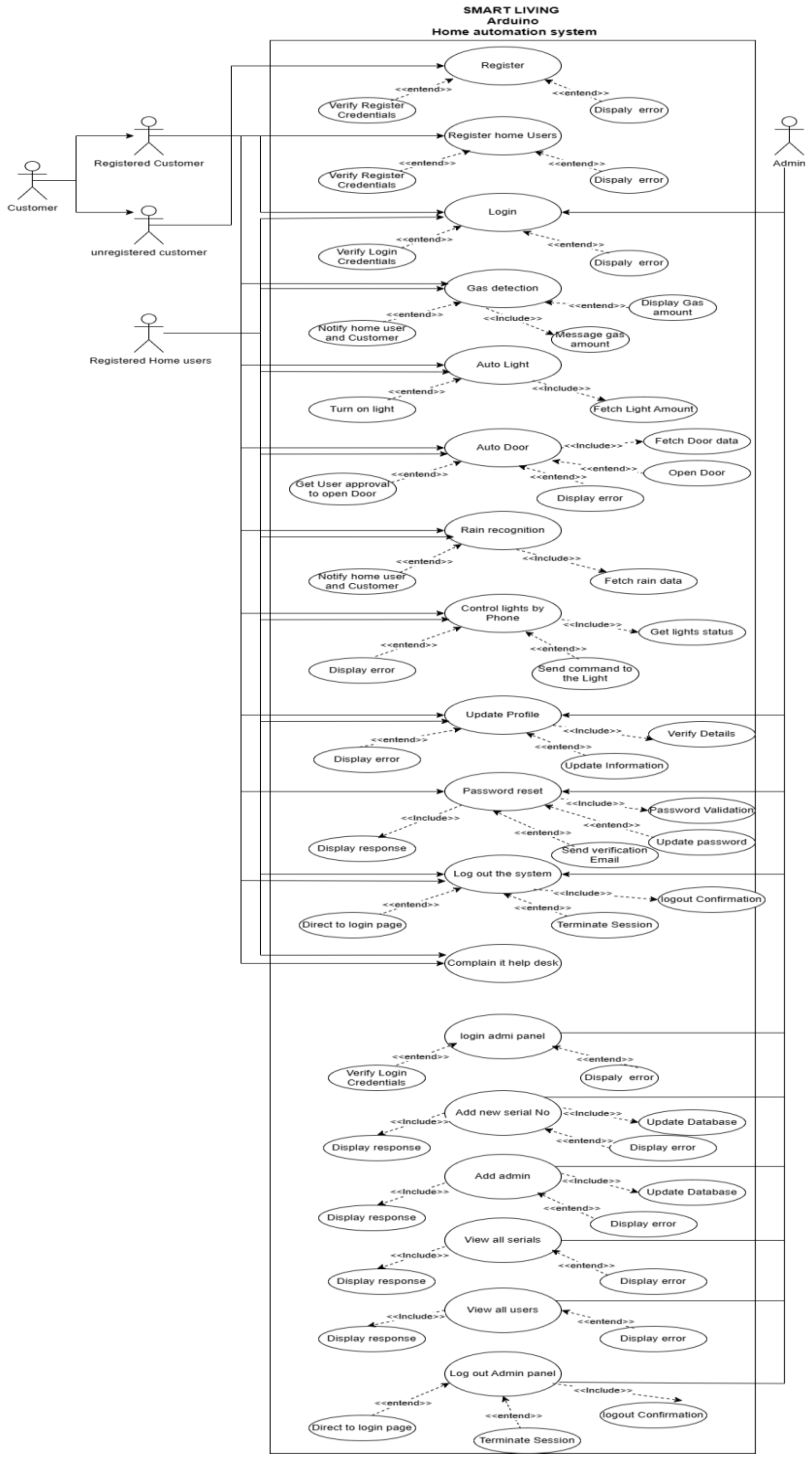


Figure 0.20 Use case diagram

3.2.2. Class Diagram.

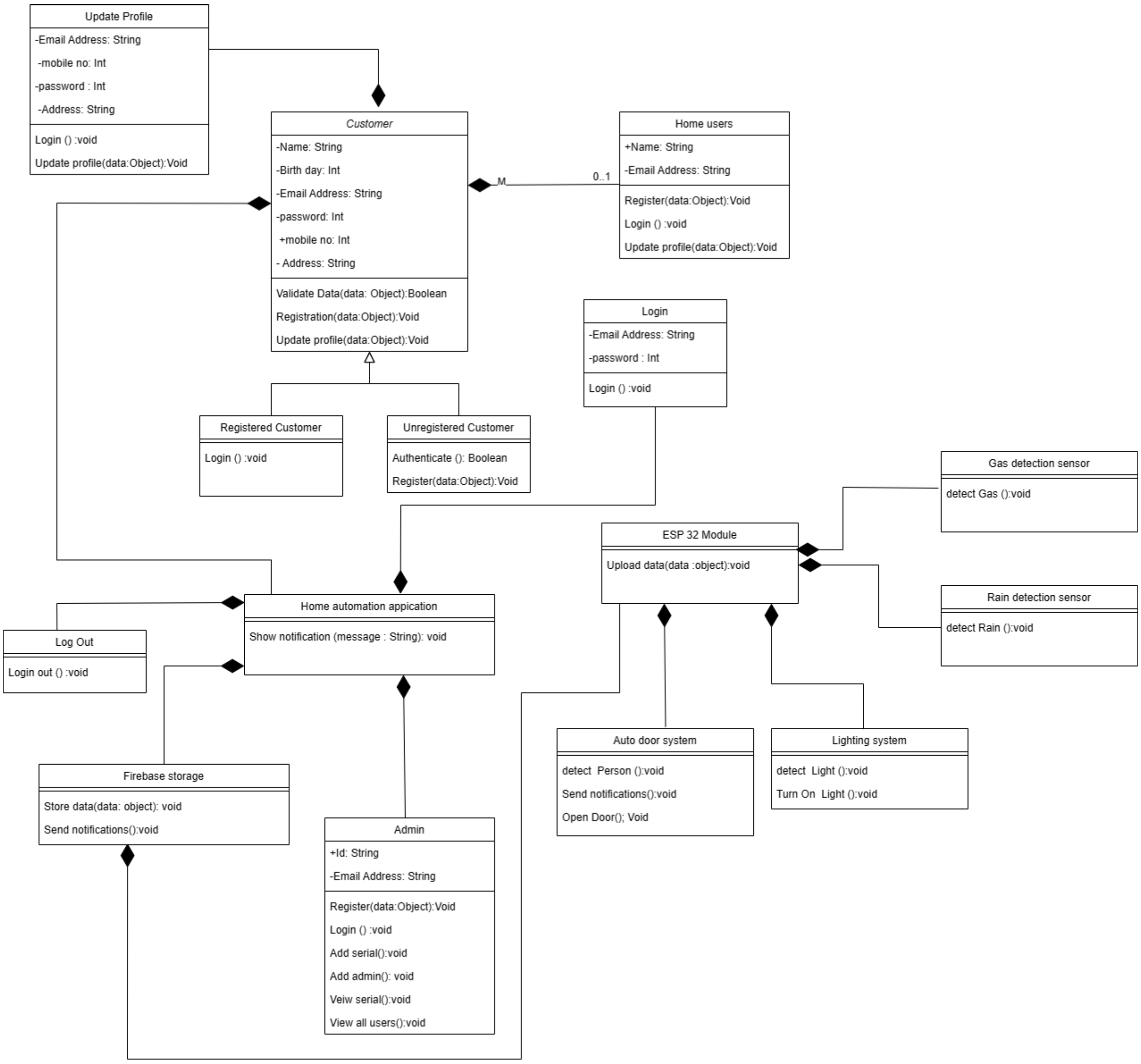


Figure 0.21 Class Diagram

3.2.3. Sequence Diagram.

3.2.3.1. Login

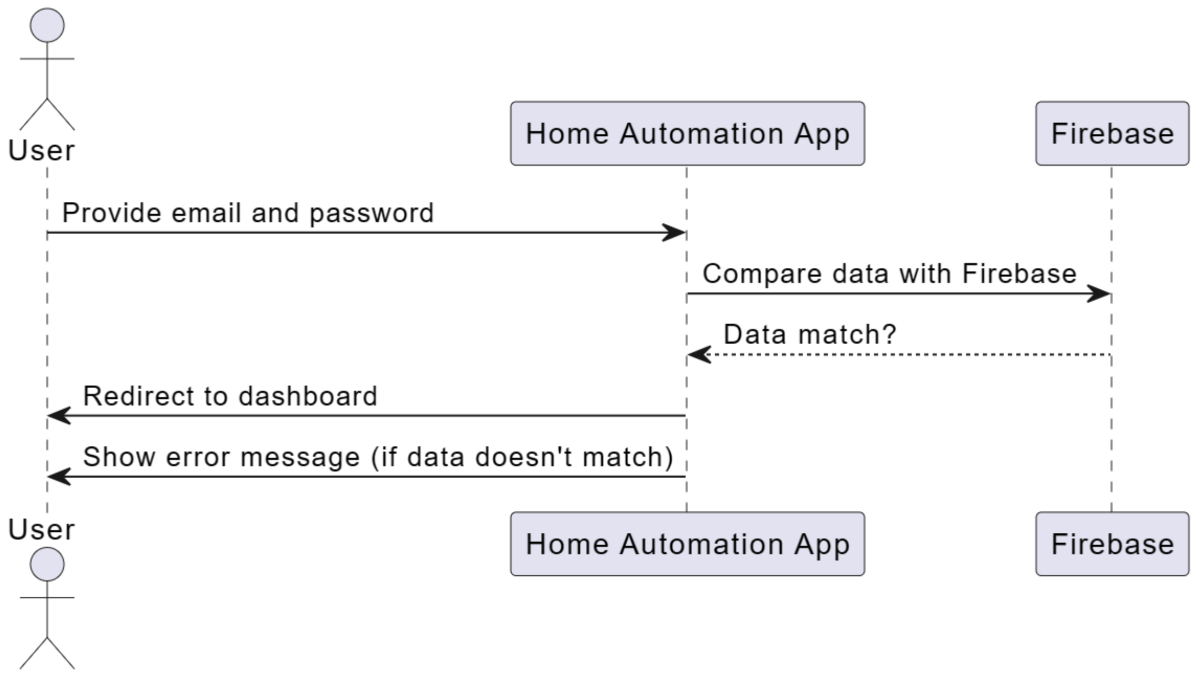


Figure 0.22 Login function sequence Diagram

3.2.3.2. Registration.

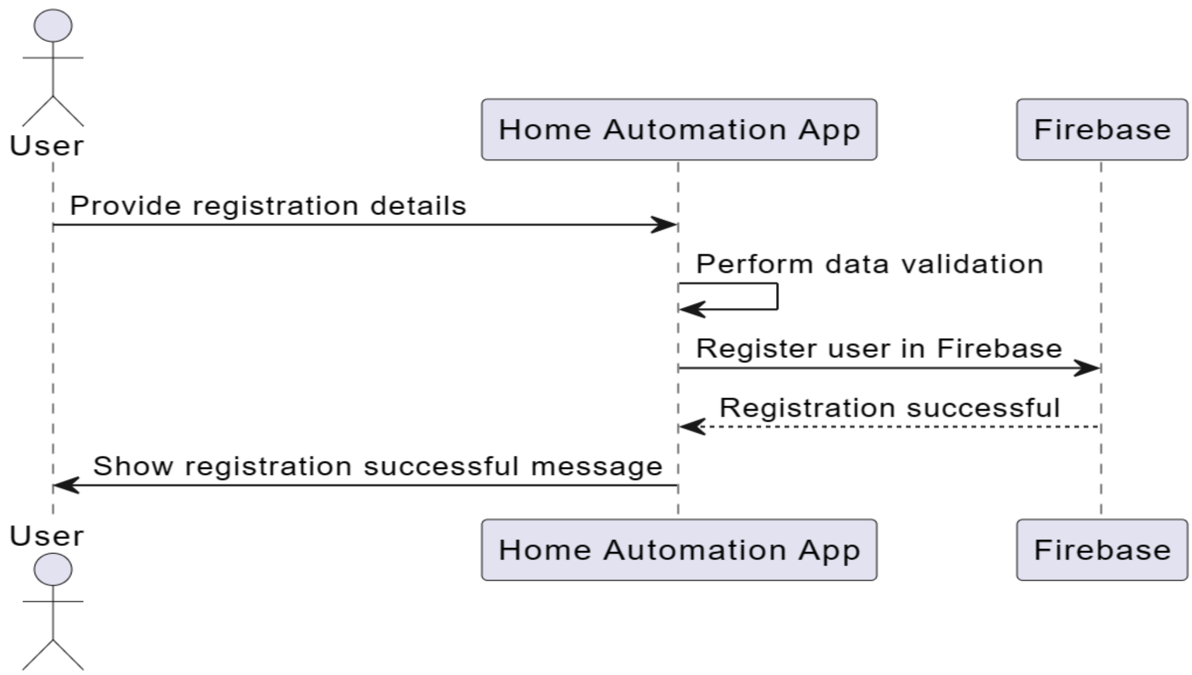


Figure 0.23 Registration faction Sequence diagram

3.2.3.3. Login out.

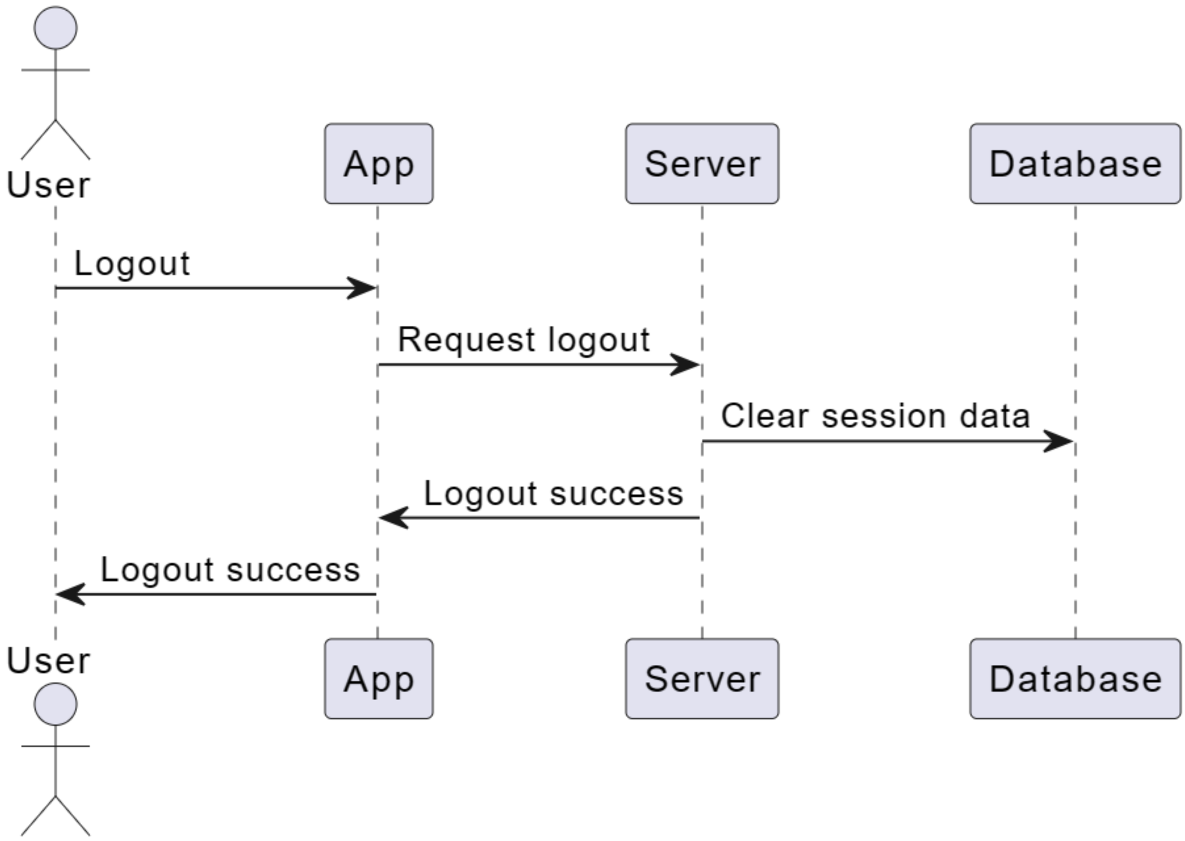


Figure 0.24 logout Function sequence diagram

3.2.3.4. Update Profile.

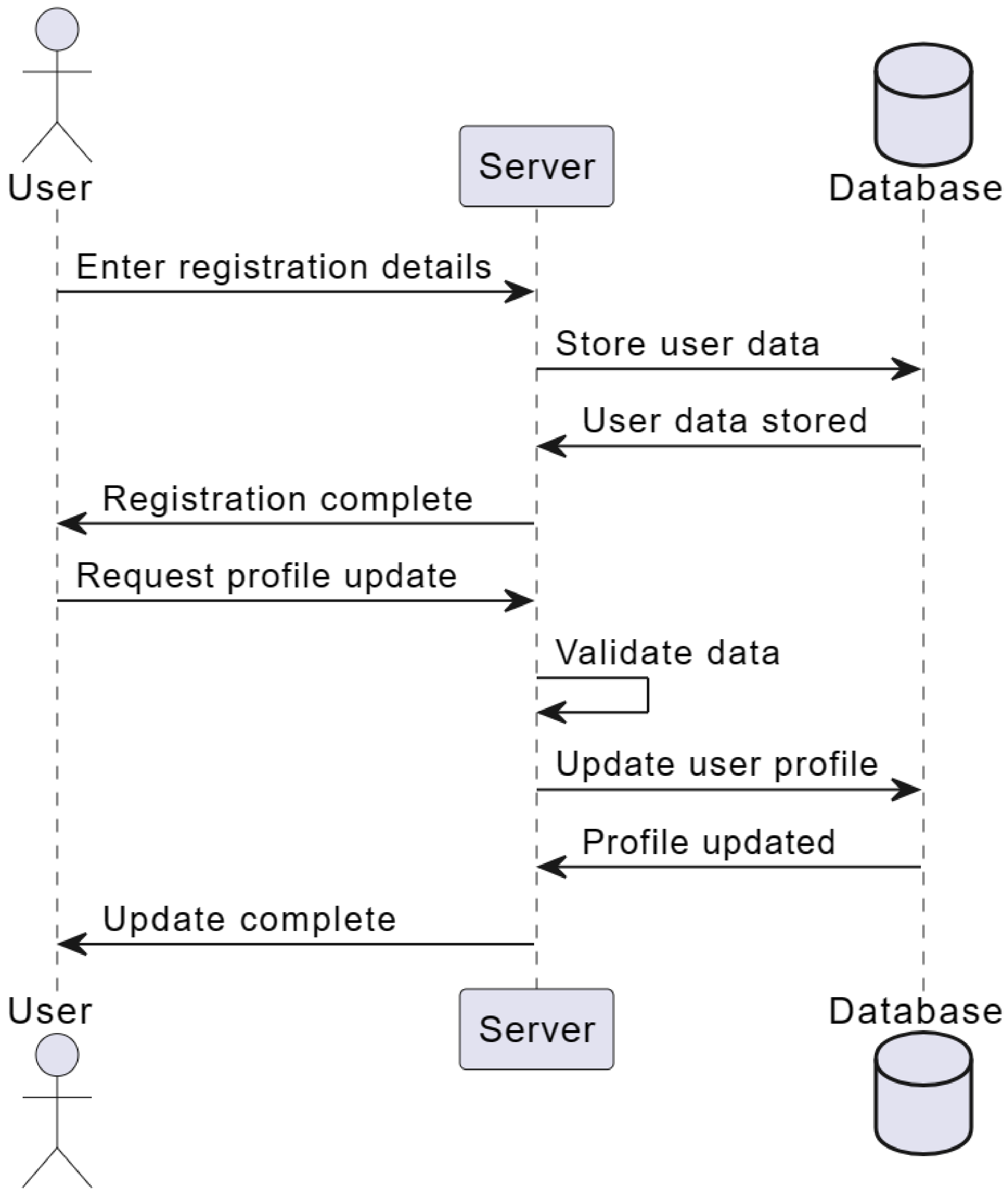


Figure 0.25 Update function Sequence Diagram

3.2.3.5. Password Reset.

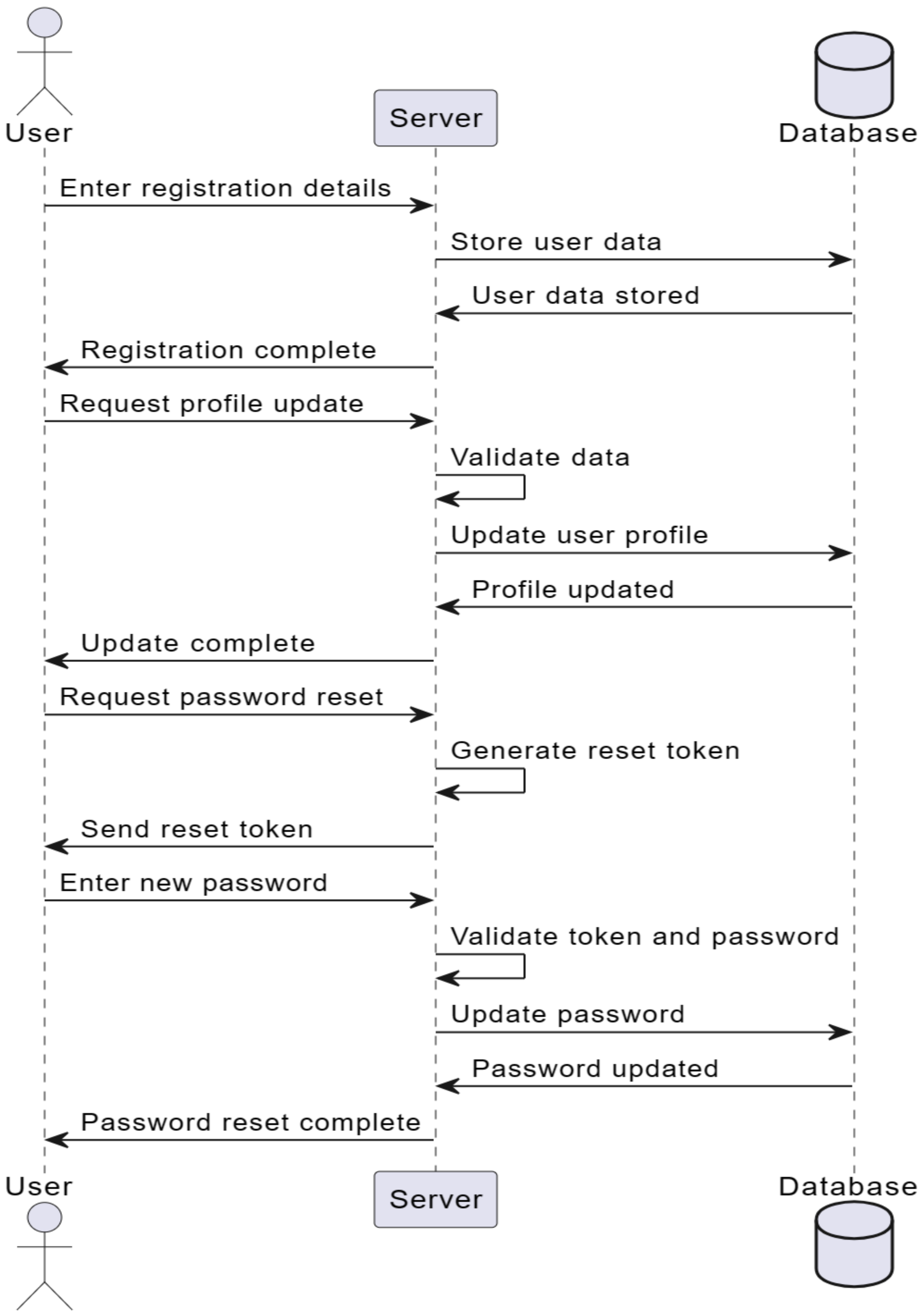


Figure 0.26 Password Reset Function

2.2.3.6.All the functionalities in user application implement Sequence diagram

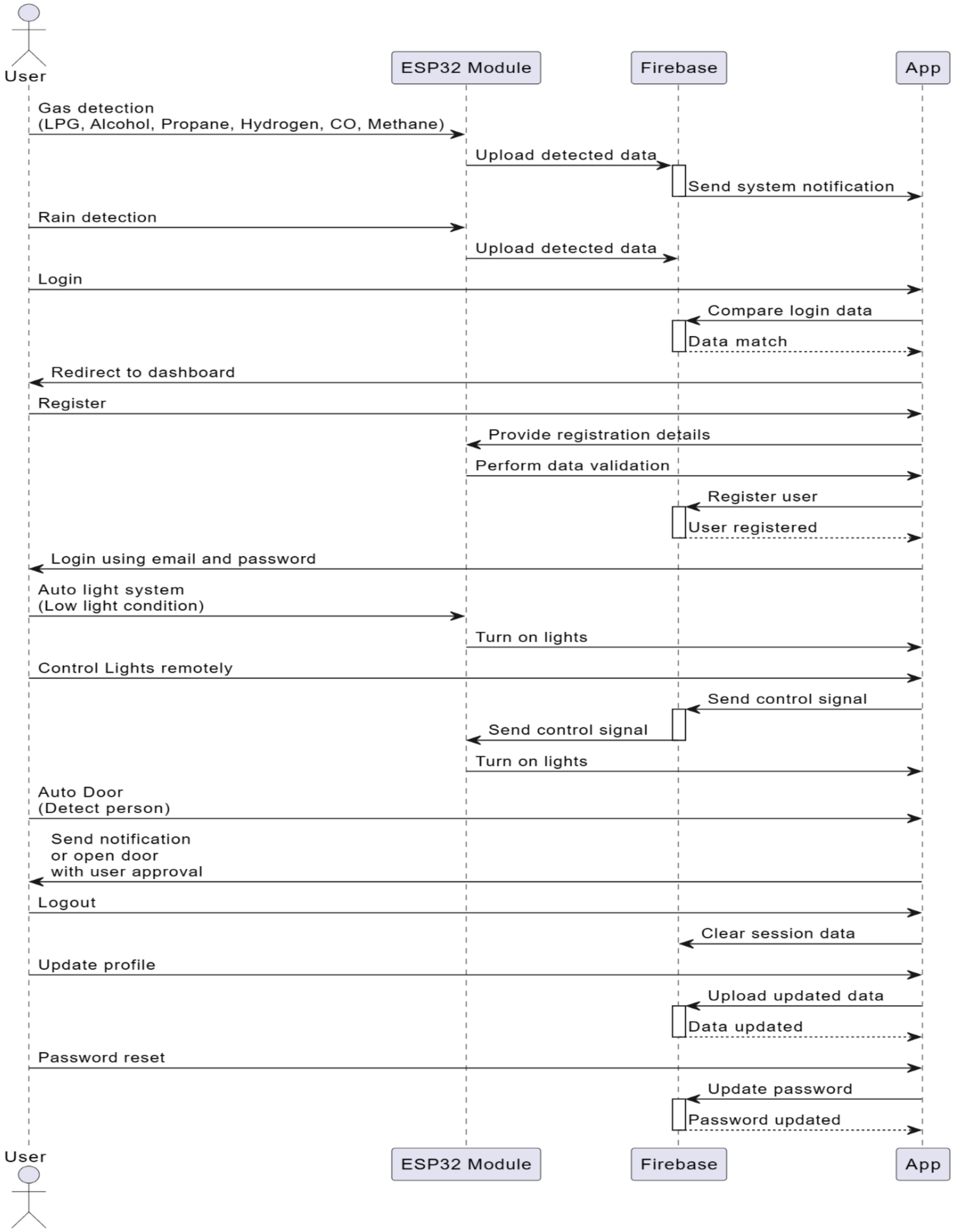


Figure 0.27 All function including sequence diagram

3.4. Pseudo code.

3.4.1. Login Faction.

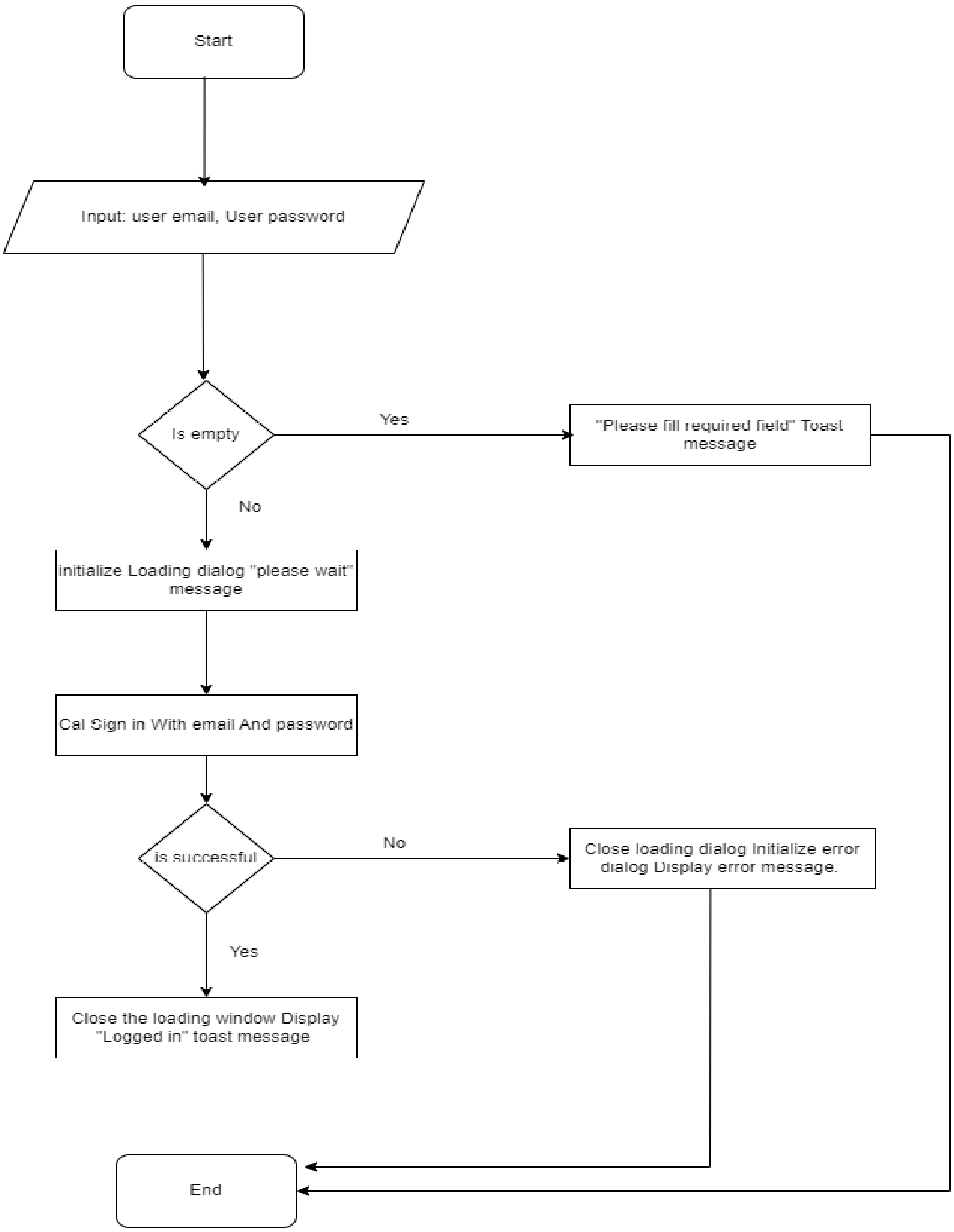


Figure 0.28 login function flow chart

Login function pseudo code

Algorithm 1 Login Algorithm

```
Input: User email, User password
Output: Success or Failure
procedure LOGIN(email, password)
    if email is not empty and password is not empty then
        Initialize loading dialog
        Display "Please Wait" message in loading dialog
        Call SIGNINWITHEMAILANDPASSWORD function with email and password
        if Sign-in is successful then
            Close loading dialog
            Display "Logged in" toast message
            Launch ControlActivity
            Finish LoginActivity
        else
            Close loading dialog
            Initialize error dialog
            Display error message from the exception
            Show error dialog
        end if
    else
        Display "Please fill required fields" toast message
    end if
end procedure
procedure SIGNINWITHEMAILANDPASSWORD(email, password)
    Initialize FirebaseAuth instance
    Call SIGNINWITHEMAILANDPASSWORD method with email and password
end procedure
```

Figure 0.29 login function pseudo code

3.4.2. Registration function flow chart.

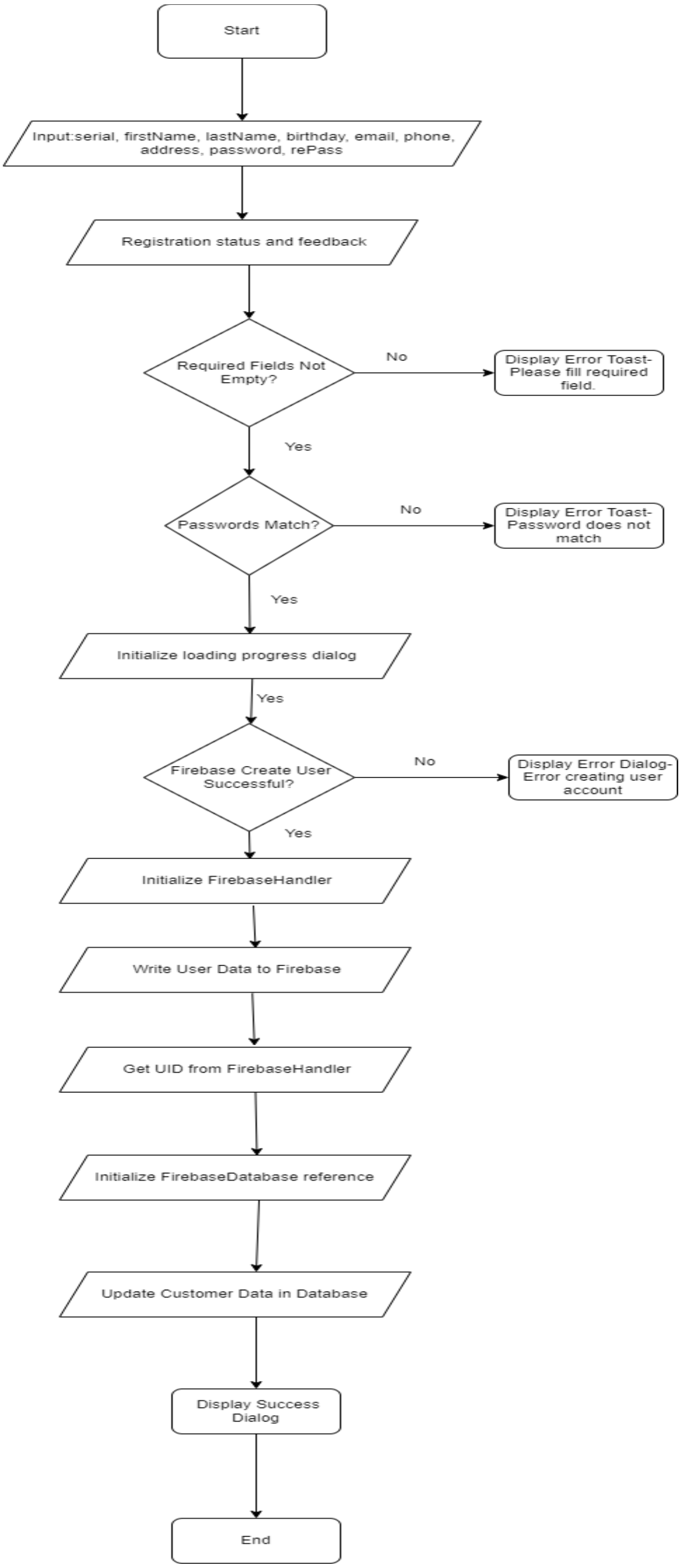


Figure 0.30 registration function flow chart

Registration function pseudo code.

```
Algorithm 1 Advanced User Registration
procedure USERREGISTRATION
    Input: User details - serial, firstName, lastName, birthday, email, phone, address, password, rePass
    Output: Registration status and feedback

    if RequiredFieldsNotEmpty(serial, firstName, lastName, birthday, email, phone, address, password, rePass) then
        if PasswordsMatch(password, rePass) then
            // Validation and Registration
            Initialize loading progress dialog

            if FirebaseCreateUser(email, password) then
                // Firebase user creation successful
                Initialize FirebaseHandler
                WriteUserDataToFirebase(serial, firstName, lastName, birthday, address, email)
                Get UID from FirebaseHandler
                Initialize FirebaseDatabase reference
                UpdateCustomerDataInDatabase(UID, serial)
                DisplaySuccessDialog("User created successfully")
            else
                // Firebase user creation failed
                DisplayErrorDialog("Error creating user account")
            end if
        else
            // Passwords do not match
            DisplayErrorToast("Password does not match")
        end if
    else
        // Required fields are empty
        DisplayErrorToast("Please fill required fields")
    end if
end procedure
```

Figure 0.31 registration function pseudo code

3.4.3. Edit function Flow chart.

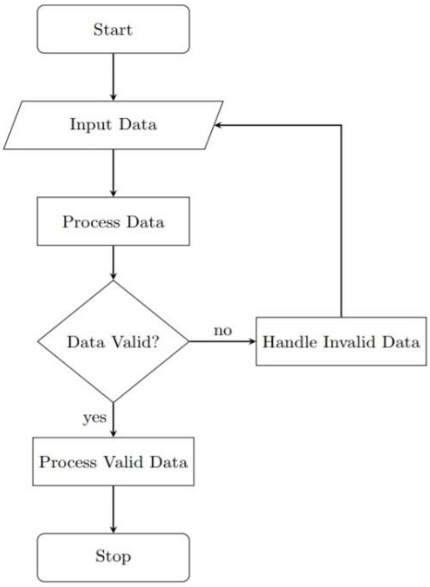


Figure 0.32 Edit function flow chart

Edit function pseudo code.

Algorithm 1 Edit Function

```
function EditProfile(profileData)
    uid ← getUid()
    loading ← new ProgressDialog()
    loading.setCancelable(false)
    loading.setMessage("Please wait")
    loading.show()
    if uid is not empty then
        dbRef ← FirebaseDatabase.getInstance().getReference("Customers").child(uid)
        dbRef.get().addOnCompleteListener(new OnCompleteListener¡DataSnapshot¿())
        dbRef.get().addOnCompleteListener(new OnCompleteListener¡DataSnapshot¿())
        override onComplete(@NonNull Task¡DataSnapshot¿ task)
        override onComplete(@NonNull Task¡DataSnapshot¿ task)
        DataSnapshot dataSnapshot ← task.getResult()
        DataSnapshot dataSnapshot ← task.getResult()
        if dataSnapshot is not empty then
            serial.setText("Serial ID " + dataSnapshot.child("serial").getValue(String.class))
            fName.setText(dataSnapshot.child("firstName").getValue(String.class))
            lastName.setText(dataSnapshot.child("lastName").getValue(String.class))
            bDay.setText(dataSnapshot.child("birthday").getValue(String.class))
            address.setText(dataSnapshot.child("address").getValue(String.class))
            email.setText(dataSnapshot.child("email").getValue(String.class))
            phone.setText(dataSnapshot.child("phone").getValue(String.class))
            loading.cancel()
        end if
    end if
    return
end function
```

Figure 0.33 Edit function pseudo code

3.4.4. Add user function Flow chart

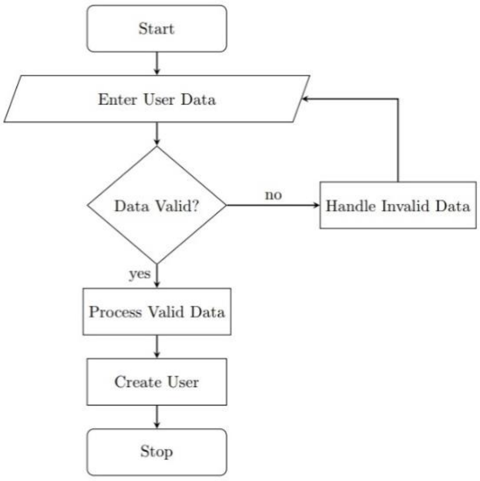


Figure 0.34Add user function flowchart

Add user function pseudo code

Algorithm 1 Create User Function

function CreateUser($firstName$, $lastName$, $email$, $password$, UID)
Input: User's first name $firstName$, last name $lastName$, email $email$, password $password$, and unique user ID UID
Output: None

if ($CheckDataValidity(firstName, lastName, email, password, UID)$)
  then
    $user \leftarrow$ Create new user object with $firstName$, $lastName$, $email$, $password$, and UID
    $SaveUserToDatabase(user)$
  else
    $HandleInvalidData()$
end if

return

Figure 0.35 Add function pseudo code

Revoke home user function flowchart

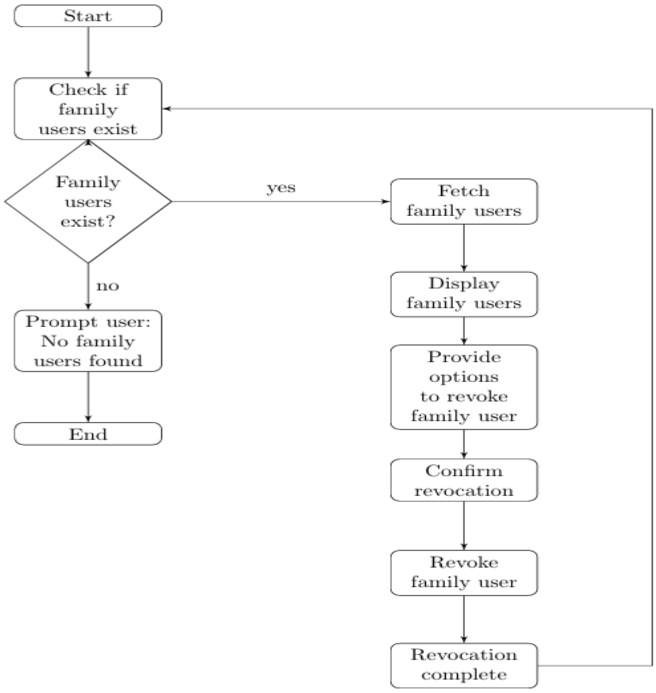


Figure 0.36 revoke user's flowcharts

Revoke home user function Pseudo code

Algorithm 1 Revoking a Family User

Start
Check if family users exist
if family users exist **then**
    Fetch family users
    Display family users
    Provide options to revoke family user
    Confirm revocation
    Revoke family user
    Revocation complete
else
    Prompt user: No family users found
    End
end if

Figure 0.37 revoke user pseudo code

Admin interface add admin function flow chart.

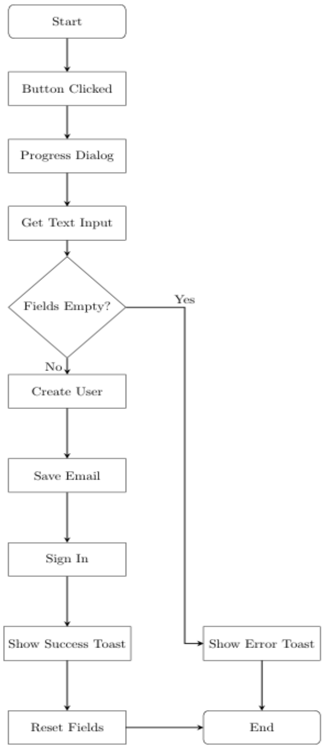


Figure 0.38 add admin flow chart

Admin interface add admin function Pseudo code.

Algorithm 1 Add Admin Fuction

```
function add admin(input)
result ← initialize an empty data structure
if input meets some condition then
    Perform operation A
else if input meets another condition then
    Perform operation B
else
    Perform operation C
end if
while condition do
    Perform iterative operation
    if additional condition then
        Perform extra operation
    end if
end while
return result
```

Figure 0.39 ad admin pseudo cod

Serial no function flow chart in admin panel

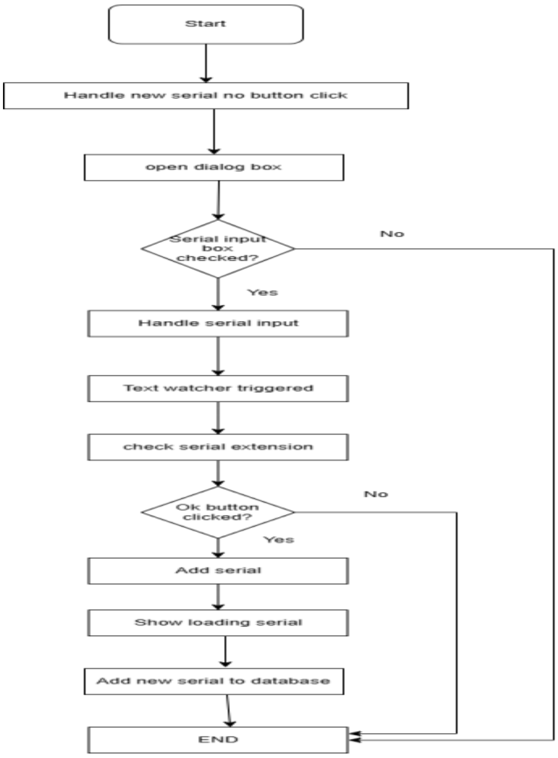


Figure 0.40 serial no function flow chart

Serial no function pseudo code in admin panel

Algorithm 1 Handle New Serial Input

```
Start
Input: User clicks on the "New Serial" button
Output: Serial is added to the database or an error message is shown
Procedure:
Open a dialog box for entering the new serial
Loop:
Check if the user clicks on the serial input box
if Serial input box is clicked then
    Handle serial input from the user
    Start a text watcher to monitor changes in the input
    Check if the serial exists in the database
    if Serial does not exist or has a sufficient length then
        Enable the "OK" button
        if "OK" button is clicked then
            Add the serial to the database
            Show a loading dialog while processing
            Close the dialog box
            End
        end if
    else
        Disable the "OK" button
        Show an error message indicating invalid serial
    end if
end if
End Loop
```

Figure 0.41 serial number function pseudo code

Admin Login function flow chart

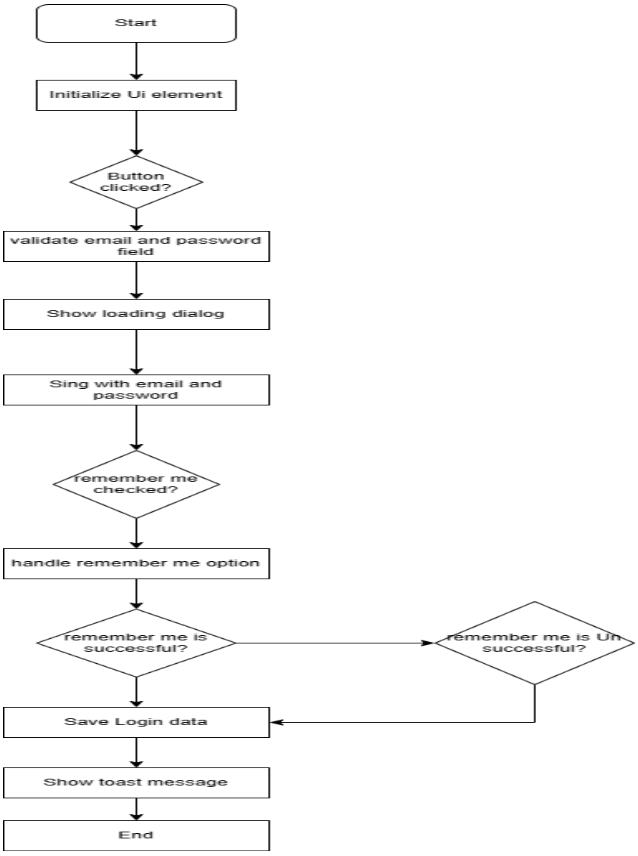


Figure 0.42 admin login flow char

Admin Login function pseudo code

Algorithm 1 Admin Login Function

Function LOGIN FUCTION($input1$, $input2$)
$result \leftarrow 0$
if $input1$ is valid **then**
    for i **from** 1 **to** $input1$ **do**
        if i is even **then**
            $result \leftarrow result + i$
        end if
    end for
else if $input2$ is valid **then**
    $result \leftarrow input2 \times 2$
else
    $result \leftarrow -1$ {Invalid inputs}
end if
return $result$

Figure 0.43admin login pseudo code

3.5. User interfaces and navigations.

Splash Screen developing system

Figure 0.44 splash screen

Login interface Developing system.

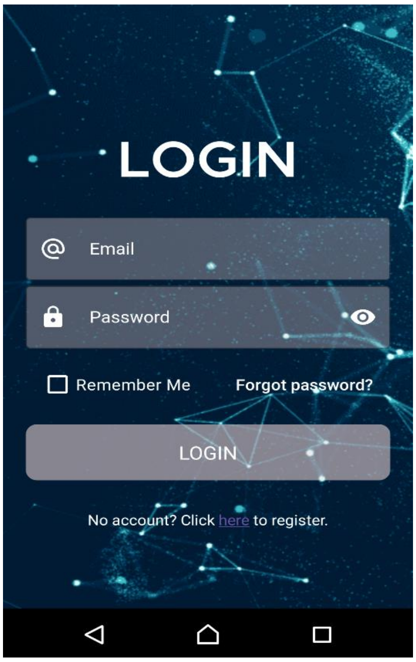


Figure 0.45 login interface

Registration interface developing system.

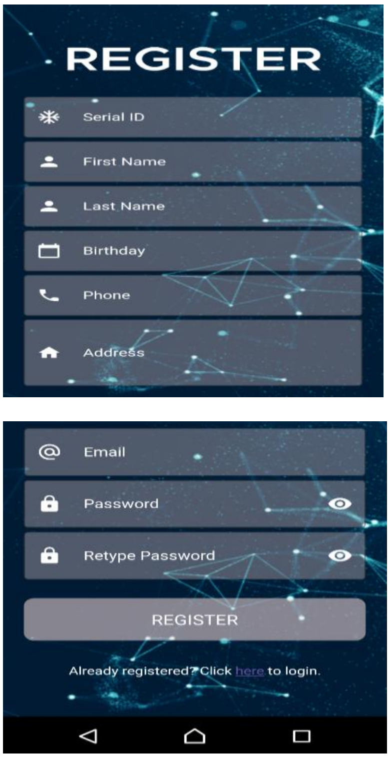


Figure 0.46 registration interface

Main dashboard Outdoor interface in developing system.

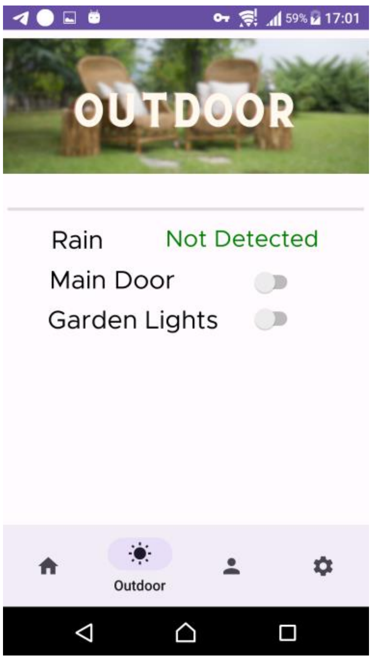
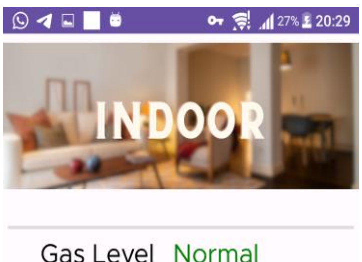


Figure 0.47 main dashboard out door interface

I ɔping system.



Setting interface in developing system.

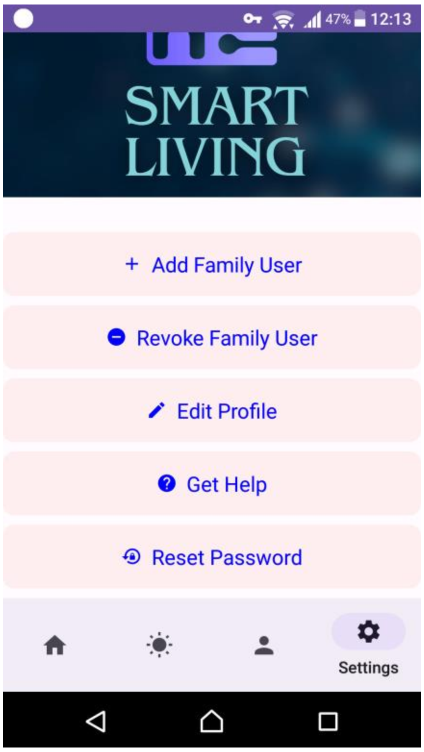
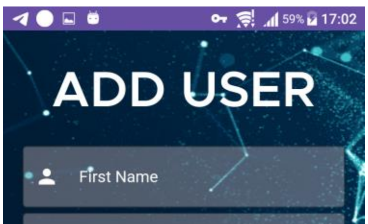


Figure 0.49 setting interface

Add family user interface in developing system.



Customer profile interface in developing system.

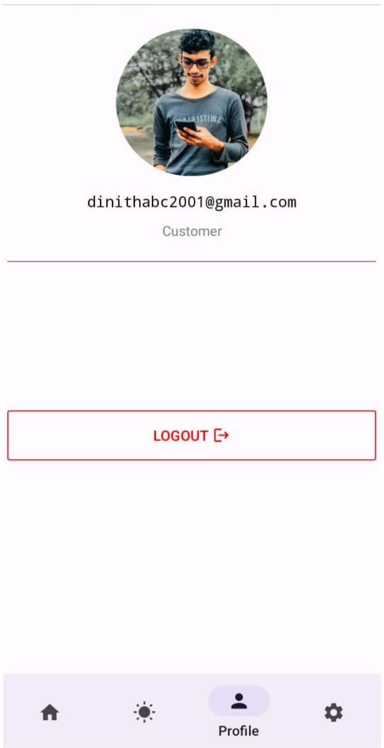
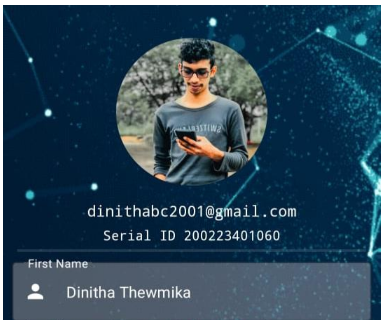


Figure 0.51 customer profile

Edit user profile interface in developing system.



Rework family user interface developing system.

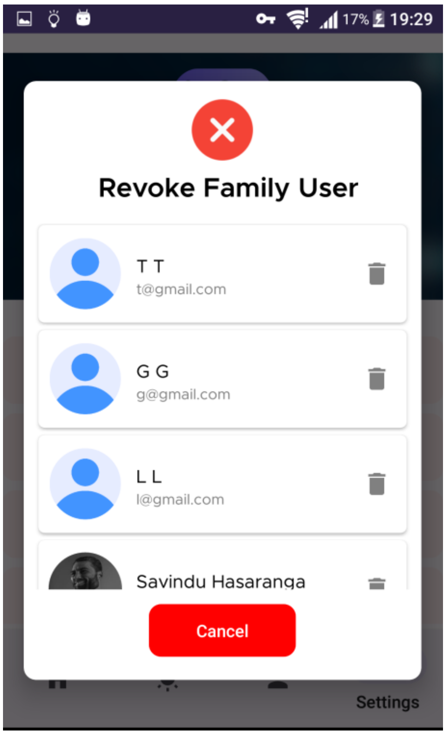
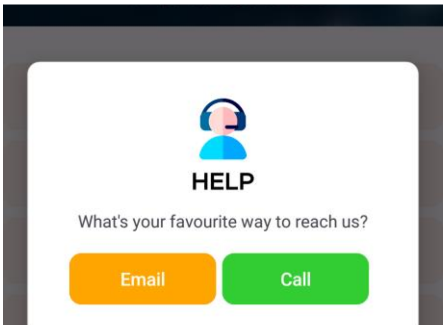


Figure 0.53 revoke family user interface



Admin Login interface

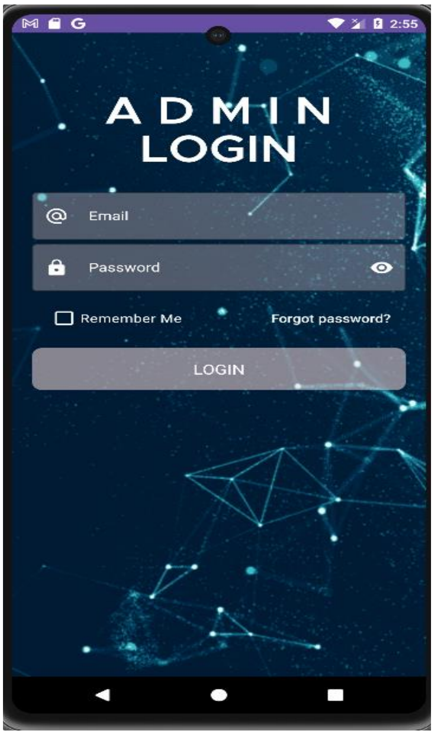


Figure 0.56 admin login interface

Admin Main interface

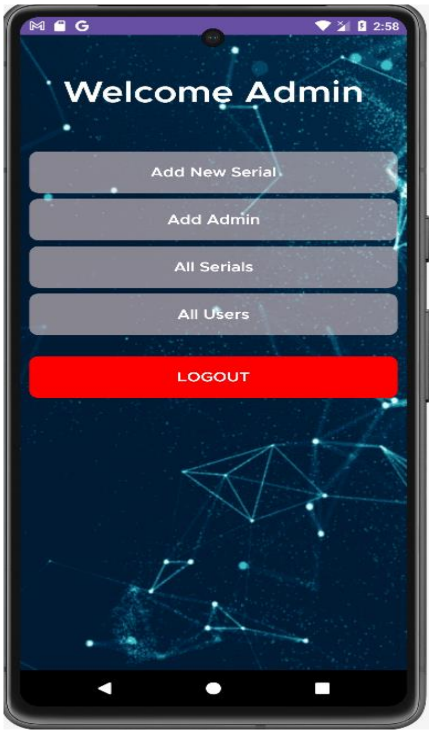
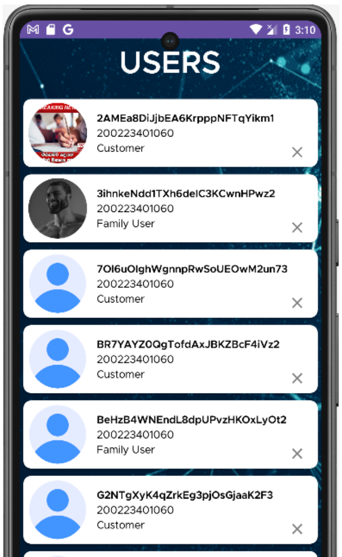


Figure 0.55admin main interface

Admin interface show all user interface



;

Add new serial interface

All serial Interface

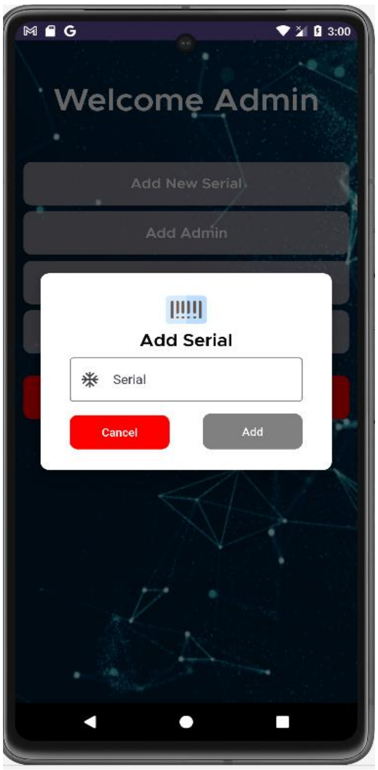


Figure 0.60 add serial no interface

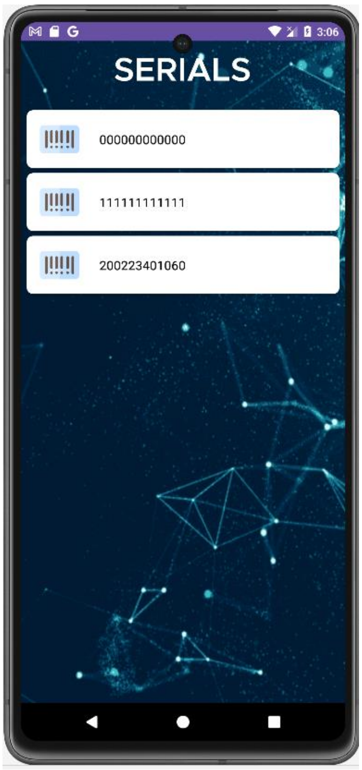


Figure 0.59 all serial interface

Chapter

Researchers introduce seven main functions when conducting research: gas detection system, rain detection system, outdoor garden lighting system, indoor living room lighting system, indoor kitchen lighting system, automatic door system and door opening system. More detailed features are provided below, and Android Studio, Arduino IDE, and related software are used as inputs for these features.

4.1. Gas detection Function.

Sample design

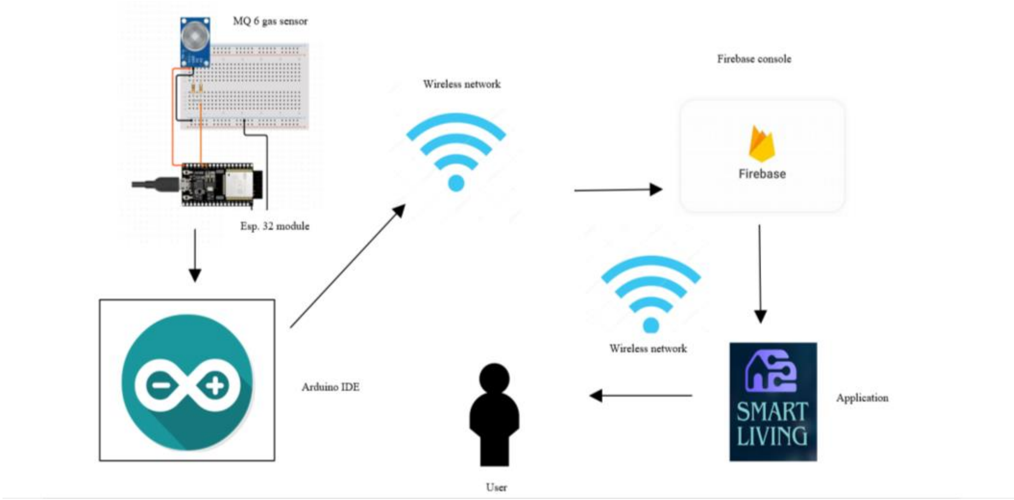


Figure 0.1 sample interface Gas detection system

In this functionality, the MQ-6 gas detection sensor detects the presence of LPG or butane gas in the surrounding environment and sends analog or digital signals to the within Esp. 32 module to Arduino IDE. The IDE then transmits this signal over a wireless network to a Firebase database. When Firebase receives a signal (true or false) it triggers a function to modify the database. Later, the mobile app will be notified online. If gas is detected, a "gas detected" notification is displayed, and if no gas is detected, a "gas not detected" notification is displayed. Additionally, the notification includes the time the gas was detected and alerts the user to the gas detection event.

Prototype version

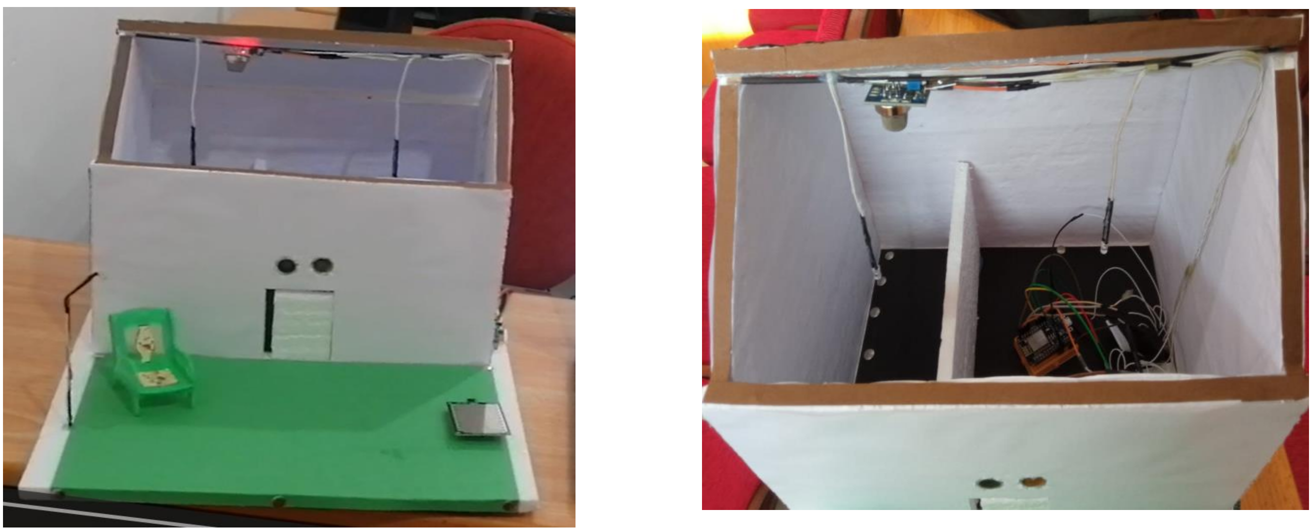


Figure 0.2 prototype picture gas sensor

Table 0.1 gas detection table

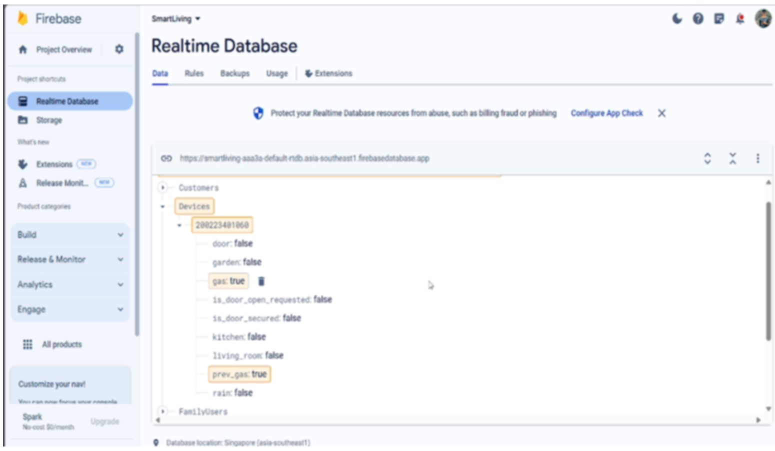
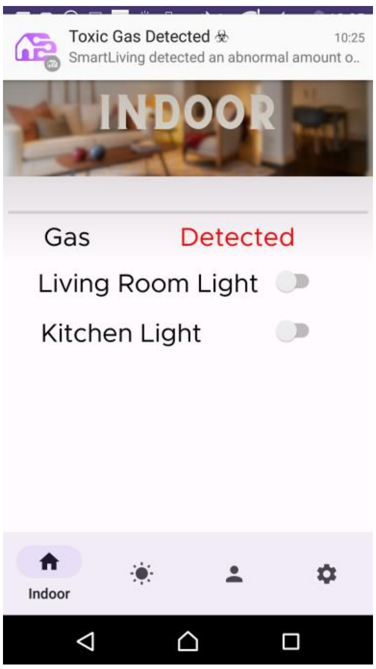
Gas detected time firebase console.	 *Figure 0.3 real-time data base update gas detection time interface*
Gas detected time mobile application console	

Figure 0.4 notify gas detection in indoor interface

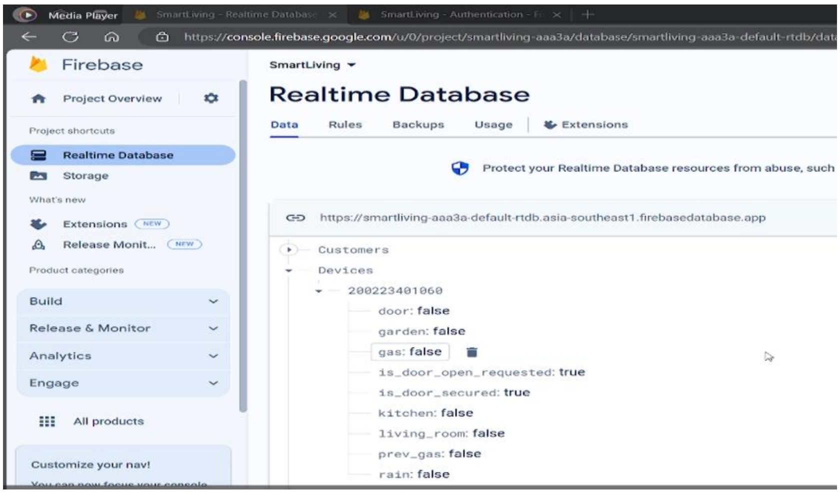
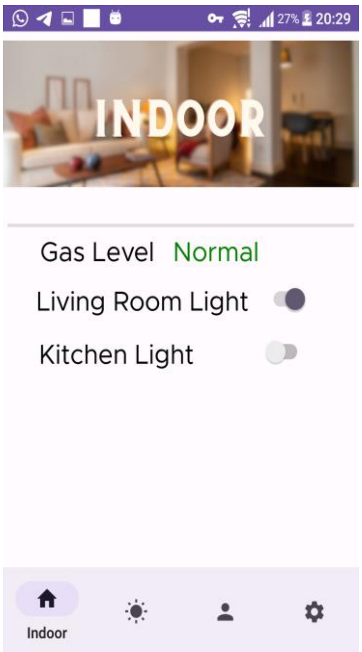
Gas not detected time Firebase console	 *Figure 0.5 real-time data base gas not detection time*
Gas not detected time Application console	

Figure 0.6 mobile application view gas not detection time

Conclusion

The gas detection system successfully uses MQ-6 sensors to detect LPG or butane gas, transmitting data seamlessly to Firebase via Arduino IDE and ESP32 modules. Notifications in both the Firebase console and mobile app effectively notify users of gas detection events, ensuring prompt action when needed and reassurance of normal gas levels.

4.2 Rain Detection functionality.

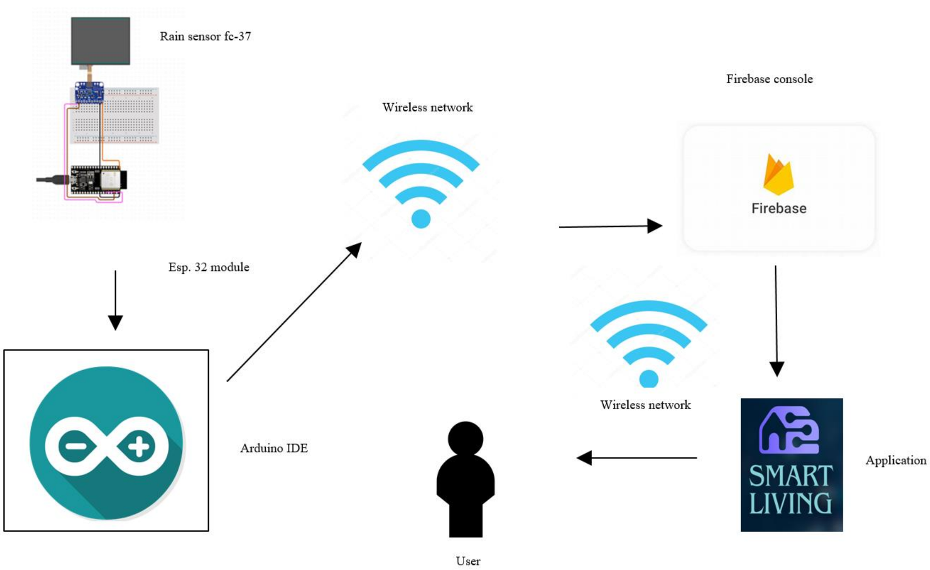


Figure 0.7 sample interface Rain detection

In this functionality, This feature detects the presence of rain by the FC-37 Rain Detection Sensor and transmits analog or digital signals to the Arduino IDE using Esp. 32 module. After that, the IDE sends this signal over a wireless network to a Firebase database. Firebase invokes a function to update the database when it receives a true or false signal. A web notification is then sent to the mobile app. A "Rain Detected" signal appears if rain is detected, and a "Rain Not Detected" notification appears if no rain is detected. The notification notifies the user of the rain detection event and specifies the moment the rain was detected.

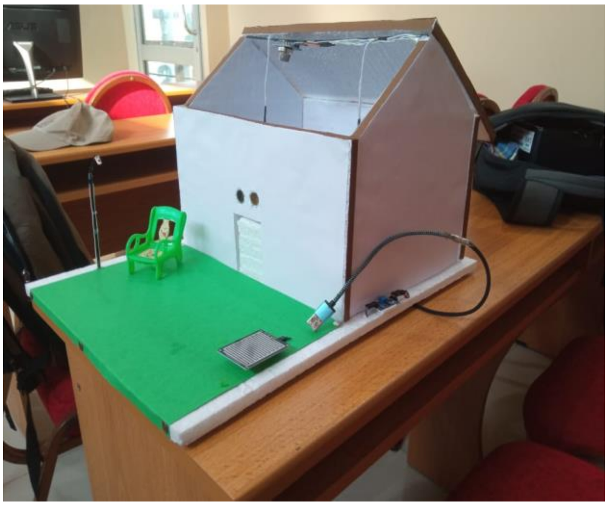



Figure 0.8 prototype interface rain detection

Table 0.2 rain detection function table

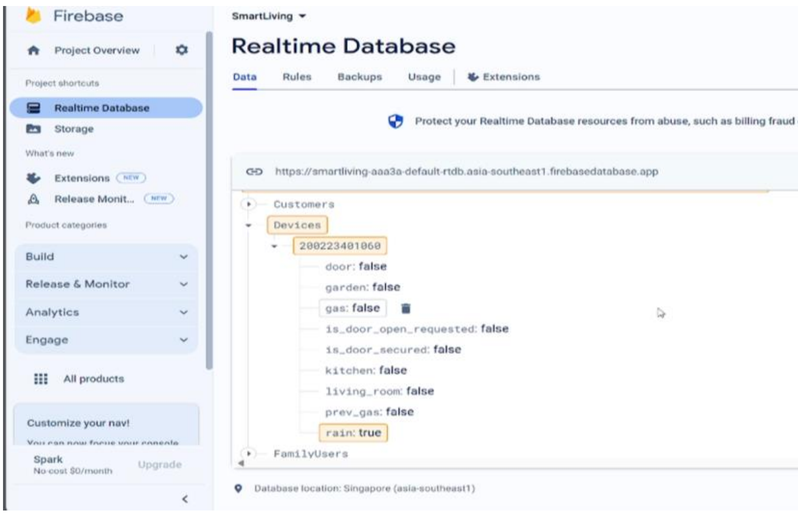
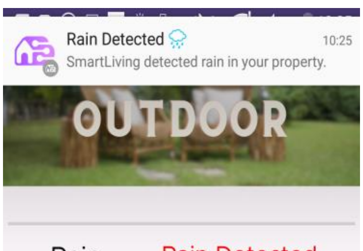
<table>
<tr><td>Rain detected time firebase console.</td><td>

Figure 0.9 real-time data base rain detection time</td></tr>
<tr><td>Rain detected time Mobile</td><td>
</td></tr>
</table>

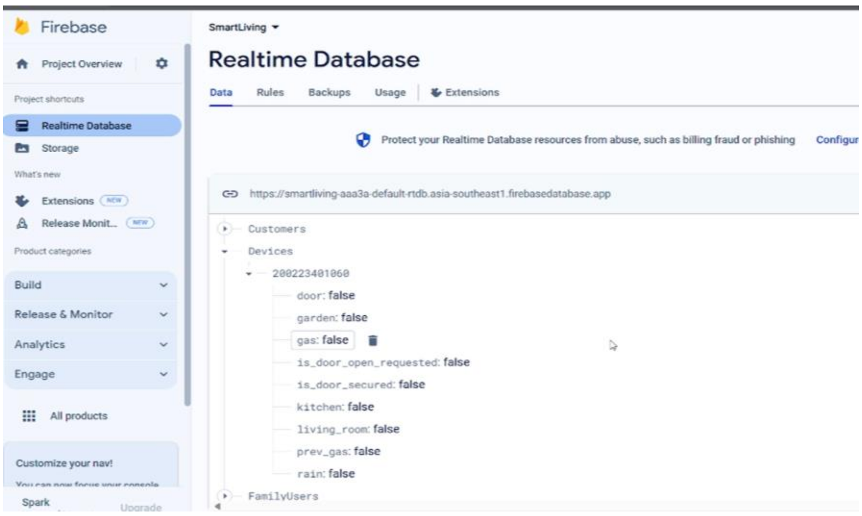
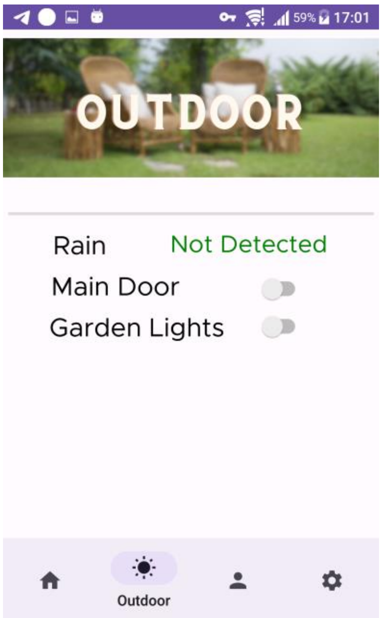
<table>
<tr><td>application
console.</td><td></td></tr>
<tr><td>Gas not detected
time
Firebase console</td><td>

Figure 0.11 real-time database rain not detected time</td></tr>
</table>

Rain Not detected time Mobile application console.	 *Figure 0.12 outdoor interface rain not*

4.3. Garden Lights functionalities

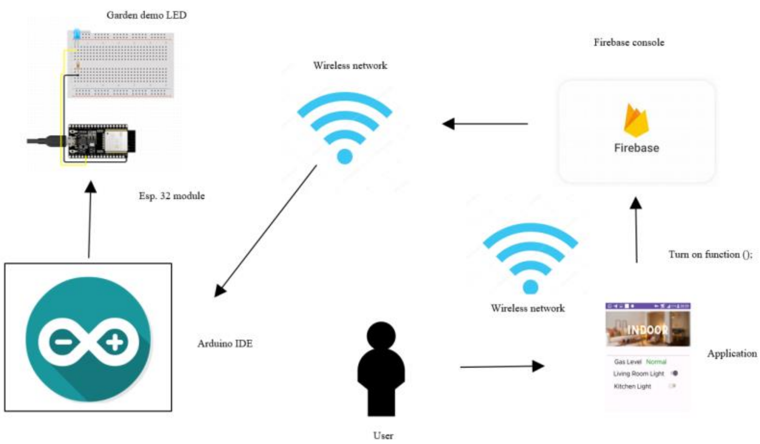


Figure 0.13 garden lights controls sample picture

In this functionality, customers can control their home lighting through a mobile app. When the customer turns on the garden lights in the app, a signal is sent to Firebase to turn on the garden lights across the network. After receiving the signal, Firebase relays the message to the

Arduino IDE. The Arduino IDE, in turn, informs the ESP32, which is responsible for turning on the Living room lights. The ESP32 then turns on the garden lights.

Prototype design

Figure 0.14 porotype garden light system

Table 0.3 garden light detection function table

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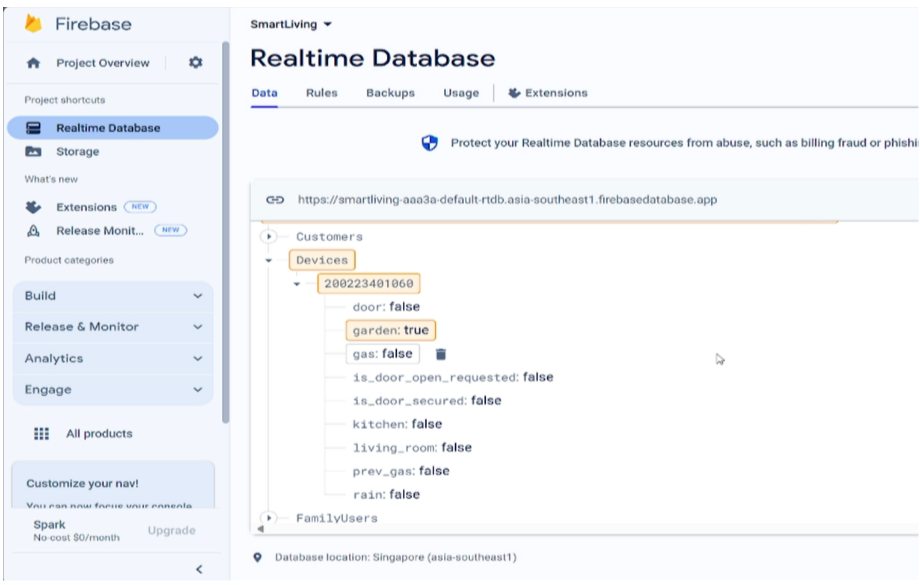
<td>Garden Lights on time fire base console interface</td>
<td>

Figure 0.15 garden lights on tme firebase console</td>
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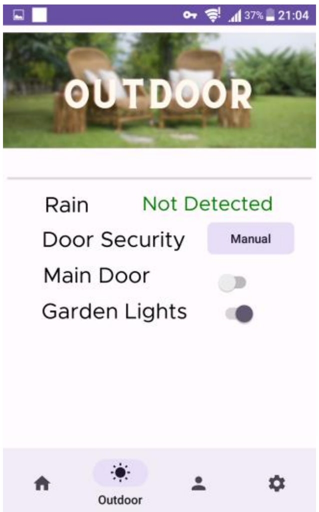
<td>

Figure 0.16 garden lights on time</td>
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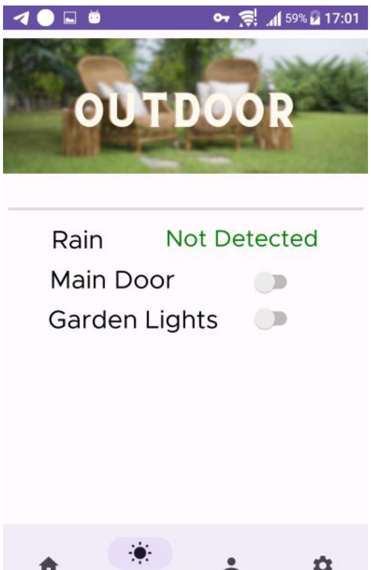
<tr>
<td>Garden Lights off time fire base console interface</td>
<td>

Figure 0.17 garden lights off time firebase console</td>
</tr>
<tr>
<td>Garden Lights off time mobile application console interface</td>
<td>
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4.4. Living room Lights functionalities

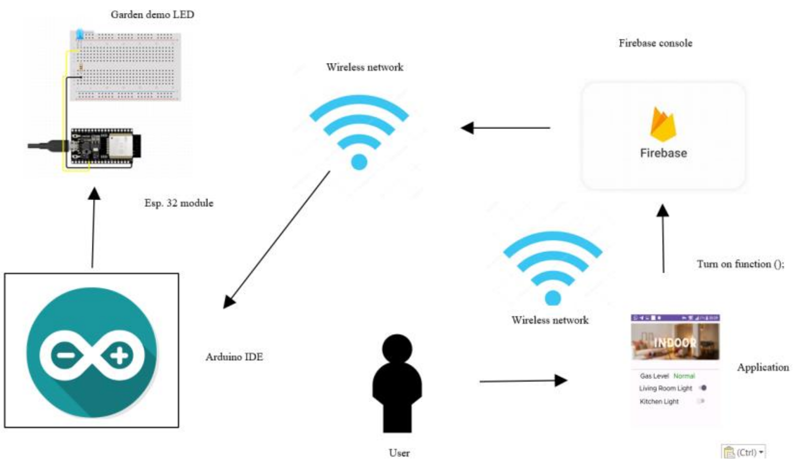


Figure 0.19 sample interface living room

In this functionality, customers can control their home lighting through a mobile app. When the customer turns on the Living room lights in the app, a signal is sent to Firebase to turn on the Livingroom lights across the network. After receiving the signal, Firebase relays the message to the Arduino IDE. The Arduino IDE, in turn, informs the ESP32, which is responsible for turning on the garden lights. The ESP32 then turns on the living room lights.

Prototype design

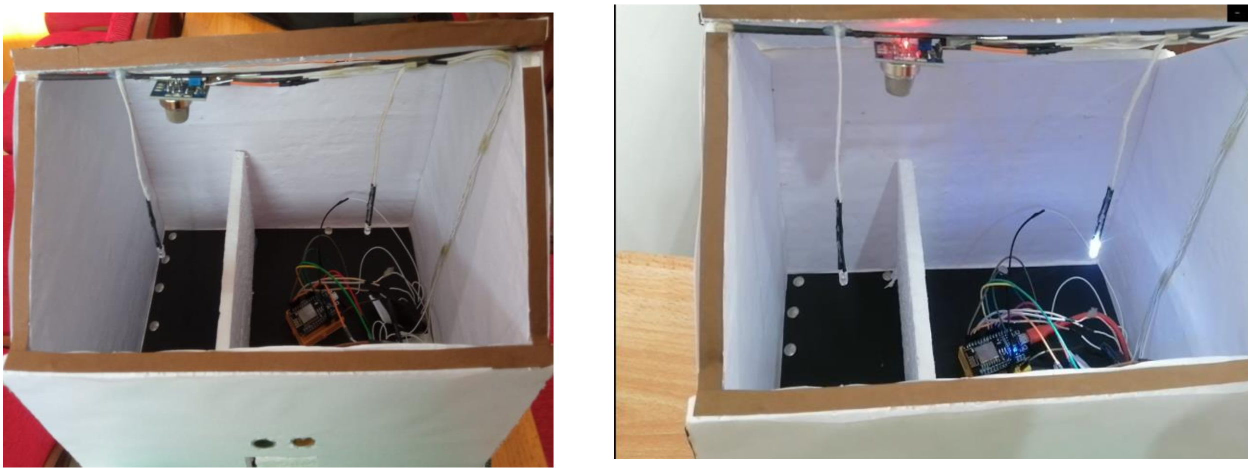
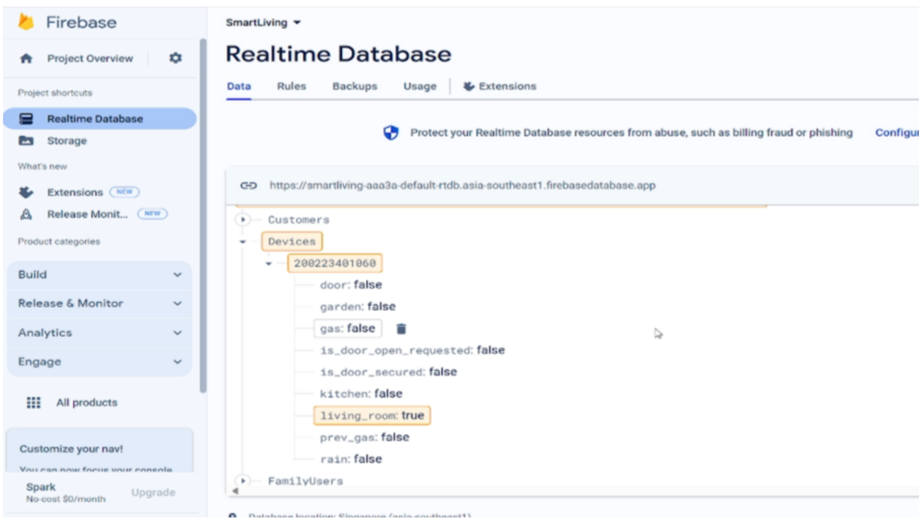


Figure 0.20 prototype version living room lighting system

Living room Lights on time fire base console interface	 *Figure 0.21 living room lights on time firebase console*

<table>
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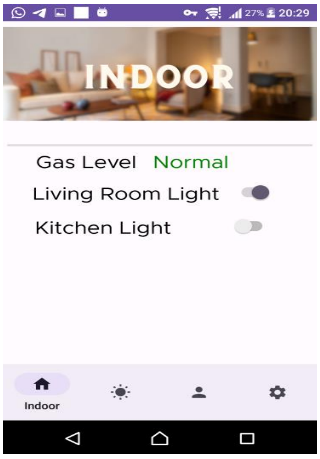

Figure 0.22living room lights on time indoor interface
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<td>Living room Lights off time fire base console interface</td>
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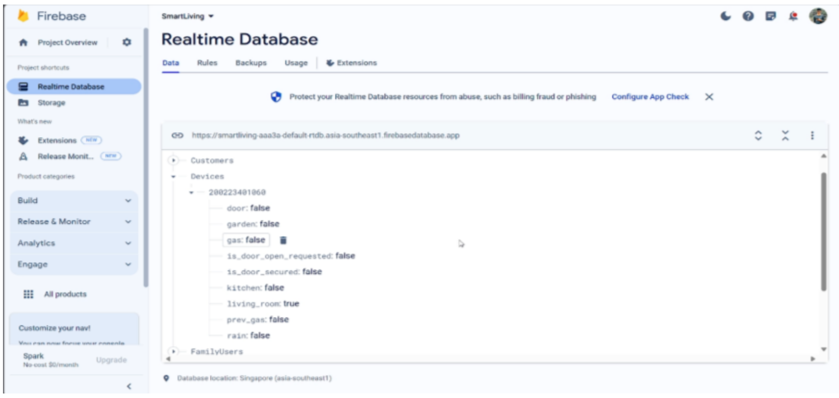

Figure 0.24 living room lights off time firebase console
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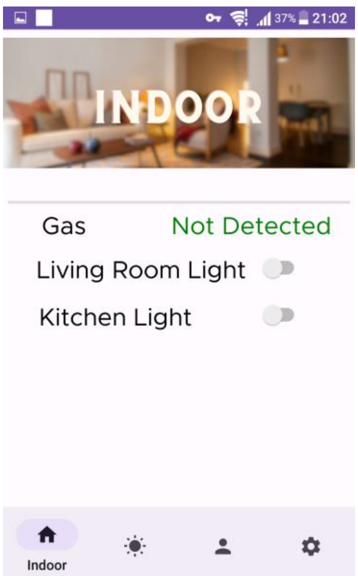

Figure 0.23 living room lights on time mobile application
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4.5. Kitchen lights functionalities

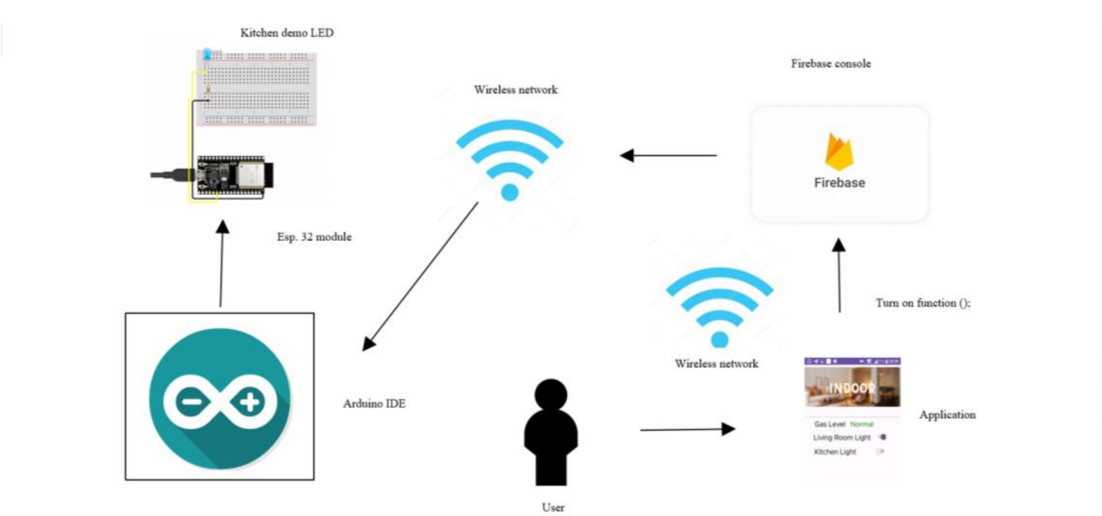


Figure 0.26 sample interface kitchen lights on interface

In this functionality, customers can control their home lighting through a mobile app. When the customer turns on the Kitchen room lights in the app, a signal is sent to Firebase to turn on the Kitchen lights across the network. After receiving the signal, Firebase relays the message to the Arduino IDE. The Arduino IDE, in turn, informs the ESP32, which is responsible for turning on the Kitchen lights. The ESP32 then turns on the kitchen room lights.

Figure 0.27 prototype kitchen lights interface

Lights on time fire base console interface

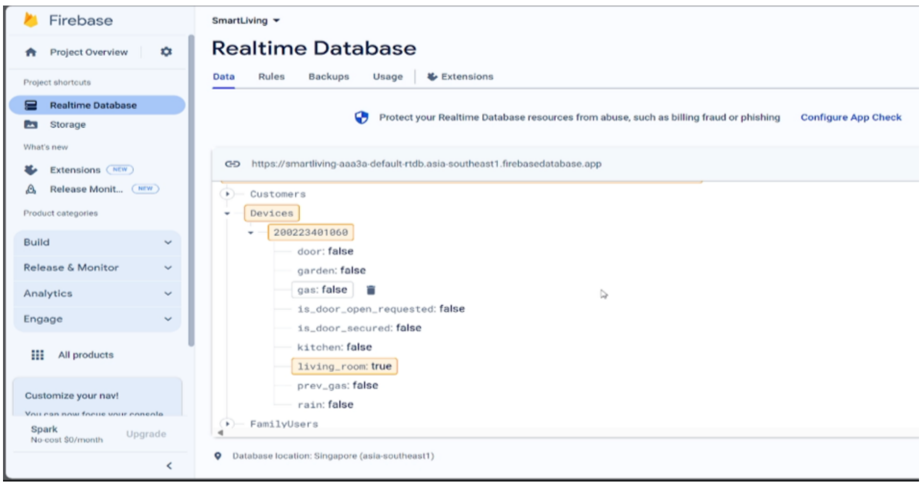
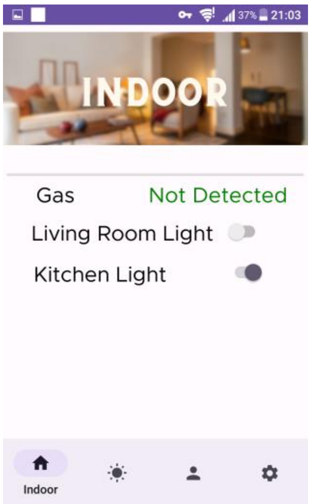
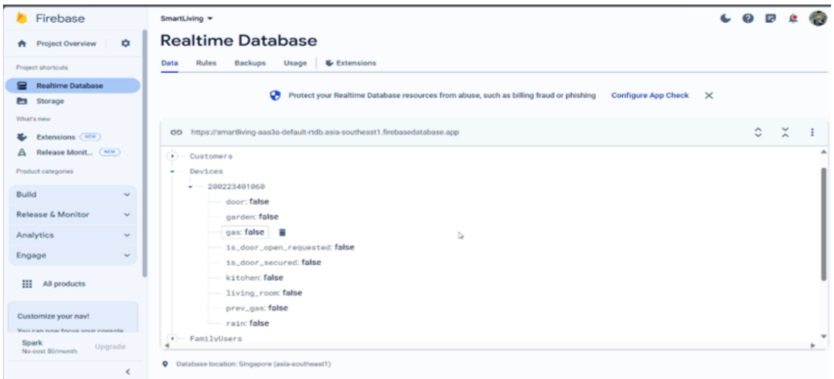
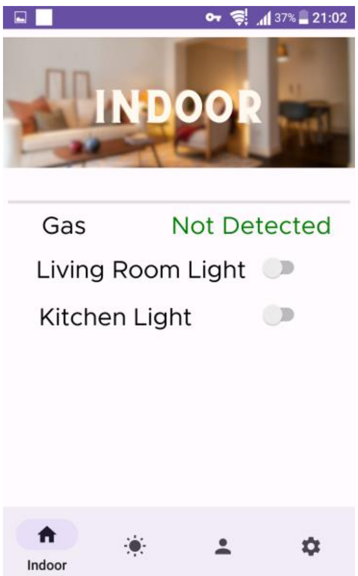


Figure 0.28 real-time database kitchen lights on time

Kitchen on time mobile application console interface	 *Figure 0.29 mobile application interface kitchen lights on time*
Kitchen off time fire base console interface	 *Figure 0.30 kitchen lights off time real-time database*
Kitchen off time mobile application console interface	

4.5. Door opening functionality

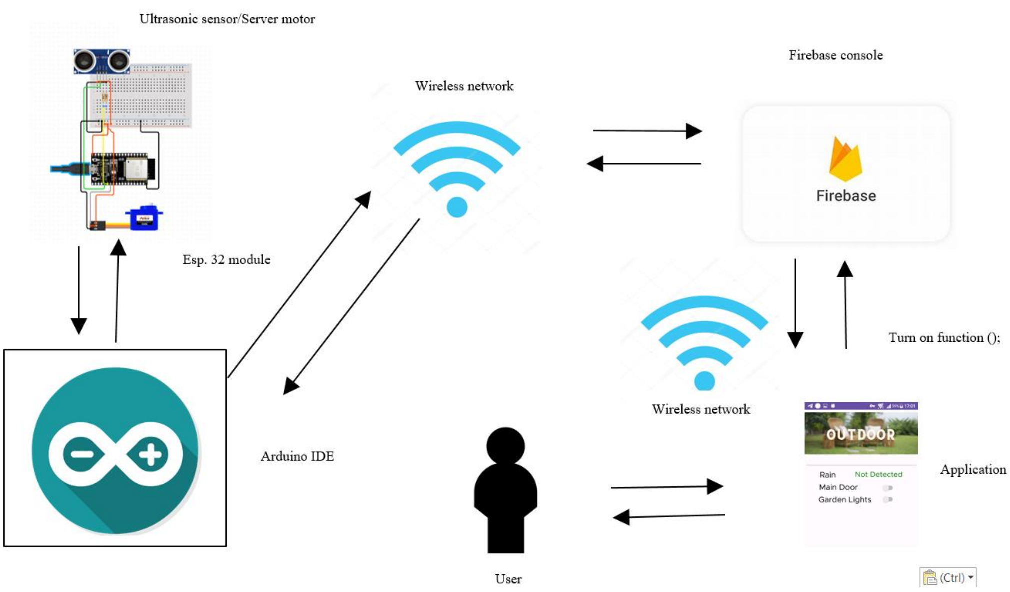


Figure 0.32sample door function interface

In this functionality, when someone approaches the door, the ultrasonic sensor detects their presence and sends a signal to the ESP32 module via the wireless network. The sensor's analog or digital signal is then transmitted to the Arduino IDE. Then, the Arduino IDE transmits this signal to Firebase over the wireless internet. After receiving the signal, Firebase updates its data and triggers a message on the user interface indicating the operation of the door.

The home owner can detect the presence of someone at the door through the application message and control the door accordingly. Upon the homeowner's action to open the door, Firebase sends a message over the Internet. Firebase receives this message, and it sends a control message to the Arduino IDE. The Arduino IDE, in turn, communicates with the ESP32 module, enabling it to control the servo motor, resulting in the door opening.

Prototype Interface

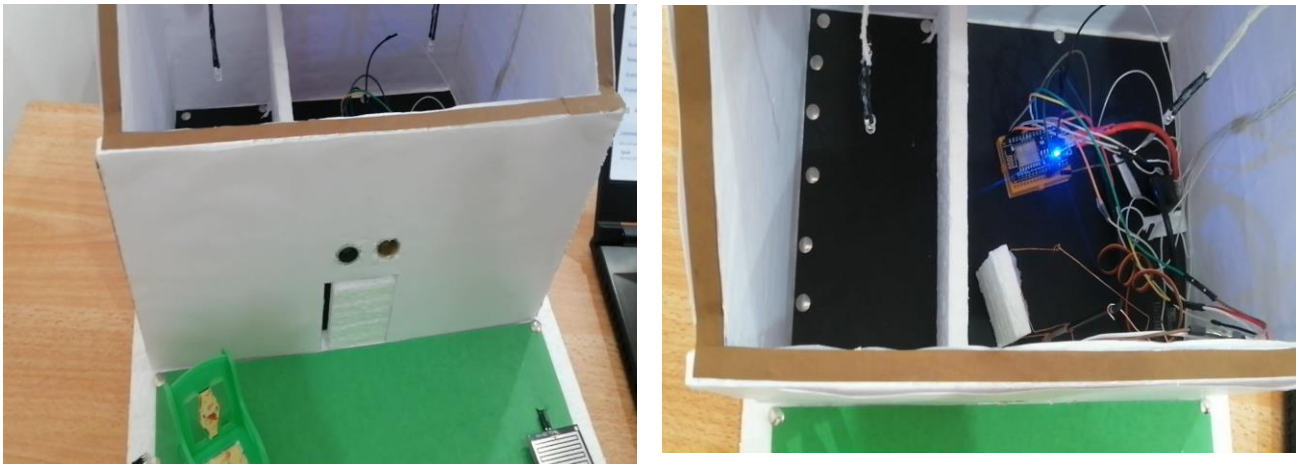
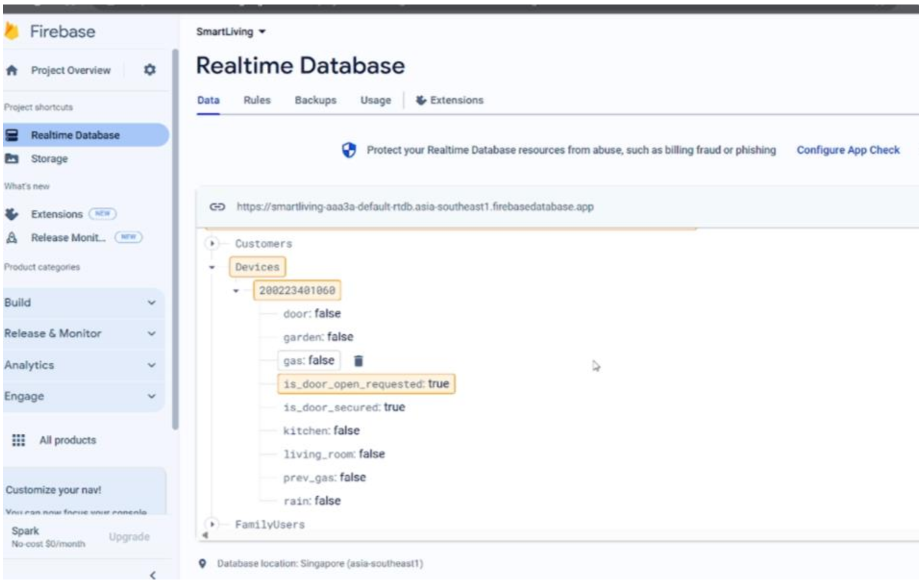
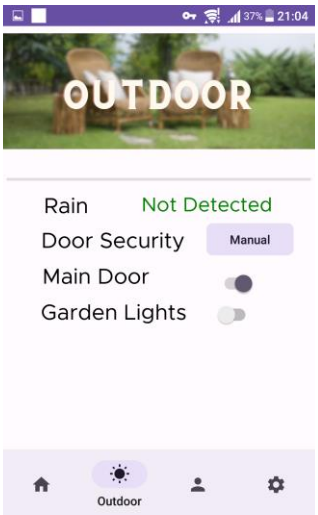
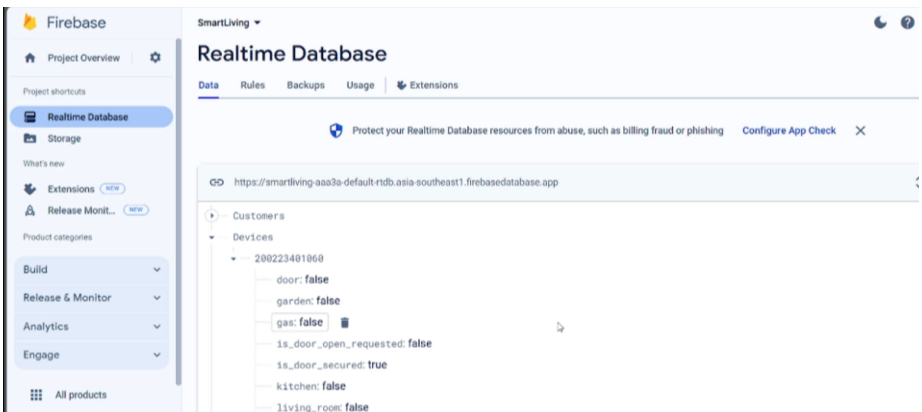


Figure 0.33 prototype door control system

Table 0.6 Door function table

Requested time Door open time fire base console interface	 *Figure 0.34 real-time database requested door open time*
Requested time Door open time mobile application console interface	 *Figure 0.35 mobile application*
Requested time fire base console interface	

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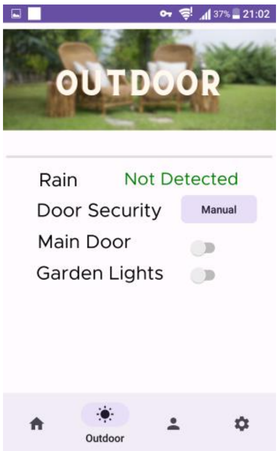
<tr><td></td><td></td></tr>
<tr><td>Requested time Door Close time mobile application console interface</td><td>


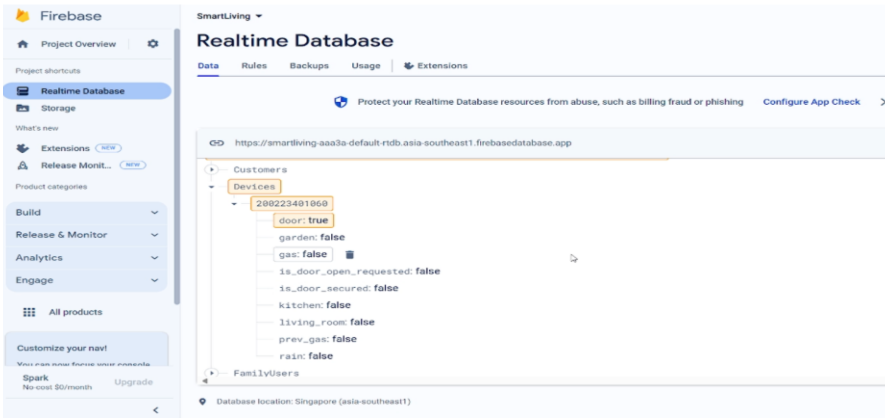
Figure 0.37 mobile application requested door close time
</td></tr>
<tr><td>Normally Door open time fire base console interface</td><td>


Figure 0.38 real-time database normally door open time
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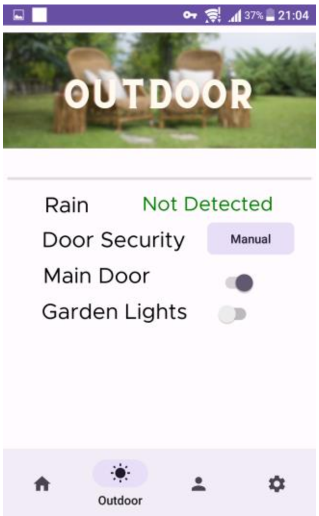

Figure 0.39 mobile application normally door open time
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<td>Normally Door Close time fire base console interface</td>
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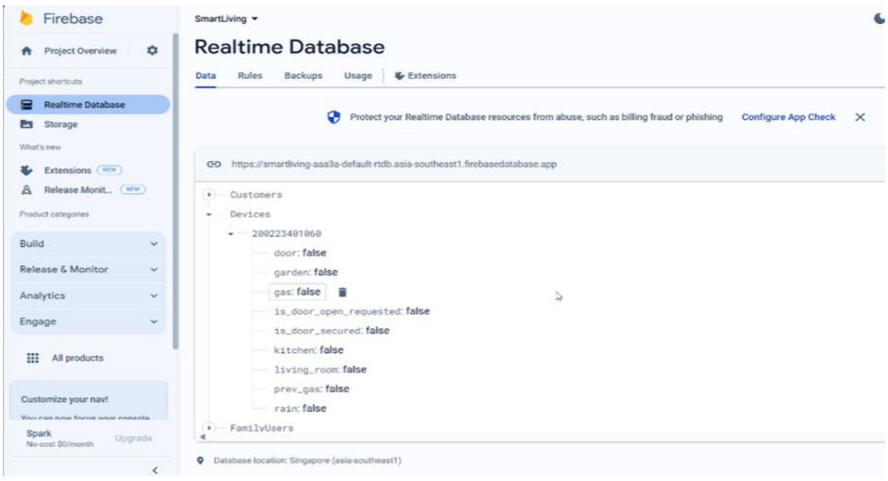

Figure 0.40 real-time database normally door close time
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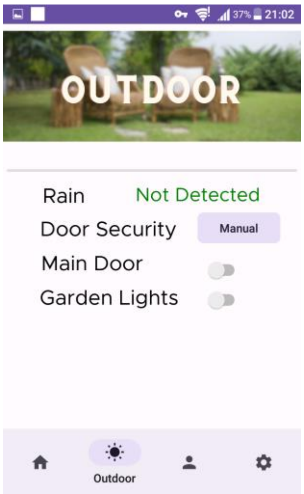
Normally Door close time Mobile app console interface	 *Figure 0.41mobile application normally door close time*

4.6. Auto door system.

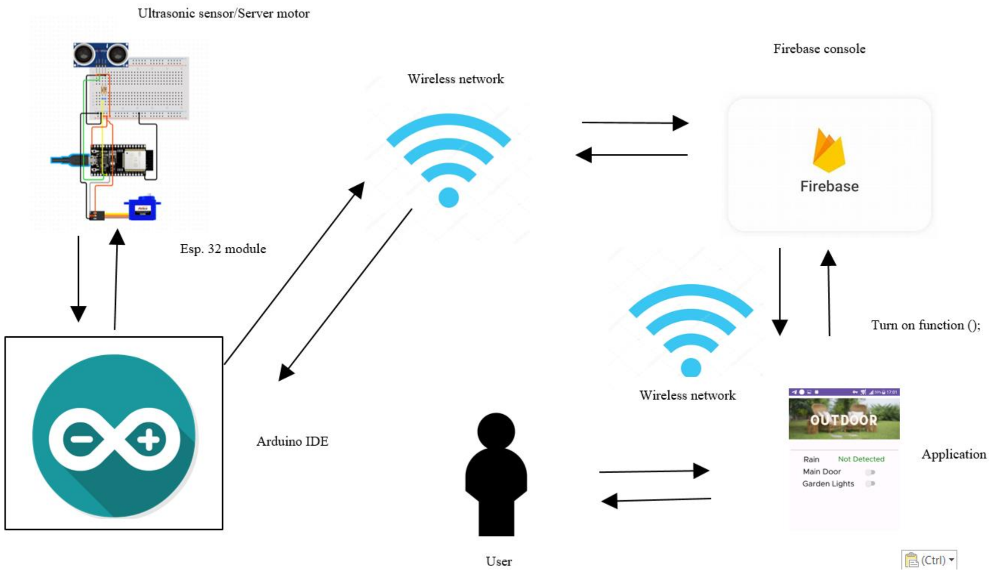
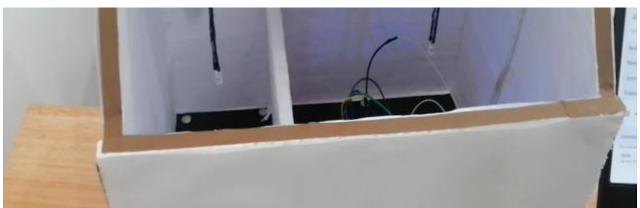


Figure 0.42 sample interface auto door system

In this function, when someone approaches the front door, the ultrasonic sensor detects their presence in automatic door mode. The ESP32 module inside the system senses the analog or digital signal from the sensor. This signal is transmitted to Firebase over the wireless network. Upon receiving the signal, Firebase updates its console, indicating detection and triggering the automatic opening of the door.

The application interface shows the door open, allowing the user to choose whether to close it manually. If the user decides to close the door, it can be done through the application interface. This action prompts Firebase to reflect a change in door status, and update its console accordingly.

Prototype Interface



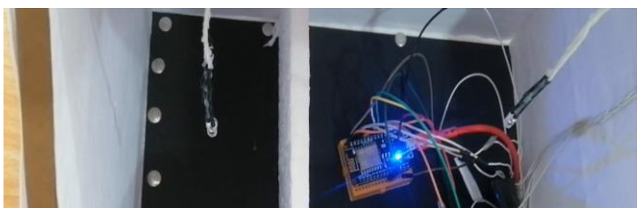


Table 0.7 Auto door function table

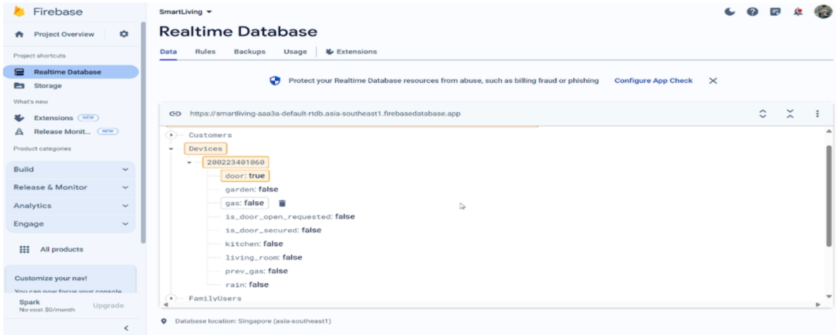
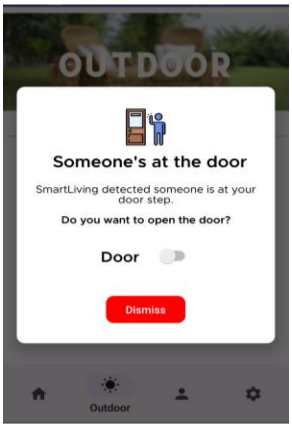
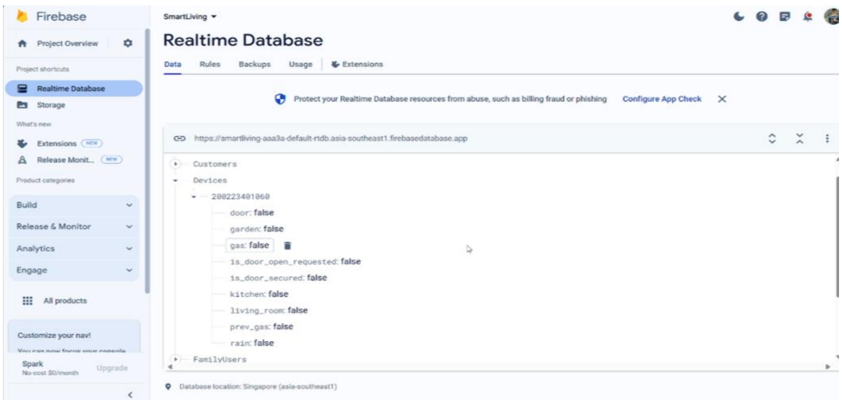
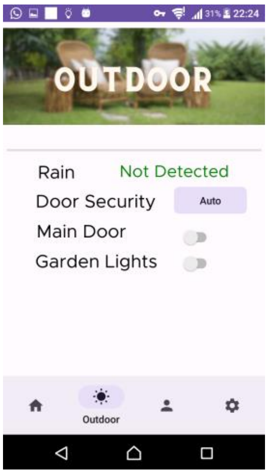
Auto door open time firebase console	 *Figure 0.44 auto door working time firebase console*
Auto door open time mobile application console notify	 *Figure 0.45 mobile application auto door working time*
Auto door close time firebase console	

Figure 0.48 firebase console auto door system doesn't working time

Auto door close time mobile application console	 *Figure 0.49 mobile application interface auto door system not working time*

4.7. Mobile applications functionalities.

When the customer purchases the home automation system, he or she can download the mobile application online. After the customer downloads the mobile app, he or she needs to register with the serial number for his home automation system. Then the customer can enter only 5 home owners into the home automation system th

Figure 0.50 mobile

Figure 0.51 mobile application auto door not working time that home can enter their username and password. System after system can control the home automation system.

Picture when the customer registered with the serial no

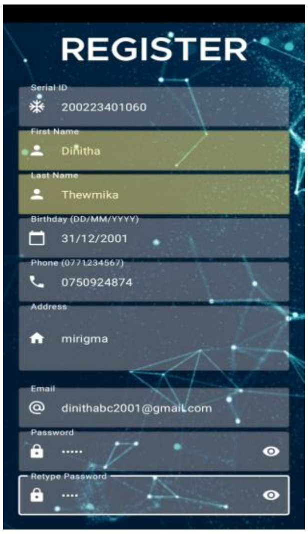


Figure 0.54 register interface customer register with there serial No

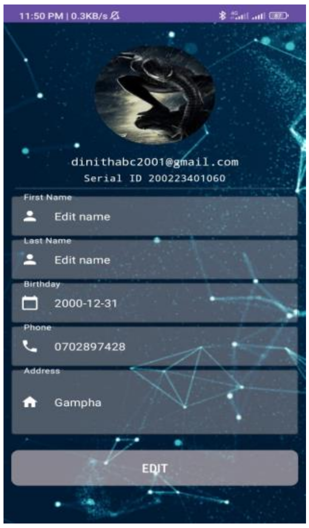


Figure 0.53 use serial no customer registration success image

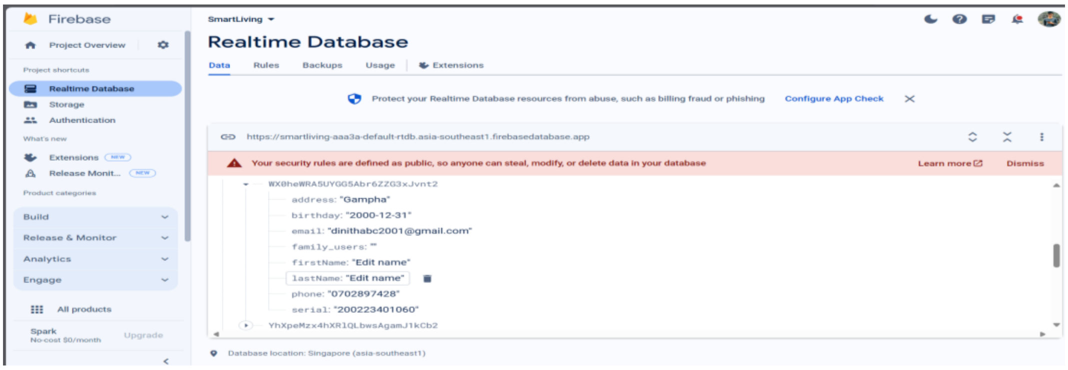
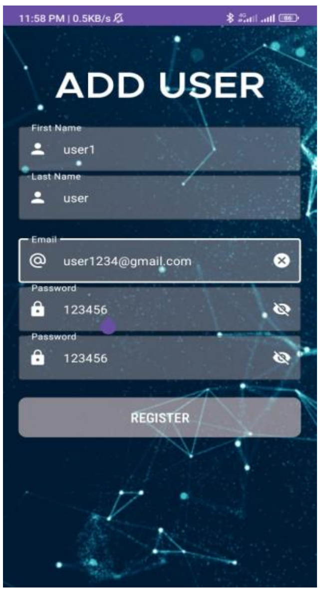


Figure 0.55 customer registration firebase update



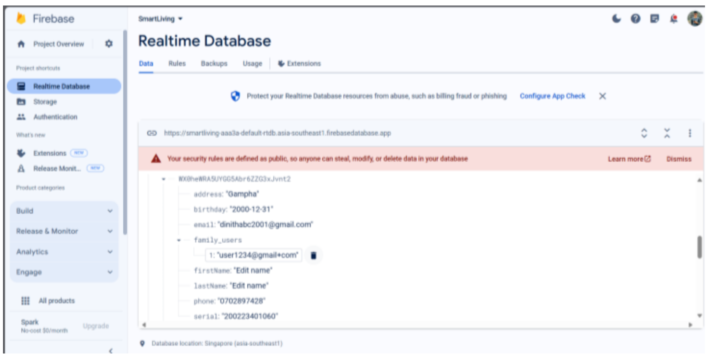
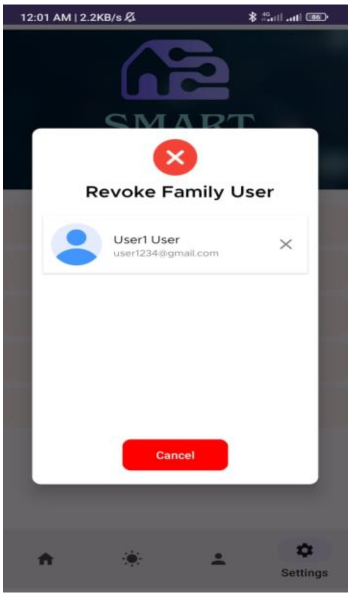
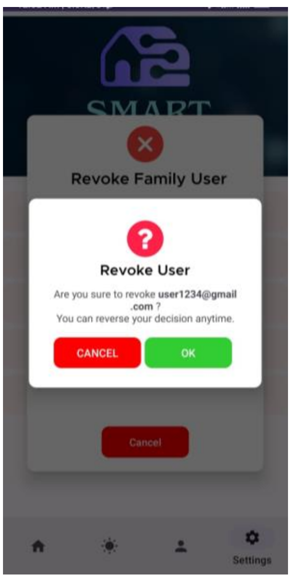


Figure 0.56 home user adding successfully firebase console

Revoke the family user



Show this interface to home user already added here system and customer can cancel family user and he can update home users again anytime he wants.



Click ok

Figure 0.60 revoke filmy user confirmation message

Figure 0.59 revoke user interface within successfully

In here redo function the revoke users.

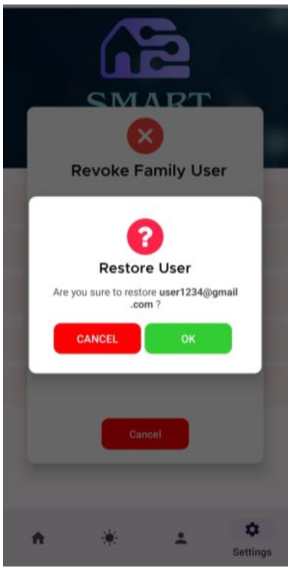


Figure 0.62 restore revoke user confirmation message

Click ok

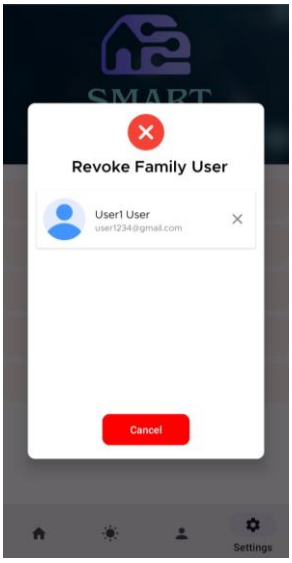


Figure 0.61 restore family user interface

Chapter 5

5.1. Testing.

5.1.1. Testing methodology and justification.

Test methodologies are systematic techniques and frameworks used in software development and quality assurance processes when a software program or system is tested for functionality, performance, and reliability. These approaches include a collection of ideas, rules, and methods that support companies and test teams in efficiently organizing, creating, implementing, and monitoring. Ensuring that programs are functional, usable, well-functioning and secure is critical in software development. It is important to note that testing methods are used to find bugs and errors in software programs before their public release says by Nazreen Ahmad (Lambda Test, 08.December 2023).

5.1.1.1. What is the software testing mythology?

Software testing methodologies are systematic approaches and strategies used to design, plan, execute, and evaluate the testing process in software development. They ensure that software applications meet specified requirements, perform reliably, and are free of defects. Different testing methodologies are employed throughout the software development life cycle to achieve these goals. Some common testing methodologies include the Waterfall model, agile methodology, iterative model, verification and validation methodology, and various testing techniques such as unit testing, integration testing, system testing, and acceptance testing. These methodologies and techniques are designed for specific purposes and are chosen based on factors such as the nature of the project, client requirements, and project schedule.

5.1.1.2. Important of the testing methodology.

Test methodologies play a critical role in the software testing lifecycle to make life easier for Quality Analysts (QA) and ensure that software applications are of the highest quality.

Their importance is evident in several key aspects:

- The increasing complexity and interconnectedness of software applications emphasizes the need to run tests on different platforms and devices. Testing methodologies enable testers to ensure cross-browser and cross-device compatibility, ensuring a seamless user experience.
- A robust testing methodology ensures that software applications are thoroughly tested throughout their development lifecycle. This proactive approach helps

identify and resolve problems at an early stage, reducing the likelihood of critical issues emerging at later stages.

- Lack of appropriate development and testing methodologies for contemporary software projects can lead to undesirable outcomes, including projects that go over budget, extend unnecessary time, and ultimately fail to align with stakeholder expectations. Test methodologies provide a structured framework for effectively managing these challenges.
- Well-structured testing methodologies contribute to project efficiency, successful delivery, and meeting stakeholder demands. They provide a roadmap for QA teams to follow, ensuring that testing processes are organized, comprehensive, and aligned with project goals.
- Adherence to proven testing methodologies increases the likelihood of satisfying stakeholder expectations. It ensures that the final software application aligns with their desired results, leading to greater confidence in the reliability and performance of the software. Overall, testing methodologies are a cornerstone of achieving high-quality software and successful project outcomes.

Implementation of test methods

Deciding when to implement test methods depends on various factors, such as project size, organizational structure, and stakeholder involvement. Test methodologies provide a framework for planning and executing tests, ensuring comprehensive testing within specified time frames. For example, in an agile development environment, Agile testing methodology can be implemented to align testing with iterative development cycles. Therefore, the **researchers have decided to use the Agile testing method as them software testing method.**

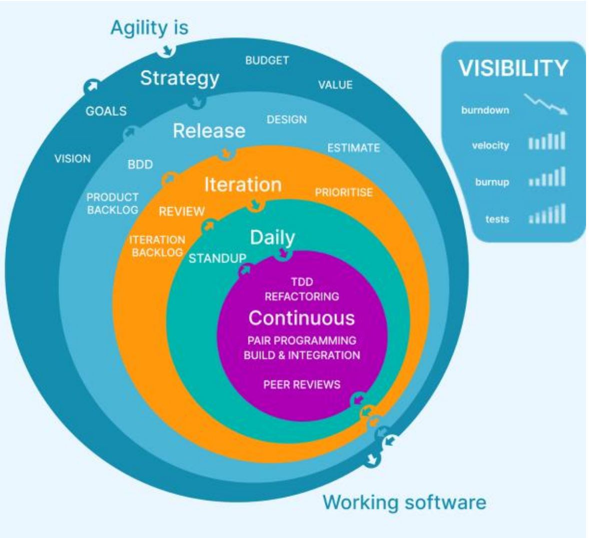


Figure 0.1 agile testing methodology

Why is agile testing methodology important to testing?

Agile testing is a critical component of the agile development methodology, which emphasizes a dynamic and iterative approach to software development. Unlike traditional testing methods that sequentially evaluate large parts of a project, agile testing focuses on evaluating specific, small tasks or user stories. This granular approach aligns seamlessly with the incremental nature of agile development, where software is built in small manageable increments called iterations or sprints. One of the main advantages of agile testing is its ability to increase efficiency throughout the development process. By continuously testing and validating small units of functionality as they are developed, teams can identify and fix problems quickly, preventing the accumulation of bugs that can be difficult to manage later in the project. This iterative testing facilitates collaboration among cross-functional team members, including developers, testers, and product owners, creating collective responsibility for software quality. Agile testing accommodates this need by allowing teams to incorporate quick feedback, adjust priorities, and respond to changing needs. This adaptability is especially useful for projects where customer needs and expectations are subject to frequent changes.

The iterative and incremental nature of agile testing aligns with the principles of the Agile Manifesto, emphasizing people and interactions, working software, customer collaboration, and responsiveness to change. By breaking down testing tasks into small, manageable units, agile testing contributes to the overall goal of delivering high-quality software that meets customer expectations while fostering a collaborative and adaptive development environment.

Table 0.1 advantages and disadvantages of agile testing methodology

Advantages	Disadvantages
• Early and Continuous Feedback Agile testing provides early and continuous feedback on the software being developed. This helps identify and address issues promptly, leading to higher-quality deliverables. • Flexibility and Adaptability Agile testing allows teams to adapt to changing requirements and priorities. It accommodates evolving customer needs and market trends, ensuring the software remains relevant. • Collaboration and Communication: Agile testing promotes collaboration among cross-functional team members, including developers, testers, and product owners. Regular communication enhances understanding and collective responsibility.	• Uncertainty with Fixed Timelines Fixed-length iterations may result in uncertainty about whether all planned features can be completed within the given time frame. This can lead to pressure on the development team. • Resource Intensive Agile methodologies require active and continuous involvement of team members, which can be resource-intensive. This may pose challenges in organizations with limited personnel or expertise. • Lack of Comprehensive Documentation Agile prioritizes working software over comprehensive documentation. While this is beneficial for quick development, it may pose challenges in environments where detailed documentation is essential.

Other Software testing method.

Waterfall Testing Methodology

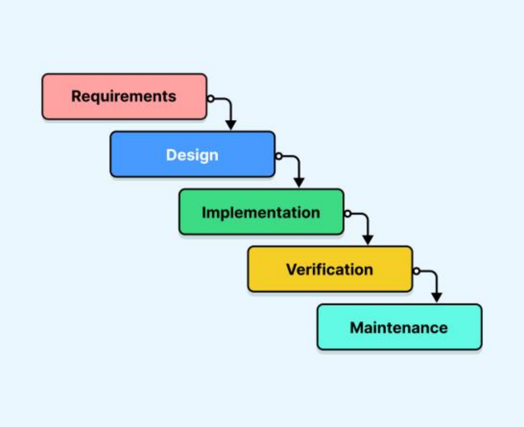


Figure 0.2 waterfall testing methodology

The Waterfall model follows a sequential and linear approach to software development. Each phase, such as requirements, design, implementation, testing, and maintenance, is completed before moving to the next.

Advantages→Well-defined phases, straightforward, easy to understand.

Disadvantages→ Limited flexibility, late detection of issues, not ideal for large and complex projects.

V-Model Testing Methodology.

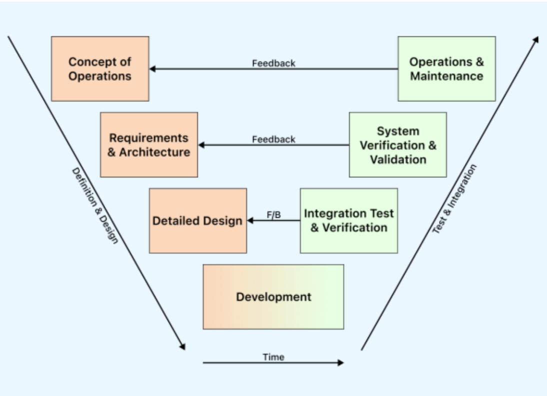


Figure 0.3V- model testing methodology

The V-Model is an extension of the Waterfall model, associating each development stage with a corresponding testing phase. It emphasizes the connection between development and testing activities.

Advantages: Clear correlation between development and testing, early test planning.

Disadvantages: Limited flexibility, late detection of defects, may not suit rapidly changing requirements.

Spiral Testing Methodology:

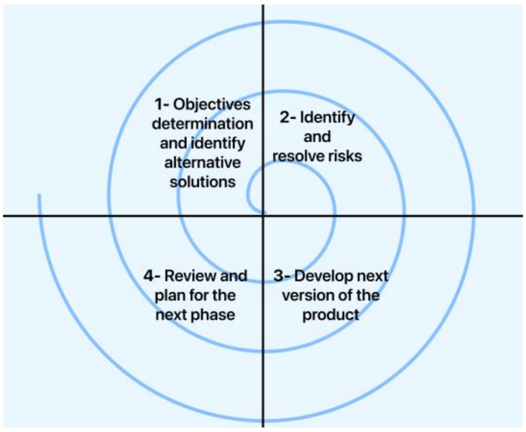


Figure 0.4spiral testing model

The Spiral model combines elements of both iterative and waterfall models. It incorporates risk assessment and allows for gradual development, with each iteration covering planning, risk analysis, engineering, and testing.

Advantages: Risk management, flexibility, accommodates changes, gradual development.

Disadvantages: Complexity, potential for scope creep, resource-intensive.

Software testing Types

The hierarchy software testing

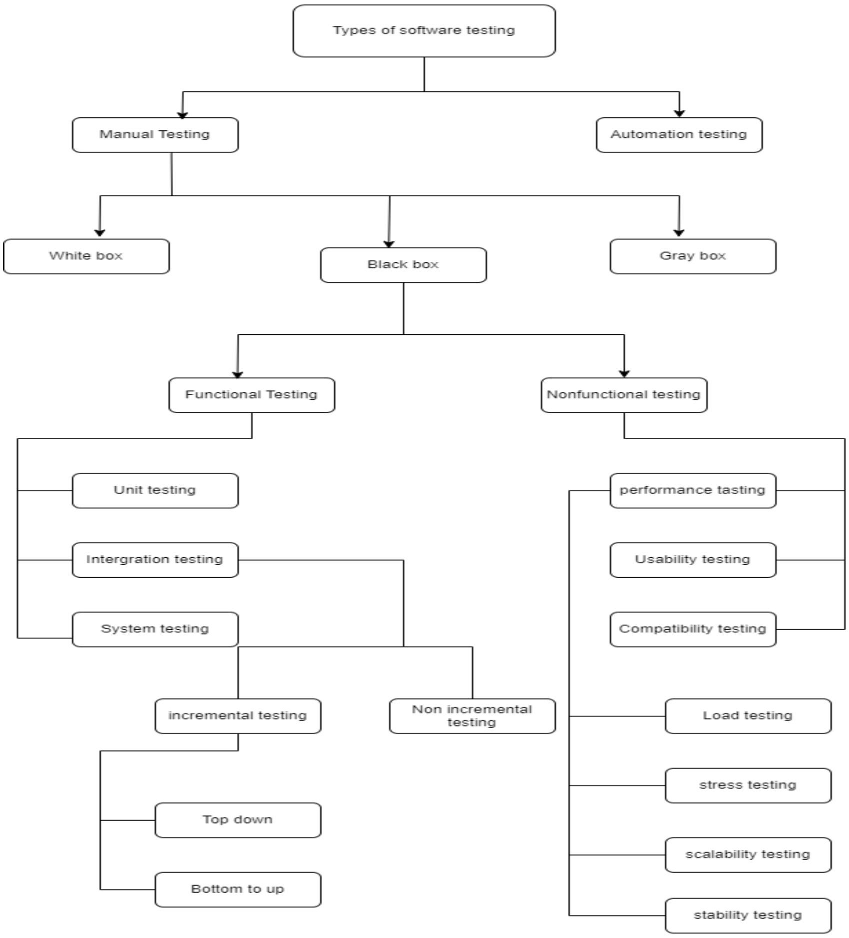


Figure 0.5 software testing hierarchy

Software testing is the process of evaluating the software to find any anomalies or bugs. It helps to ensure that the software works correctly and meets the specified requirements. There are different types of software testing, which can be broadly classified as manual testing, automated testing and various testing methods such as black box, white box and gray box testing.

A **manual test** selected by the researchers by examining the hierarchy. Home automation system testing is done through **black box, white box and gray box testing** methods and the reasons behind its use are shown.

Black box testing is essential for testing a home automation system because it focuses on evaluating the system's functionality without requiring knowledge of the system's inner workings. This is a testing technique where the tester does not have any knowledge of the internal workings of the software. The tester can only test the software based on its input and output. It is also known as functional testing or opaque box testing.

Here are some reasons why black box testing is important for a home automation system:

User Experience Validation

Black-box testing simulates real-world scenarios by focusing on the system's inputs and outputs. This helps ensure that the end-user experience is seamless and aligned with homeowners' expectations.

Functional test

Home automation systems typically include lighting control, thermostat adjustments, security system integration, and many other functions. Black box testing allows testers to verify that each function works as intended and that the system operates correctly under various conditions

Integration Test

Home automation systems often consist of multiple interconnected devices and components. Black box testing helps assess how well these various elements integrate and communicate with each other. This is critical to ensure that the system works as a cohesive unit.

White box testing is very important for a home automation system, it involves testing and evaluating the internal workings, code and architecture of the system. With this method of testing, the tester has full access to the inner workings of the program. The code is visible to the tester, who can inspect any path the code may take. It is sometimes called structural testing or transparent box testing.

Here are some reasons why white box testing is important for a home automation system:

Code Verification:

White box testing allows thorough testing of the source code. This helps verify that the code is written correctly, adheres to coding standards, and is free of syntax errors, logic errors, or potential errors that could affect the functionality of the home automation system.

Road coverage:

Home automation systems can be complex, with many different paths and branches of code. White-box testing ensures that different paths in the code are covered, helping to identify any code segments that might not be executed under normal conditions. This is essential to get comprehensive test coverage.

Security Analysis:

White box testing is especially useful for security testing. Testers can examine code for vulnerabilities such as insecure coding practices, potential entry points for cyberattacks, or inadequate encryption methods. This helps identify and mitigate security risks early in development.

Performance Optimization

By analyzing the code structure, white box testing can contribute to optimizing the performance of the home automation system. Testers can identify areas where code efficiency can be improved, leading to faster response times and better overall system performance.

Gray box testing is especially important for a home automation system because it combines elements of both black box and white box. This is a testing technique where the tester has some knowledge of the inner workings of the software. The tester can see some codes, but not all. It is a combination of white box and black box testing.

Here are some reasons why gray box testing is valuable for a home automation system:

Partial knowledge of system architecture:

Understanding some aspects of the internal architecture of a home automation system can be helpful. Gray-box testing allows testers to gain partial knowledge, enable them to design test cases that target specific components or interfaces, and uncover vulnerabilities or problems that may be missed by purely black-box testing.

API and Integration Testing:

Home automation systems often rely on various application programming interfaces (APIs) to communicate between devices and platforms. With gray-box testing, testers can have a limited understanding of these APIs and are able to evaluate integration points between different components and identify potential issues related to data exchange and interoperability.

Behavioral Testing:

Gray box testing allows testers to observe and assess the behavioral aspects of the home automation system. With some knowledge of internal logic, testers can design test cases that focus on specific behaviors or sequences, ensuring that the system responds appropriately to different user inputs or scenarios.

The existing upper case the researcher choose the **gray box testing** to testing the Home automation system. Because it is combination of white box and black box testing method.

5.1.2. Test Plan.

Table 0.2 test plan proposed system

Home Automation system Test plan

Test Phase	Description	Time estimation
1. Project Initiation a. Define Release Scope b. Schedule Timelines	Identify features included in the release Establish testing milestones and deadlines	2 hours 3 hours
2. Requirements Review	Review system requirements and user needs	2 hours
3. Test Planning a. Define Test Objectives b. Determine Test deliverables c. Design Test Strategy d. Plan Test Environment and Test Data	• Specify what each test should accomplish. • Identify documents and artifacts to be • delivered at the end of testing • Plan the overall approach to testing • Define the required test environment and prepare necessary test data	3 hours 2 hours 4 hours 5 hours
4. White box testing a. System architecture b. Code review c. Unit testing	• Examine internal logic and components • Review source code for correctness • Test individual modules and functions	5 hours 4 hours 6 hours
5. Black Box Testing a. Functional Testing b. Usability Testing c. Compatibility Testing d. Security Testing	• Verify system functions according to spec • Evaluate user interface and experience • Ensure compatibility with devices • Identify and address security concerns	8 hours 5 hours 6 hours 7 hours
6. Integration Testing	• Test interactions between system modules	5 hours
7. Performance Testing	• Assess system responsiveness and capacity	4 hours
8. Regression Testing	• Ensure new changes do not break existing	3 hours
9. Documentation review	• Verify documentation completeness and accuracy	2 hours

10. User Acceptance Testing	• User Acceptance Testing	6 hours

82 hours (3 days 10 hours) estimate to the testing the system.

Test automation process architect.

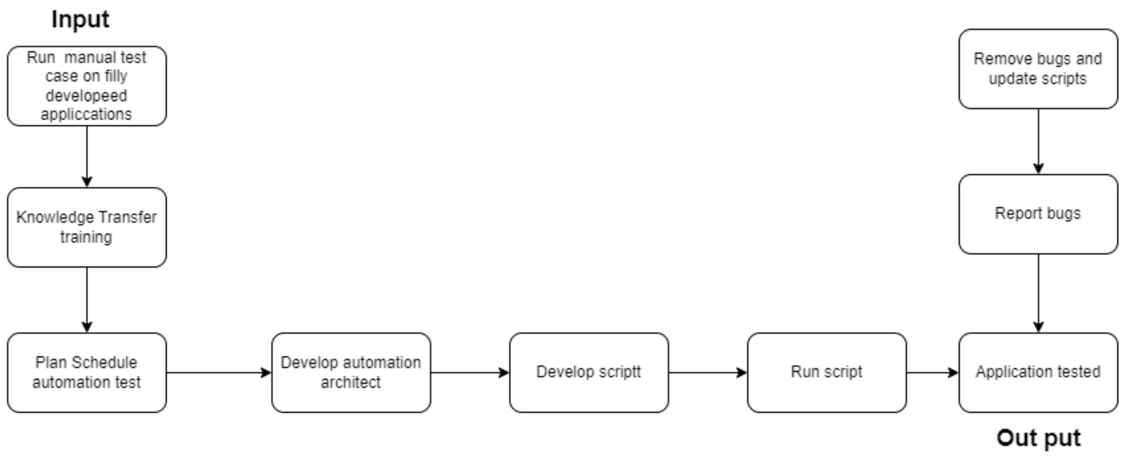


Figure 0.6 test automation architect

5.1.2.1. Test plan structure.

Figure 0.7 Test plan template

Title	Smart Living Home Automation system
Project description	This test plan outlines test procedures for a home automation system designed to control various smart devices within a home.

Version	1.0
Date	12/03/2024
Author	Dinitha Thewmika Ranathunga / Navindu sankalpa / Didula madushan nirasha
Scope	Testing of all features and functionalities of the home automation system including but not limited to controlling lights, thermostats, security cameras, door locks, and entertainment systems.
Out of scope	Testing of third-party devices not compatible with the system's protocols.
Test Objectives	• Ensure core functionalities work as expected. • Identify and report bugs and defects. • Verify system performance meets specified requirements.
Test methodologies Test approaches Test element Test management tools	 Black box, white box and gray box testing with elements of exploratory testing. Unit testing, integration testing, system testing, and acceptance testing. Jira for test case management and defect tracking, TestRail for reporting.
Test deliverables	Test plan Test cases Test conclusion
Recourse and environment needs Hardware and software requirement	

personnel	Smart devices compatible with the home automation system, testing devices (computers, smartphones), stable internet connection. Testing Team Lead, Test Engineers, and Developers (for debugging and fixing issues).
Schedule Overall testing schedule	 February 20 to February 27 in 2024
Risk migration and strategies	Risk • Incompatibility issues with certain smart devices. • Security vulnerabilities leading to potential breaches. • Software bugs causing system malfunctions. Migration strategies: • Thorough compatibility testing with a range of devices. • Regular security audits and updates. • Rigorous testing and debugging during development phases.
Approval	Project manager signature here:

5.1.3. Test plan for Mobile application

5.1.3.1 Test plan for Login.

Table 0.3 test plan login function

Test ID	Test Title	Scenario	Expected Result
L01	Test login function	Enter some random inputs for the email field and password field.	If the email and password is correct, user will be redirected to the user panel according to the user type. If the username or

			password is incorrect, "Invalid login credentials" alert will be displayed.
L02	Test the "Remember me" option.	Testing the remember me function with checking the check box.	If the login credentials are ok, "remember" value will be "true" and "user type" will be written according to the logged in user's user type in the checkbox.xml file.
L03	Test the Spendable Text "here" text.	Testing the "here" function in the login page.	User will be directed to the Register activity.
L04	Test the "Forgot password" option	Testing the forgot password option with some valid and invalid emails.	If the email is ok, password resetting email will be sent to the given mail. If it is invalid, "Not a valid mail" message will be displayed. After the password resetting email is sent, a successful toast will be displayed.
L05	Test the back button	Testing the back button by clicking it.	"Are you sure to exit the app" alert will be displayed.

5.1.3.2 Test plan for customer Registration

Table 0.4 Test plan for Customer registration.

Test ID	Test Title	Scenario	Expected Result
R01	Test the serial no field.	Enter already registered serial no, a new serial no and invalid text as the serial no.	If the serial no is already registered to the system, and occur error message saying " "The provided serial ID is invalid. Please try with a different one "Alert will be displayed. If the serial no is new and the text are matching update profile within serial no and update database
R02	Test the email field.	Enter already registered email, a new email, and an invalid text as the email.	If the email is already registered, an error message saying "Email is already registered" alert will be displayed. If the email is new and the password fields are matching, the given email will be registered, and a successful message will be displayed.
R03	Test the Phone no Fields.	Input the random text for the Phone number.	If the input invalid no or texts for the phone no filed .an saying error from the system. " "Error message.
R04	Test the password fields	Input random text in the password and confirm password field.	If the password fields are matching and the email is an authorized one, user will be registered, and a success

			message will be displayed. If the password fields are not matching, “password does not match” toast will be displayed, and the password fields will be cleared. If the password length is not equal or larger than six “The given password invalid (password should be at least 6 character” toast will be displayed.
R04	Test the Birthday Fields.	Input the random text for the Birthday.	If the input invalid no or texts for the phone no filed .an saying error from the system. “Not a valid date” Error message.
R06	Test the spendable text “Here” text.	Testing the “here” function in the register page.	Customer will be directed to the login activity.
R07	Testing the back button.	Testing the back button by clicking it.	Customer will be directed to the login activity.
R08	Testing Registration button	Testing registration button by click it.	Customer will inputted after the detail Clicked the register button. If the all customer fields are not filled, show error message “ please fill required field ” and All fields are filled successfully Show message “User create successfully “Like this. But any issue filled field System show “ “failed to registration.

5.1.3.3 Test plan for Family User Registration

Table 0.5 Test plan for User registration

Test ID	Test Title	Scenario	Expected Result
R01	Test the email field.	Enter already registered email, a new email, and an invalid text as the email.	If the email is already registered, an error message saying “Email is already registered” alert will be displayed. If the email is new and the password fields are matching, the given email will be registered, and a successful message will be displayed.
R02	Test the password fields	Input random text in the password and confirm password field.	If the password fields are matching and the email is an authorized one, user will be registered, and a success message will be displayed. If the password fields are not matching, “passwords do not match” toast will be displayed, and the password fields will be cleared. If the password length is not equal or larger than six “Password length is not enough” toast will be displayed.
R03	Testing Registration button	Testing registration button by click it.	Customer will inputted after the detail Clicked the register button. If the all customer fields are not filled, show error message “please fill all required field ” and All fields

			are filled successfully Show message "User create successfully "Like this.
R04	Testing add family user limitation	When the customer add family user to the system show limitation working proper	Show error message "You have registered more than five family user. You can't added anymore" will show.

5.1.3.4 Test plan for Customer Update (Edit).

Table 0.6 test plan for Customer update

Test ID	Test Title	Scenario	Expected Result
R01	Test the Name field.	Enter another name to the First name field.	After entering new name in First name field and click edit button system will give message "data edit successful". If the user not input the name filed First name system show "please fill required filed" toast displayed.
R02	Test the Last name fields	Enter another last name to the First name field.	After entering new name in last name field and click edit button system will give message "data edit successful". If the user not input the name filed First name system shows "please fill required filed" toast displayed.

R03	Testing Birthday field	Enter another Birthday to the Birthday field	After entering the new date of birth in the date of birth field and clicking on the edit button, the system will give the message "Data editing successful". If the user not input the Birthday filed Birthday system shows “please fill required filed” toast displayed.
R04	Testing Phone field	Enter another Phone no to the Phone no field	After entering the new Phone no in the Phone no field and clicking on the edit button, the system will give the message "Data editing successful". If the user not input the Phone no filed Phone no system shows “please fill required filed” toast displayed.
R05	Testing Address field	Enter another Address to the Address	After entering the new address no in the Address field and clicking on the edit button, the system will give the message "Data editing successful". If the user not input the Address filed address system shows “please fill required filed” toast displayed.

5.1.3.5 Test plan for Indoor Interface.

Table 0.7 test plan for indoor interface

Test ID	Test Title	Scenario	Expected Result
R01	Testing indoor interface	Clicking indoor option working proper	Indoor interface loading
R02	Testing Gas level function	Testing the gas sensor Show message gas level working proper	If the gas sensor detects toxic gas, the "gas" variable in Firebase database will become "true" and user will receive a notification about the abnormal gas level and gas status will become "Detected" in the app. If the gas level is normal, the "gas" variable will become "false" and gas status will become "Not Detected" in the users app.
R03	Testing Living room lights	Testing living room lights work proper	Living room light turn on or off according to the command and update database
R04	Testing Kitchen lights	Testing Kitchen lights work proper	Kitchen light turn on or off according to the command and update database.

5.1.3.6 Test plan for Outdoor Interface.

Table 0.8 test plan for outdoor interface

Test ID	Test Title	Scenario	Expected Result
R01	Testing outdoor interface	Clicking outdoor option working proper	outdoor interface loading
R02	Testing rain detection	Testing the Rain sensor Show message Rain detection working proper	If the rain sensor detects rain in the area, the " rain " variable in Firebase database will become "true" and user will receive a notification about the rain level and rain status will become "Detected" in the app. If the rain status is normal, the "rain" variable will become "false" and rain status will become "Not Detected" in the users app.
R03	Testing Main door	Testing the main door open working proper	If the user has chosen “Manual" as the door security, when the ultrasonic sensor detects someone at the door the "is door open requested" variable will become true. Then the user will receive a notification to grant the request to open the door. If the user has set "Auto" as the door security, the door will automatically open without sending a notification to the user. After the door opening the "door"

			variable in the Firebase database will become true.
R04	Testing Garden Lights	Testing garden lights work proper	Garden light turn on or off according to the command and update database.

5.1.3.7 Test plan for Profile Interface.

Table 0.9 test plan for profile interface

Test ID	Test Title	Scenario	Expected Result
R01	Testing Image Upload	Testing the Upload the Customer image to the customer profile.	If the Click the user.png icon User select the picture and automatically upload the picture to the System if the picture uploading time show the toast message "image is uploading" after complete uploading picture show the message " image uploaded"
R02	Testing Logout button	Testing the logout button by click.	If the user click log out button show the message "are you sure to logout from the app" system gives the option "Ok or Cancel" user select OK button automatically log out the system and open Login interface again.

			User select cancel button system user can stay current page.
R03	Testing profile interface	Checking clicking testing interface work proper	Loading the profile interface.

5.1.3.8 Test plan for Password Reset option.

Table 0.10Test plan for password reset option

Test ID	Test Title	Scenario	Expected Result
R01	Testing password reset button	Testing password reset by click.	If the user click the password reset button system show message box “are you sure to reset your password “ user can select the button “Cancel or OK” If the cancel button click user can cancel password reset option. If the user click ok button system show toast “please wait “and after show message “Password reset email sent your inbox”. And after send email from firebase to the inbox and click

			that link user can add new password for the system.
R02	Testing the setting interface	Checking clicking setting interface work proper	Loading the setting interface.

5.1.3.9 Test plan for the Revoke family users

Table 0.11Test plan for password reset option

Test ID	Test Title	Scenario	Expected Result
R01	Testing the revoke user function loading interface	When a clicking revoke user interface working proper	Loading revoke family user interface
R02	Testing the revoke button in revoke family user in the system	revoke family user in revoke interface user delete successfully working proper	When the user clicks the revoke button, "is Revoked" variable in the Firebase database will become true.

5.1.4. Test plan for admin interface

5.1.4.1 Admin login interface test plan

Table 0.12 Test plan admin logging function

Test ID	Test Title	Scenario	Expected Result
L01	Test login function	Enter some random inputs for the email field and password field.	If the email and password is correct, user will be redirected to the admin panel according to the user type. If the username or password is incorrect, "Invalid login credentials" alert will be displayed.
L02	Test the "Remember me" option.	Testing remember me function with checking the check box.	If the login credentials are ok, "remember" value will be "true" and "user type" will be written according to the logged in user's user type in the checkbox.xml file.

L03	Test the “Forgot password” option	Testing forgot password option with some valid and invalid emails.	If the email is ok, password resetting email will be sent to the given mail. If it is invalid, “Not a valid mail” message will be displayed. After the password resetting email is sent, a successful toast will be displayed.
L04	Test the back button	Testing the back button by clicking it.	“Are you sure to exit the app” alert will be displayed.

5.1.4.2 Testing the Add admin option.

Table 0.13 Test plan add admin function

Test ID	Test Title	Scenario	Expected Result
L01	Testing the click Add admin button	Test the click admin button	Show add admin panel
L02	Test the password fields	Input random text in the password and confirm password field.	If the password fields are matching and the email is an authorized one, user will be registered, and a success message will be displayed. If the password fields are not matching show the error message in firebase console
L03	Testing the Email field	Input correct method type email and already registered email	If the user input the email wrong method show the error message firebase console and the user enter already registered email show error message from the firebase console

L04	Testing the add button filed	Fill the email and password filed	If the user fill all the field correctly and click the add button show successful message. If the user not fill any required field show error message in the application If the user input already registered email and password show error message firebase console

5.1.4.3. Test the add new serial option

Table 0.14 Test plan for add new serial no function

Test ID	Test Title	Scenario	Expected Result
L01	Click the add new serial button	test the click the serial button	Show the add serial interface
L02	Click add button work proper	Input serial no click add button	If the user add the seral number show the message serial no add successfully. If the number of digits in the serial number does not exceed 10 digits by the system, display the error message "Insufficient sequence length".
L03	Click cancel button work proper	Click cancel button	If the user click cancel button go back to the admin main interface.
L04	Test the all serial button	Click all serial button	Show the all serials interface .

5.1.4.4. Test the all user option.

Table 0.15 Test plan for all user show function

Test ID	Test Title	Scenario	Expected Result
L01	Test the all user button	Click all user button	Show the all user interface

5.1.4.5. Test the Logout option.

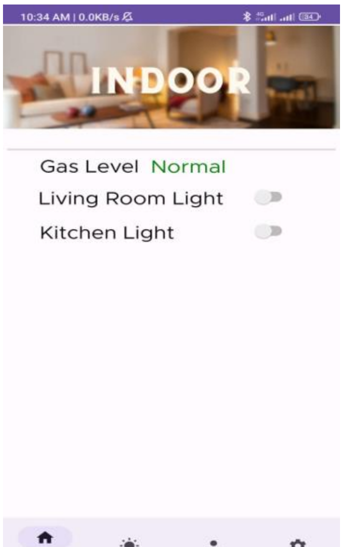
Table 0.16 Test plan for logout function

Test ID	Test Title	Scenario	Expected Result
L01	Test the logout button	Click Log out button	Show the login interface

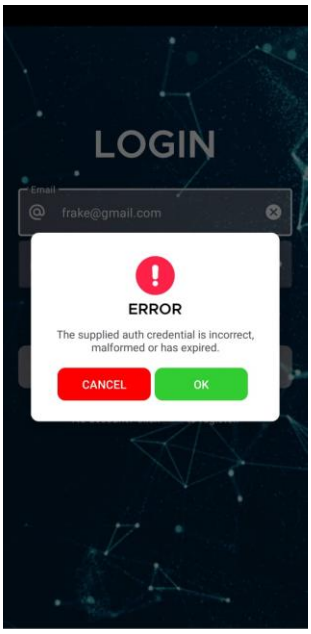
5.1.5. Test Cases user Mobile application

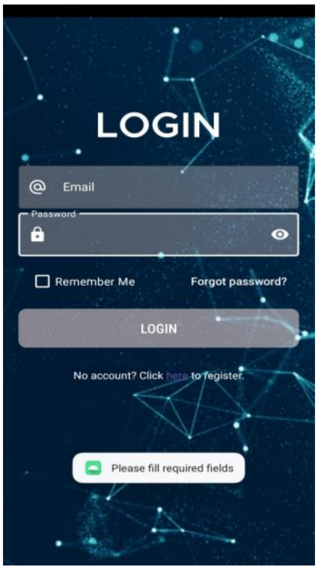
5.1.5.1 Test case for Login

Table 0.17 Test cases for login interface

Test case	L01.1
Objective	To confirm the login function works fine with the correct credentials.
Test data	Email = dinithabc2001@gmail.com Password = 123456
Expected Result	Because of the user type is "customer", the user will be directed to "Customer Activity".
Actual Result	

Conclusion	Working as expected

Test case	L01.2
Objective	To confirm the login function works fine with the incorrect credentials.
Test data	Email = fake@gmail.com Password = fake password
Expected Result	Display an error.
Actual Result	 *Figure 0.9 login error message interface*
Conclusion	Working as expected.

Test case	L01.3
Objective	To confirm the login function works fine with empty credentials.
Test data	Email = “” Password = “”
Expected Result	Error toast will be displayed.
Actual Result	 *Figure 0.10 toast message display interface*
Conclusion	Working as expected

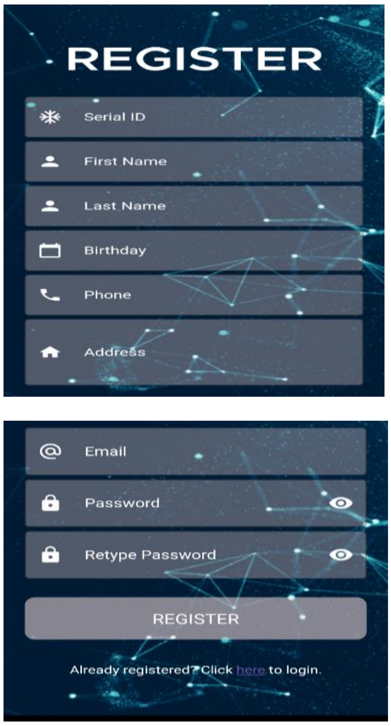
<table>
<tr><td>Test case</td><td></td></tr>
<tr><td>Objective</td><td>Test the remember me function working fine</td></tr>
<tr><td>Test data</td><td>Remember me = true</td></tr>
<tr><td>Expected Result</td><td>Saves the data in checkbox.xml file</td></tr>
<tr><td>Actual Result</td><td>

Figure 0.11 remember me true interface</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

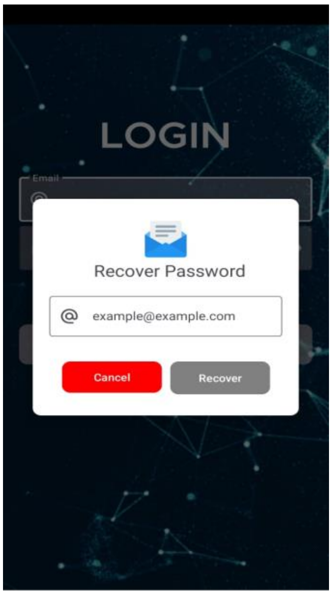
<table>
<tr><td>Test case</td><td>L02.2</td></tr>
<tr><td>Objective</td><td>Logout from the app to make sure that the data is written in the checkbox.xml correctly.</td></tr>
<tr><td>Test data</td><td>Logout</td></tr>
<tr><td>Expected Result</td><td>Saves the remember=false.</td></tr>
<tr><td>Actual Result</td><td>

Figure 0.12 remember me interface(false)</td></tr>
</table>

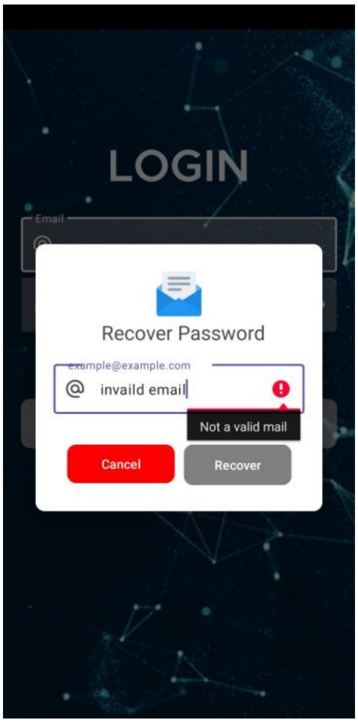
Conclusion	Working as expected.

Test case	L03.1
Objective	Check the “here” method working fine
Test data	Click “here”
Expected Result	Direct user to the register activity.
Actual Result	 *Figure 0.13 registration interface*
Conclusion	Working as expected

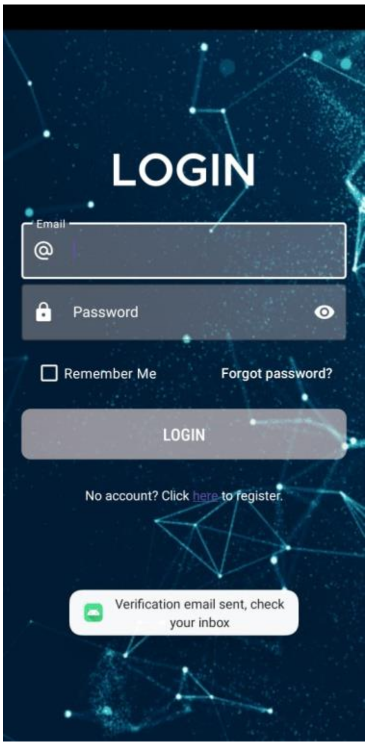
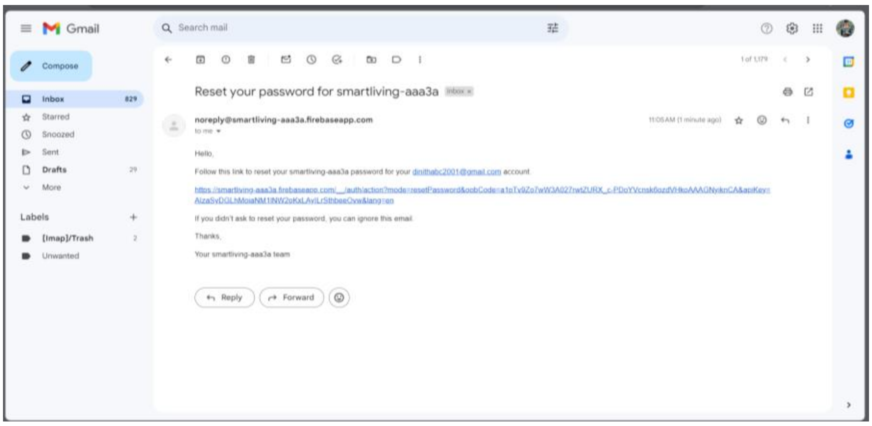
Test case	L04.1

Objective	Check the “forgot password” method working fine.
Test data	Click the forgot password button
Expected Result	Display the recover password window.
Actual Result	 *Figure 0.14 recovery password interface*
Conclusion	Working as expected

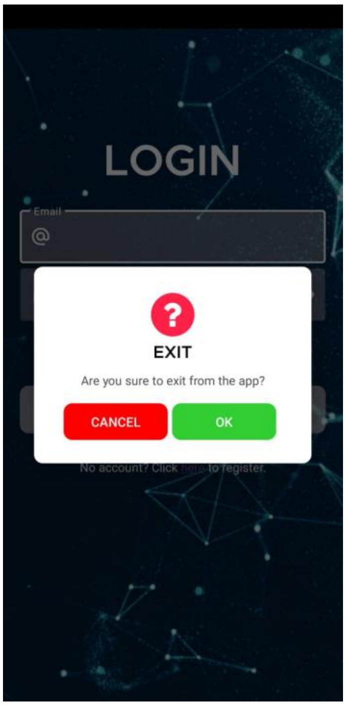
Test case	L04.2
Objective	Check the “forgot password” method working fine when a wrong email is entered.
Test data	Email = invalid email
Expected Result	“Not a valid mail” error will be displayed
Actual Result	

	 *Figure 0.15 invalid email input time interface*
Conclusion	Working as expected

Test case	L04.3

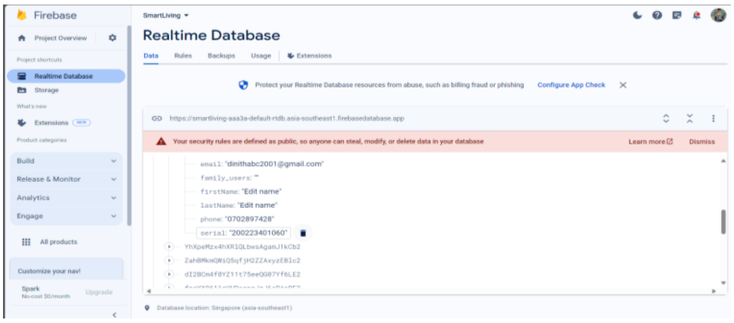
Objective	Check the “forgot password” method working fine when a valid email is entered.
Test data	Email =dinithabc2001@gmail.com
Expected Result	Successful toast will be displayed
Actual Result	 *Figure 0.16 successful toast message result on phone*  *Figure 0.17 successful Gmail verification result*

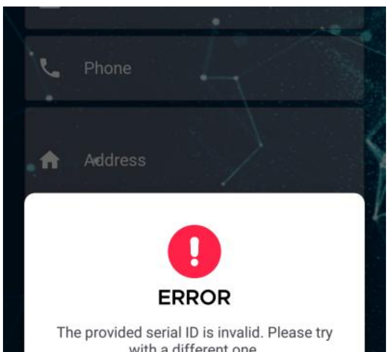
Conclusion	Email is received, working as expected

Test case	L05.1
Objective	Test the back button
Test data	Click the back button
Expected Result	A dialog box will be displayed to get the confirmation from the user to exit from the app.
Actual Result	 *Figure 0.18 back button working interface*
Conclusion	Working as expected

5.1.5.2 Test case for Registration.

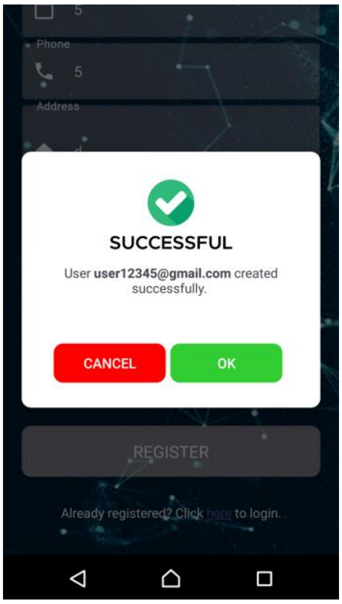
Table 0.18Test cases for customer registration interface

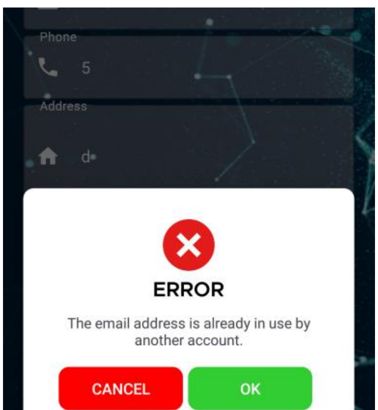
Test case	R01.1
Objective	Test the serial no field.
Test data	Enter serial No “200223401060”
Expected Result	The serial no is new and the text are matching update profile within serial no and update database.
Actual Result	 *Figure 0.19 Update serial No interface*  *Figure 0.20 real time date base update interface*
Conclusion	Working as expected

Test case	R01.2
Objective	Test the serial no field.
Test data	Already Enter serial No “200223401060” Again enter serial no “200223401060”
Expected Result	Showing alert box “the provided serial ID is invalid. Please try with a different one”.
Actual Result	

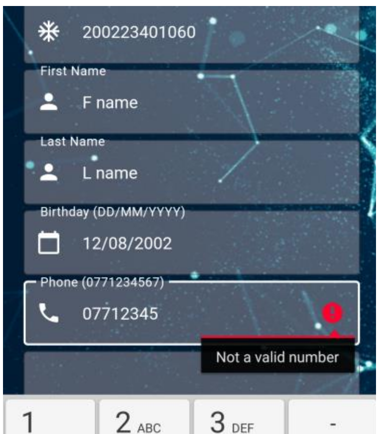
Conclusion	Working as expected

Test case	R02.1
Objective	Test the register function with new email. (Registers a new user)
Test data	Email = user12345@gmail.com Password = qwerty Confirm-pass = qwerty
Expected Result	“User registered” confirmation dialog will be displayed.
Actual Result	

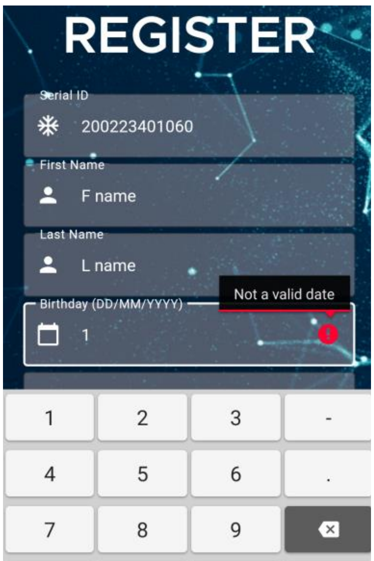
	 *Figure 0.22 user registration successfully messaging interface*
Conclusion	Working as expected

Test case	R02.2
Objective	Test the register function with new email. (Registers a new user)
Test data	Already registered Email = user12345@gmail.com Again registration email=user12345@gmail.com
Expected Result	“The email address is already in use by another account” alert will be displayed.
Actual Result	

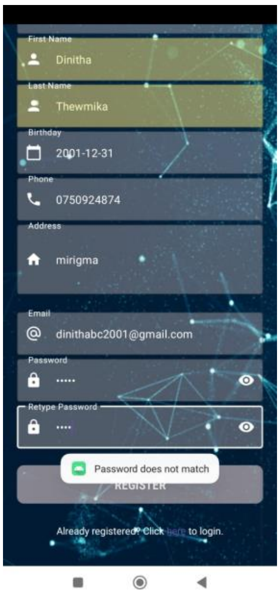
Conclusion	Working as expected

Test case	R03.1
Objective	Test the Phone no field invalid input
Test data	Phone no= (07712345)
Expected Result	Input the invalid no after system show error “ not a valid no”
Actual Result	

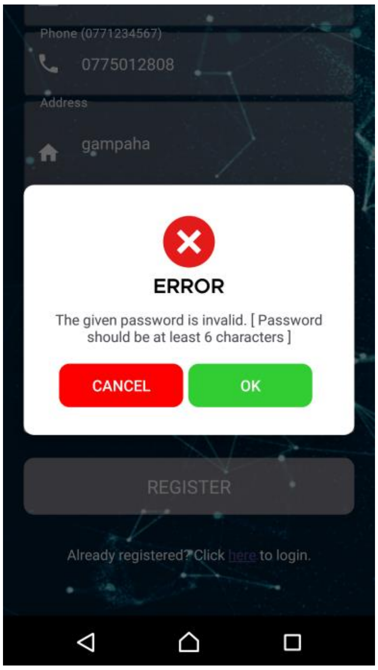
Conclusion	Working as expected

Test case	R04.1
Objective	Test the Phone no field invalid input
Test data	Birthday = invalid type
Expected Result	Input the invalid no after system show error “ not a valid date”
Actual Result	

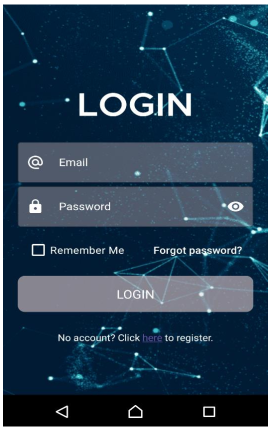
Conclusion	Working as expected

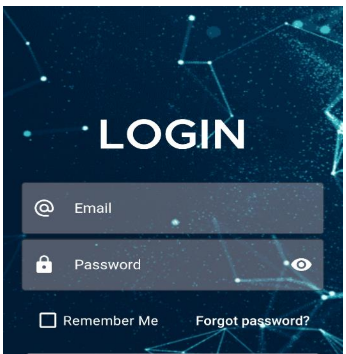
Test case	R05.1
Objective	Check the register button works fine with the un matching passwords
Test data	Email = dinithabc@gmail.com Password = qwerty Confirm = fake password
Expected Result	Password doesn't match toast will be displayed and the password fields will be cleared.
Actual Result	

Conclusion	Working as expected

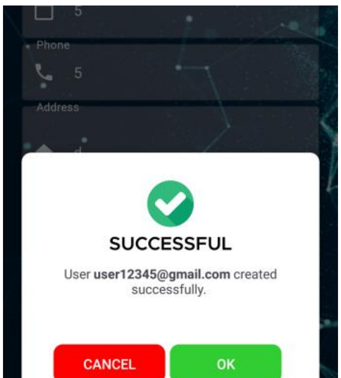
Test case	R05.2
Objective	Check the register button works fine with the passwords without enough length.
Test data	Email = testemail@gmail.com Password = q Confirm = q
Expected Result	"The given password invalid (password should be at least 6 character" toast will be displayed
Actual Result	 *Figure 0.27 password error interface*
Conclusion	Working as expected

Test case	R06

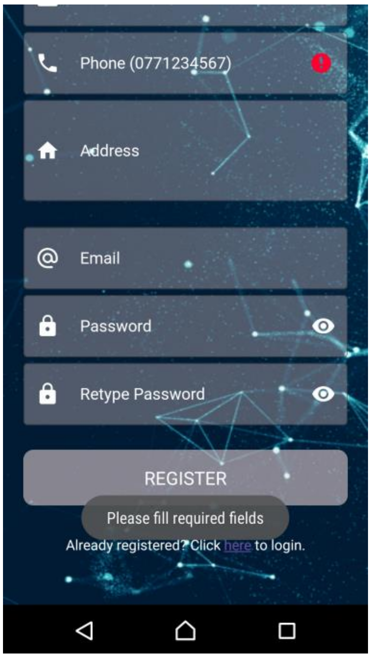
Objective	Check the here function.
Test data	Click “Here”
Expected Result	Direct the user to the Login page
Actual Result	 *Figure 0.28 login interface*
Conclusion	Working as expected

Test case	R07
Objective	Check the back button is working fine
Test data	Click the back button
Expected Result	Go to the login page
Actual Result	

Conclusion	Working as expected

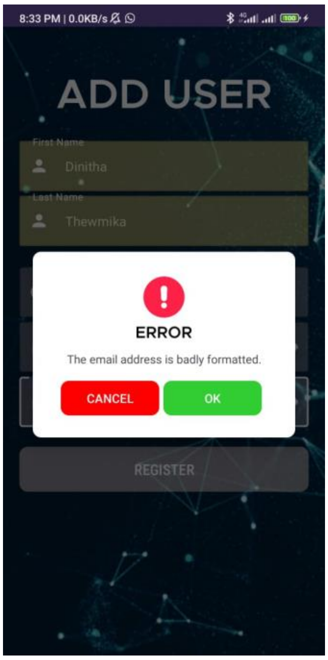
Test case	R08.1
Objective	Check the register button works fine.
Test data	Enter the all field successfully
Expected Result	Show message “user create successfully”
Actual Result	

Conclusion	Working as expected

Test case	R08.2
Objective	Check the register button works fine.
Test data	Not fill all the required fields.
Expected Result	Show message all
Actual Result	 *Figure 0.31 error message not fill required fields*
Conclusion	Working as expected

5.1.5.3 Test case for Family user registration.

Table 0.19 test cases for user registration interface

Test case	R01.1
Objective	Checking the already registered and invalid email or invalid text email working.
Test data	Invalid Email type “dinitha gamil.com”
Expected Result	Showing message “email address is badly formatted”.
Actual Result	 *Figure 0.32 home user email error message interface*

Conclusion	Working as expected

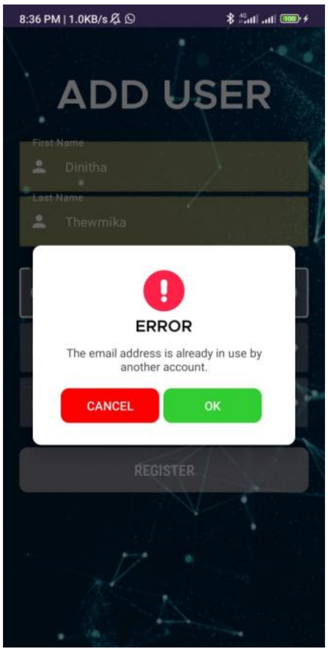
<table>
<tr><td>Test case</td><td>R01.2</td></tr>
<tr><td>Objective</td><td>Checking the already registered email.</td></tr>
<tr><td>Test data</td><td>Input registered email dinitha@gamil.com.</td></tr>
<tr><td>Expected Result</td><td>Showing message “the email address already in use by another account”.</td></tr>
<tr><td>Actual Result</td><td>

Figure 0.33 home user email error message interface</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

Test case	R02.1
Objective	Checking password field input random text.
Test data	Email= dinithabc2001@gmail.com Password= 123456 Re type password=fake password

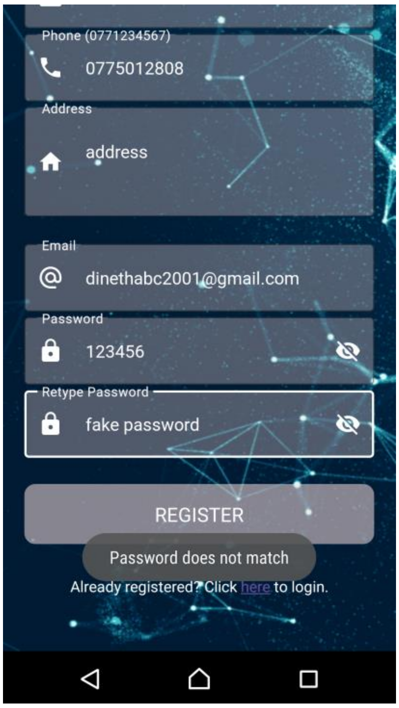
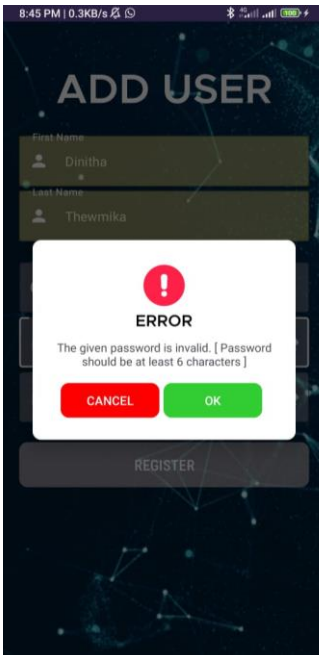
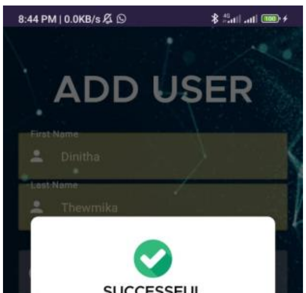
<table>
<tr><td>Expected Result</td><td>Show error message “password does not match”</td></tr>
<tr><td>Actual Result</td><td>

Figure 0.34 password does not match error interface</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

Test case	R02.2
Objective	Check the register button works fine with the passwords without enough length.
Test data	Email= dinithabc2001@gmail.com Password= q Re type password=q
Expected Result	“the given password is invalid.[password should be at least 6 characters” toast will be displayed

Actual Result	 *Figure 0.35 home user password field error message*
Conclusion	Working as expected

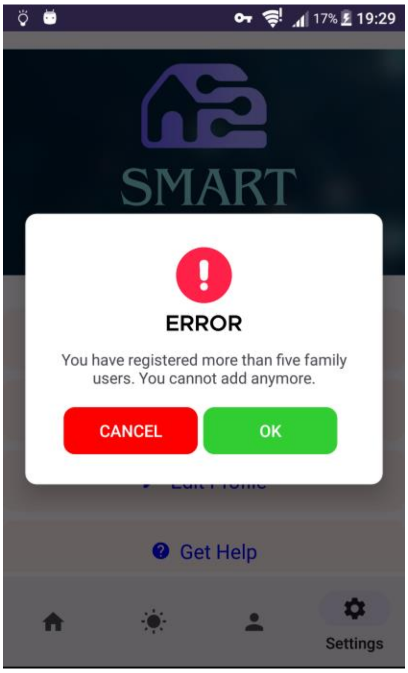
Test case	R03.1
Objective	Check the register button works fine.
Test data	Enter the all field successfully
Expected Result	Show message "user create successfully"
Actual Result	

Conclusion	Working as expected

<table>
<tr><td>Test case</td><td>R03.2</td></tr>
<tr><td>Objective</td><td>Check the register button works fine.</td></tr>
<tr><td>Test data</td><td>Not fill all the required fields.</td></tr>
<tr><td>Expected Result</td><td>Show message “please fill all required field”.</td></tr>
<tr><td>Actual Result</td><td>


Figure 0.37 show error message please fill required fields add user interface
</td></tr>
</table>

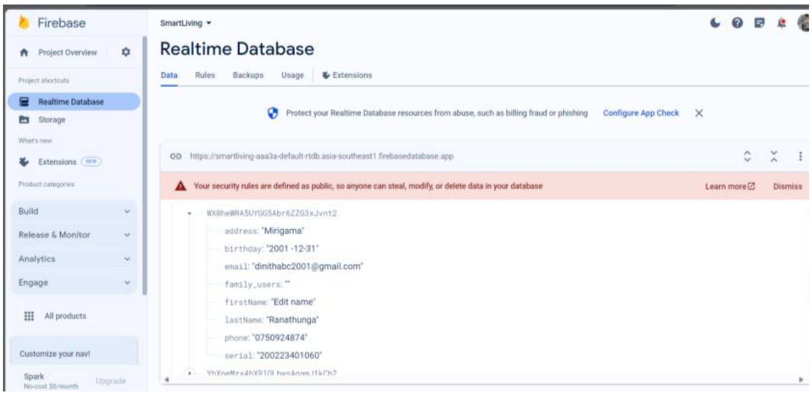
Conclusion	Working as expected

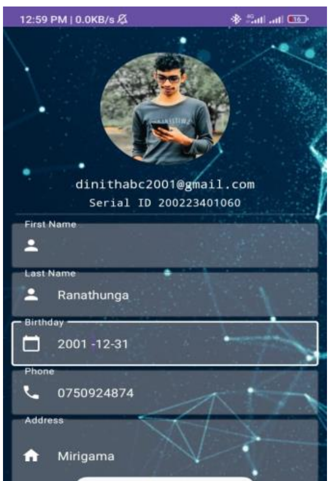
Test case	R04
Objective	Check the family user adding limitation
Test data	Fill the more than 5 family user .
Expected Result	Show message “please fill all required field”.
Actual Result	
Conclusion	Working as expected

5.1.5.4 Test case for Customer Update

Table 0.20 test cases for Customer update interface

Test case	R01.1
Objective	Check the first name field work proper.
Test data	Current name = "Dinitha thewmika" Updated first Name(edit name)= "Edit name"
Expected Result	The entering new name in First name field and click edit button system will give message "data edit successful". And update firebase
Actual Result	 *Figure 0.38 First name Data edit interface*

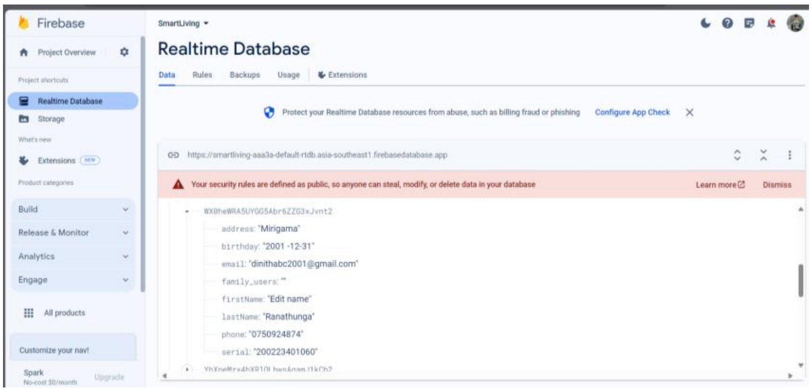
	 *Figure 0.39 updated firebase console*
Conclusion	Working as expected

Test case	R01.2
Objective	Check the first name field work proper.
Test data	No enter First name
Expected Result	User not input the name filed First name system show “please fill required filed” toast displayed.
Actual Result	

Conclusion	Working as expected

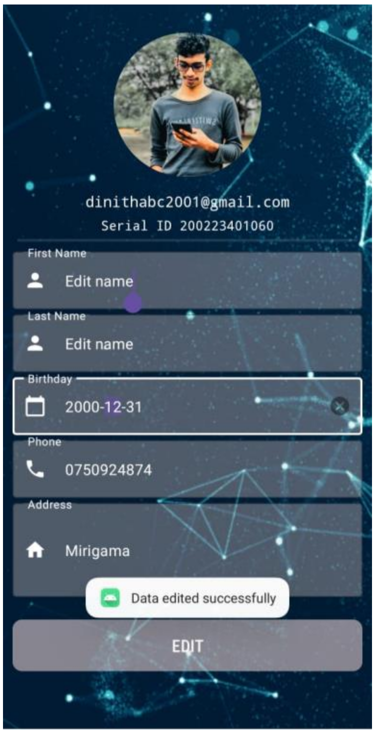
Test case	R02.1
Objective	Check the last name field work proper.
Test data	Current name = “Ranathunga” Updated Name(edit last name)= “Edit name”
Expected Result	The entering new name in Last name field and click edit button system will give message "data edit successful". And update firebase
Actual Result	

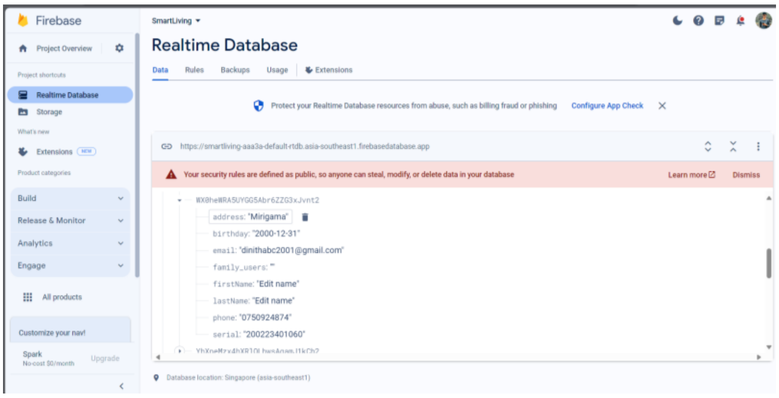
Figure 0.42 First name Data edit interface

	 *Figure 0.43 updated firebase console*
Conclusion	Working as expected

Test case	R02.2
Objective	Check the Last name field work proper.
Test data	No enter last name
Expected Result	User not input the name filed Last name system show “please fill required filed” toast displayed.
Actual Result	

Conclusion	Working as expected

Test case	R03.1
Objective	Check the Birthday field work proper.
Test data	Current birth day = “2001-12-31” Updated Birth day(edit birth day)= “2000-12-31”
Expected Result	The entering the new date of birth in the date of birth field and clicking on the edit button, the system will give the message "Data editing successful". And update firebase
Actual Result	 *Figure 0.46Birthday Data edit interface*

	 *Figure 0.47updated firebase console*
Conclusion	Working as expected

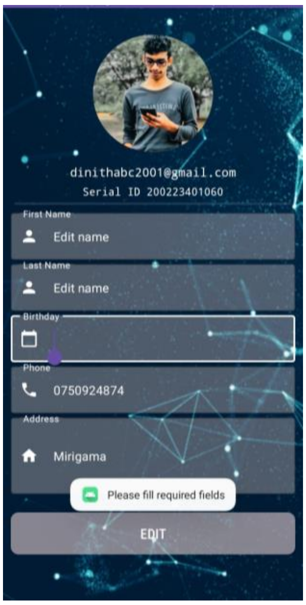
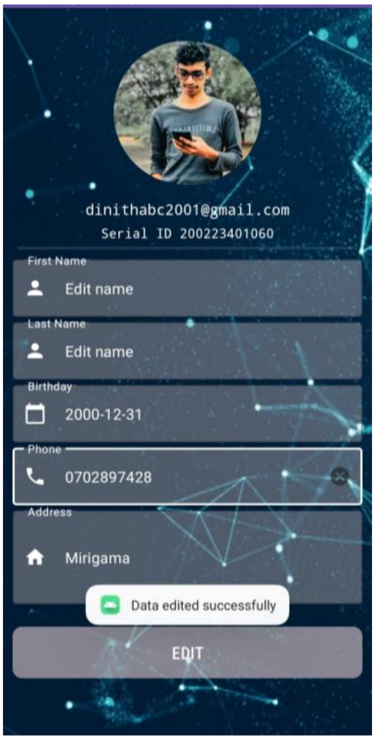
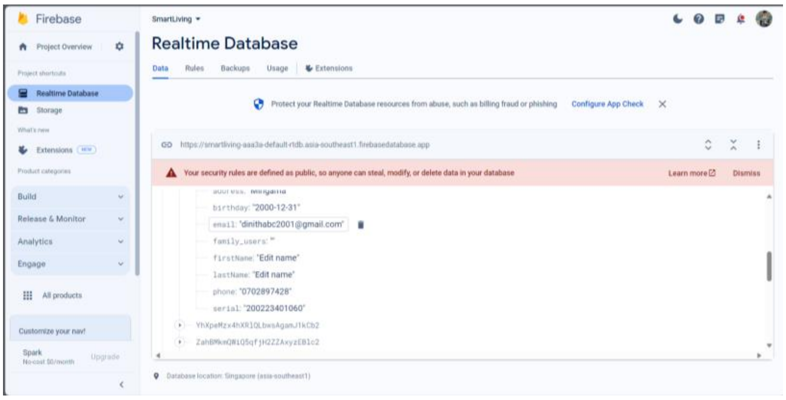
Test case	R03.2
Objective	Check the name field work proper.
Test data	No enter date
Expected Result	User not input the Birthday filed birthday system show “please fill required filed” toast displayed.
Actual Result	

Figure 0.48 notify in required field in Edit interface

Conclusion	Working as expected

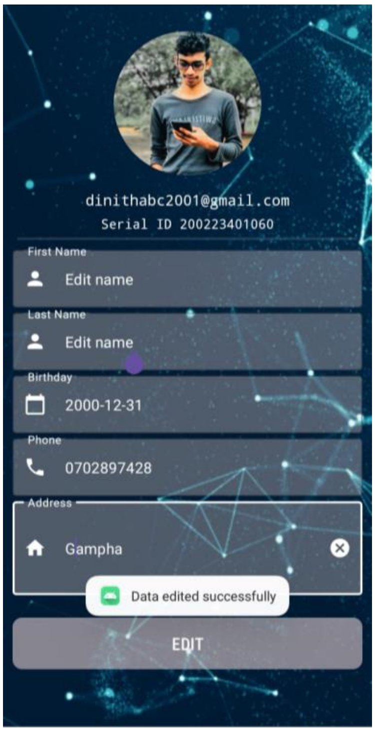
Test case	R04.1
Objective	Check the Phone no field work proper.
Test data	Current Phone no = “0750924874” Updated phone no (edit phone no)= “0702897428”
Expected Result	The entering the new Phone no in the Phone no field and clicking on the edit button, the system will give the message "Data editing successful". And update firebase
Actual Result	 *Figure 0.50Phone No Data edit interface*

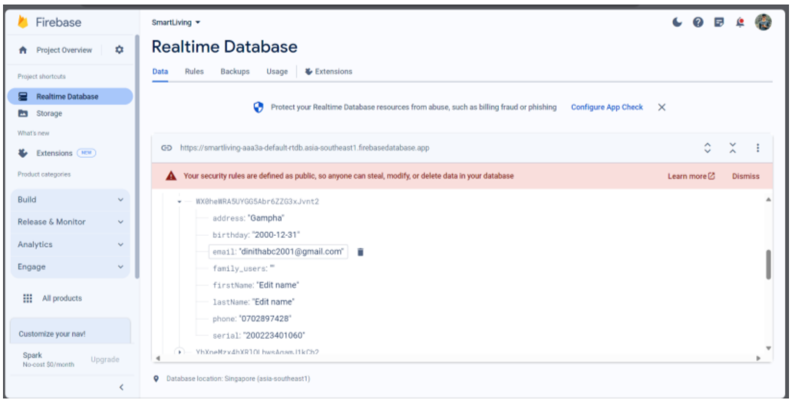
	 *Figure 0.51 updated firebase console*
Conclusion	Working as expected

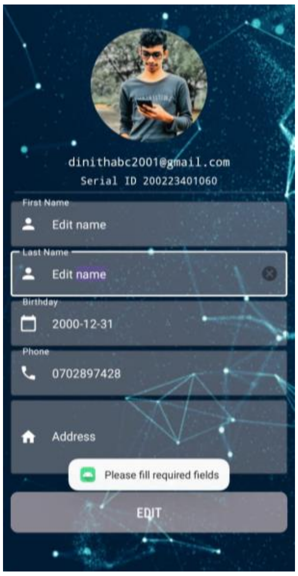
Test case	R04.2
Objective	Check the Phone no field work proper.
Test data	No enter phone no
Expected Result	User not input the name filed Phone no system show “please fill required filed” toast displayed.
Actual Result	

Figure 0.52Phone No Data edit interface

Conclusion	Working as expected

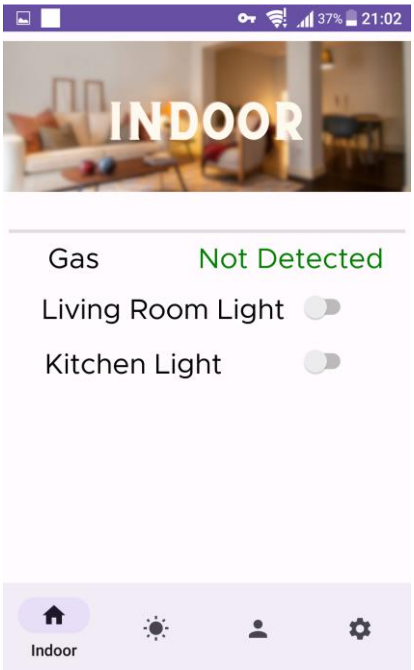
Test case	R05.1
Objective	Check the Address no field work proper.
Test data	Current Address = “Mirigama” Updated Address (edit Address)= “Gampaha”
Expected Result	The entering the new address no in the Address field and clicking on the edit button, the system will give the message "Data editing successful". The And update firebase
Actual Result	 *Figure 0.54Address Data edit interface*

	 *Figure 0.55 updated firebase console*
Conclusion	Working as expected

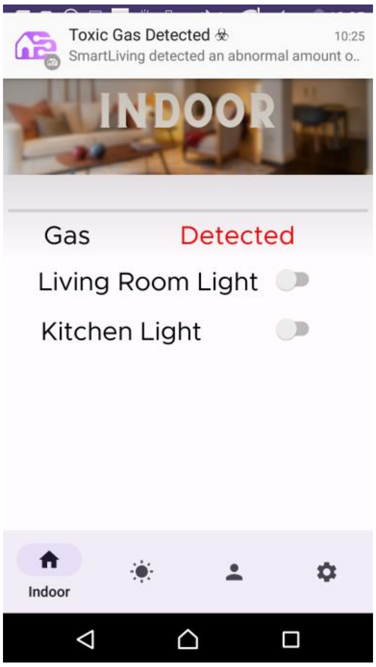
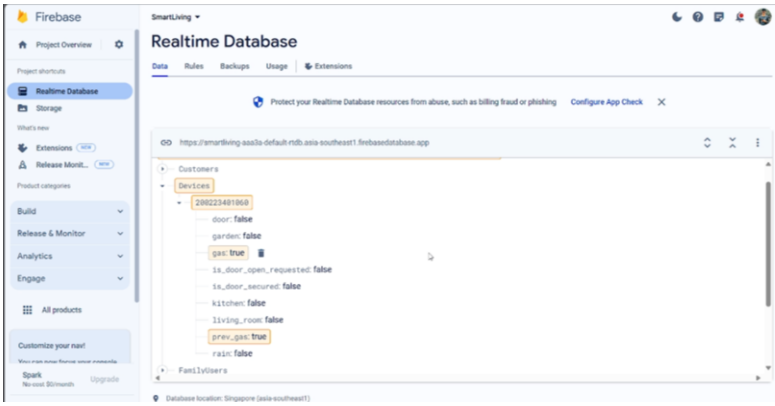
Test case	R04.2
Objective	Check the Phone no field work proper.
Test data	No enter Address
Expected Result	User not input the Address filed Address system show “please fill required filed” toast displayed.
Actual Result	 *Figure 0.56AddressData edit interface*

Conclusion	Working as expected

5.1.5.5 Test cases for Indoor Interface.

Test case	R01
Objective	Testing indoor interface
Test data	
Expected Result	Loading in door interface
Actual Result	 *Figure 0.58 indoor interface*
Conclusion	Working as expected

Test case	R02.1
Objective	Testing gas level function
Test data	

Expected Result	If the gas sensor detects toxic gas, the "gas" variable in Firebase database will become "true" and user will receive a notification about the abnormal gas level and gas status will become "Detected" in the app.
Actual Result	 *Figure 0.59 gas detect notify interface*  *Figure 0.60 firebase console update within gas level notify*
Conclusion	Working as expected

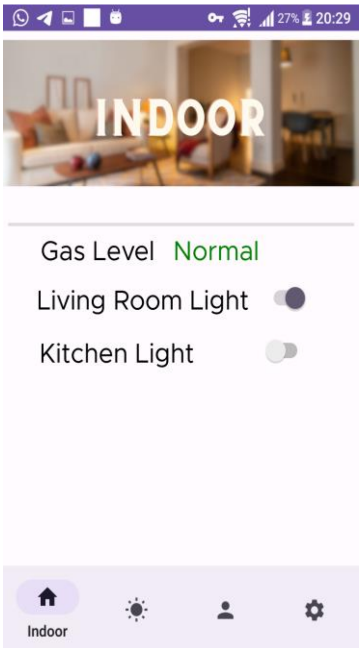
<table>
<tr><td>Test case</td><td>R02.2</td></tr>
<tr><td>Objective</td><td>Testing gas level function</td></tr>
<tr><td>Test data</td><td></td></tr>
<tr><td>Expected Result</td><td>. If the gas level is normal, the "gas" variable will become "false" and gas status will become "Not Detected" in the users app.</td></tr>
<tr><td>Actual Result</td><td>


Figure 0.61 Gas level normal time interface

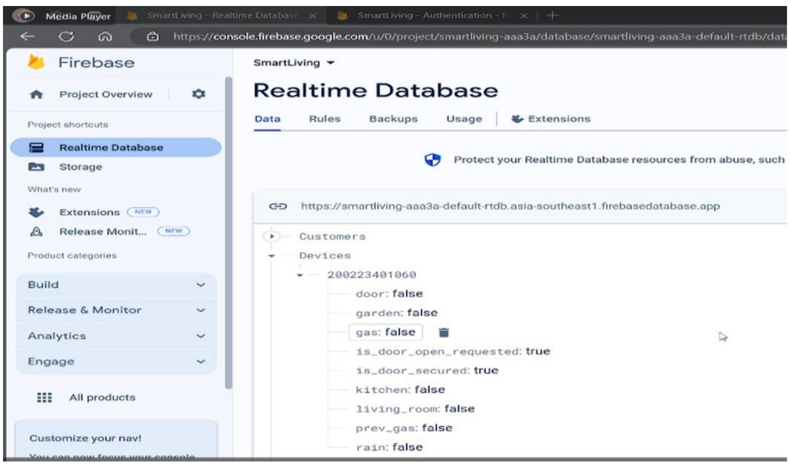


Figure 0.62 gas level normal time firebase console
</td></tr>
</table>

Conclusion	Working as expected

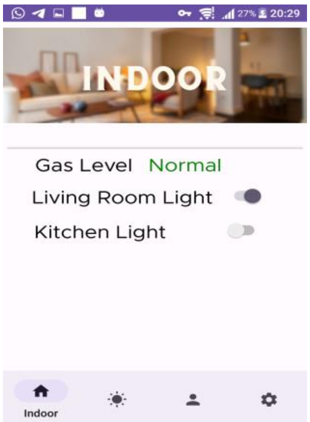
<table>
<tr><td>Test case</td><td>R03.1</td></tr>
<tr><td>Objective</td><td>Testing Living room Lights work proper</td></tr>
<tr><td>Test data</td><td></td></tr>
<tr><td>Expected Result</td><td>Living room light turn on according to the command and update database.</td></tr>
<tr><td>Actual Result</td><td>


Figure 0.63 living room lights on time mobile application

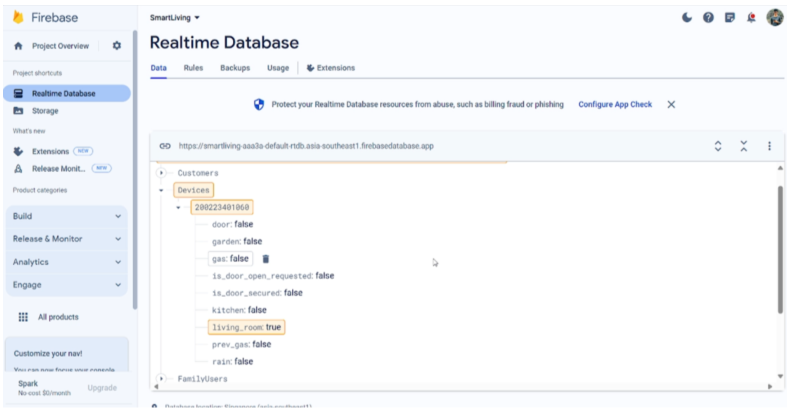
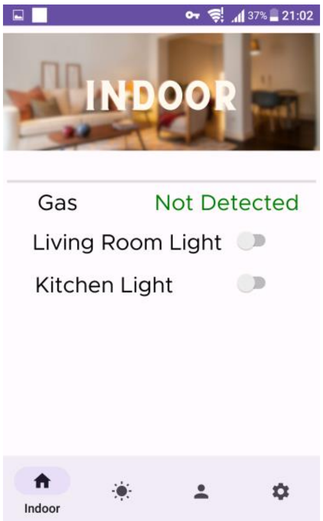
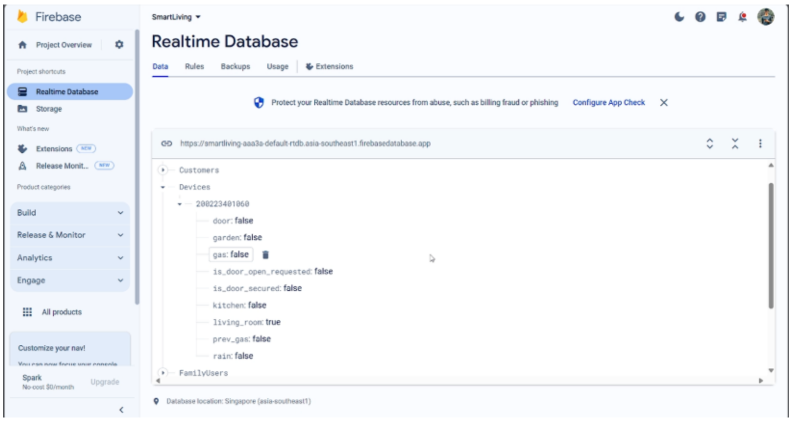


Figure 0.64 firebase console living room lights on time
</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

Test case	R03.2

Objective	Testing Living room work proper
Test data	
Expected Result	Living room light turn off according to the command and update database.
Actual Result	 *Figure 0.65 living room lights off time mobile application interface*  *Figure 0.66living room lights off time firebase console*
Conclusion	Working as expected

Test case	R04.1
Objective	Testing Kitchen Lights work proper

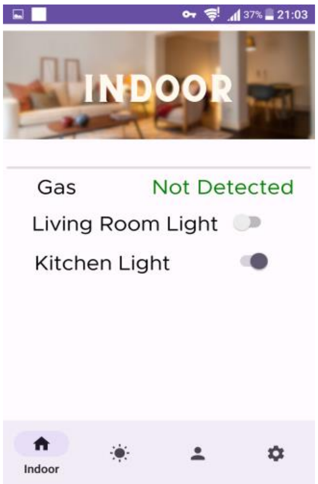
<table>
<tr><td>Test data</td><td></td></tr>
<tr><td>Expected Result</td><td>Living kitchen light turn on according to the command and update database.</td></tr>
<tr><td>Actual Result</td><td>

Figure 0.67 kitchen lights on time mobile application

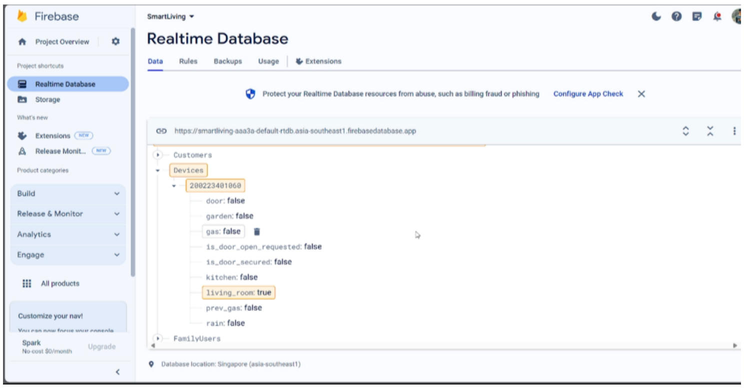
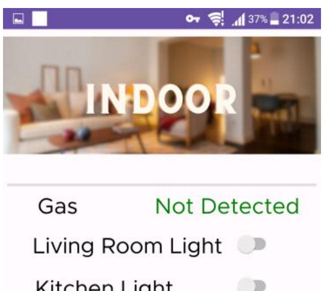
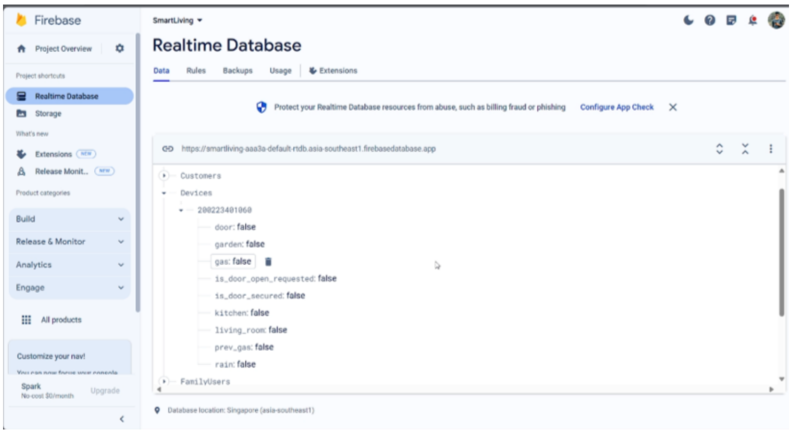


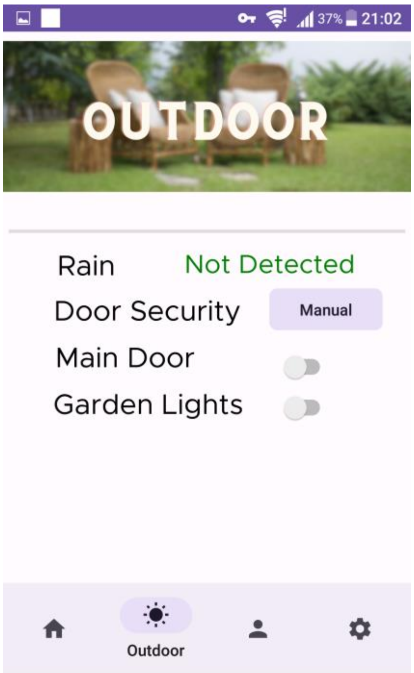
Figure 0.68 real-time database kitchen lights on time</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

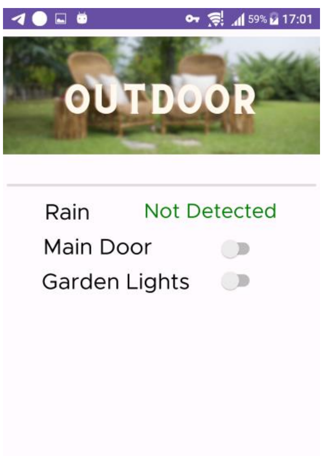
Test case	R04.2
Objective	Testing Kitchen work proper
Test data	
Expected Result	Kitchen light turn off according to the command and update database.
Actual Result	

	 *Figure 0.70 real-time database console kitchen lights off time*
Conclusion	Working as expected

5.1.5.6 Test Cases for Outdoor Interface

Test case	R01
Objective	Testing outdoor interface

Test data	
Expected Result	Loading out door interface
Actual Result	 *Figure 0.71 out door interface*
Conclusion	Working as expected

Test case	R02.1
Objective	Testing rain detection sensor working
Test data	
Expected Result	If the rain status is normal, the "rain" variable will become "false" and rain status will become "Not Detected" in the user's app.
Actual Result	

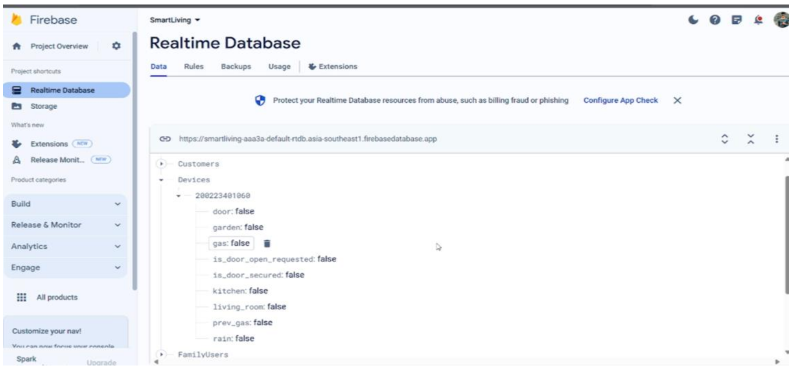
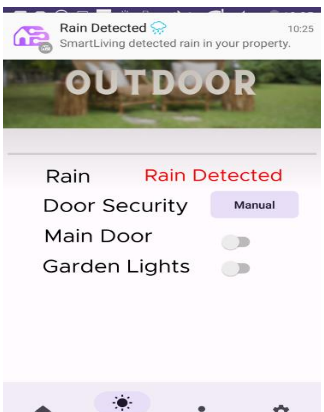


Figure 0.73 rain not detect time firebase console

Conclusion	Working as expected

Test case	R02.2
Objective	Testing rain detection sensor working
Test data	
Expected Result	If the rain sensor detects rain in the area, the " rain " variable in Firebase database will become "true" and user will receive a notification about the rain level and rain status will become "Detected" in the app.
Actual Result	



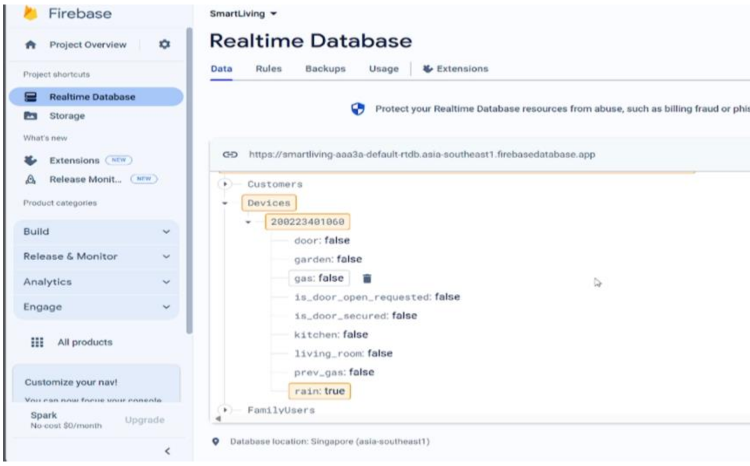
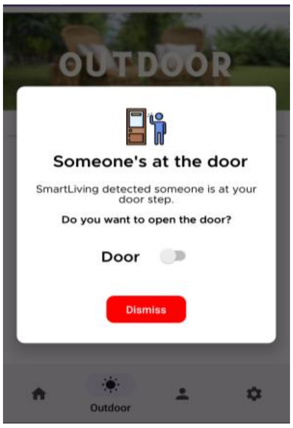
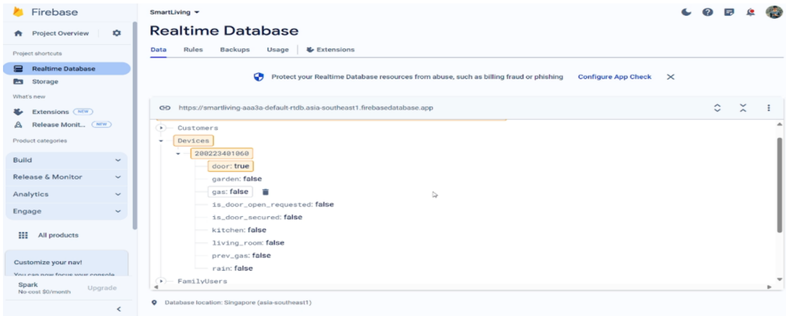
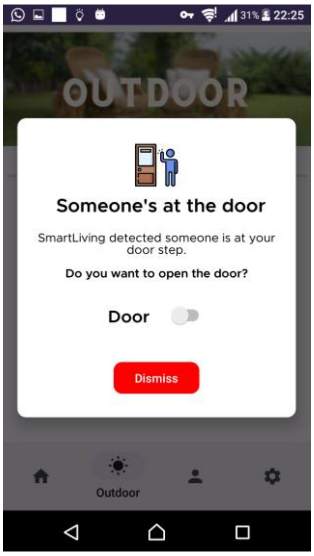
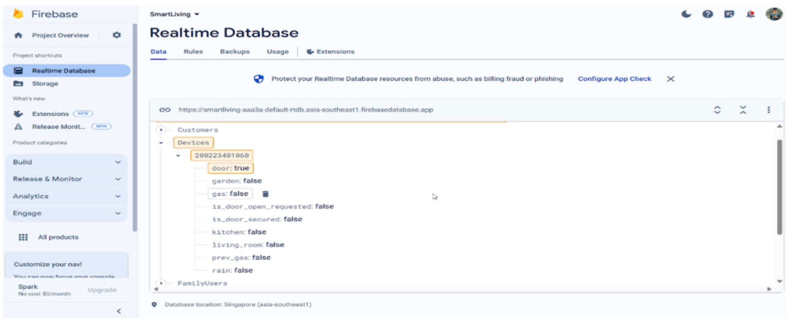
<table>
<tr><td></td><td>

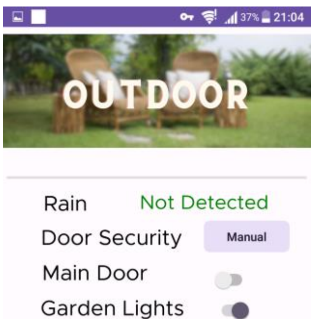
Figure 0.75 rain notify time firebase console</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

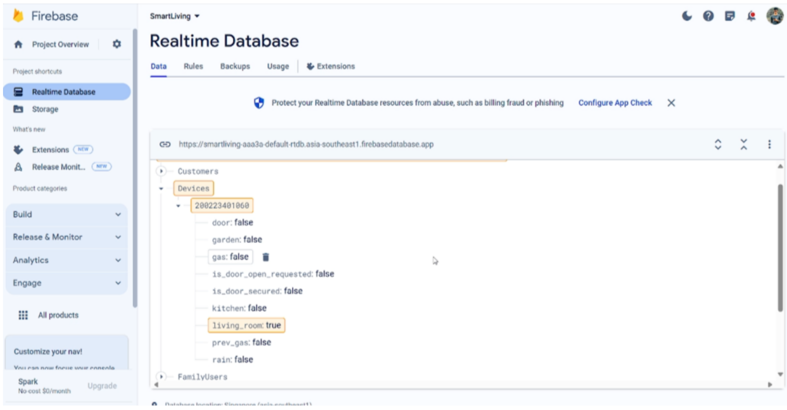
Test case	R03.1
Objective	Testing Main door working proper
Test data	
Expected Result	If the user has set "Auto" as the door security, the door will automatically open without sending a notification to the user. After the door opening the "door" variable in the Firebase database will become true.

Actual Result	 *Figure 0.76 auto door open time show message interface*  *Figure 0.77firebase console auto door open time*
Conclusion	Working as expected

Test case	R03.2
Objective	Testing Main door working proper
Test data	
Expected Result	If the user has chosen “Manual" as the door security, when the ultrasonic sensor detects someone at the door the "is door open requested" variable will become true. Then the user will receive a notification to grant the request to open the door.

Actual Result	 *Figure 0.78 mobile application interface door open time*  *Figure 0.79 real-time database door open time*
Conclusion	Working as expected

Test case	R04.1
Objective	Testing Garden Lights work proper
Test data	
Expected Result	Garden light turn on according to the command and update database.
Actual Result	

	 *Figure 0.81 firebase interface garden lights on time*
Conclusion	Working as expected

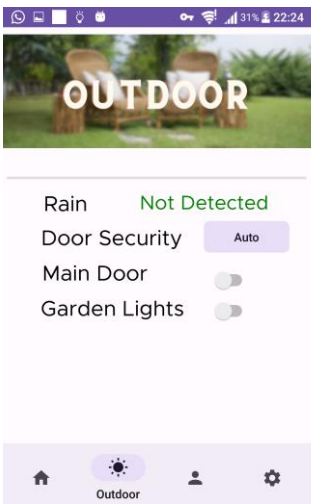
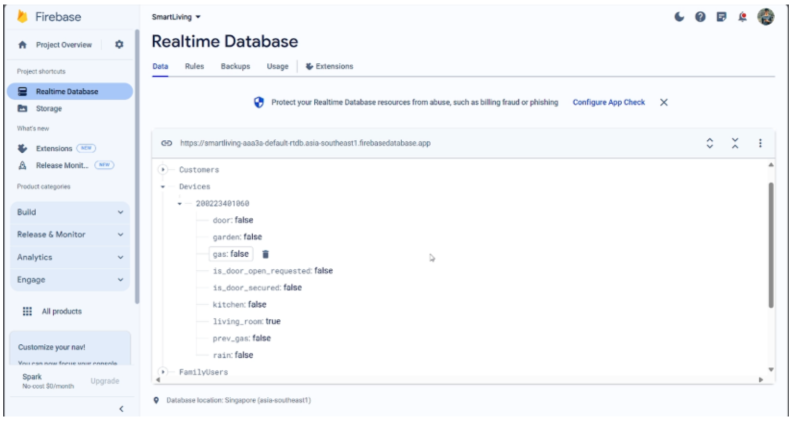
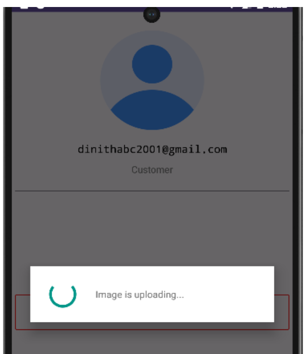
Test case	R04.2
Objective	Testing Garden Lights work proper
Test data	
Expected Result	Garden light turn off according to the command and update database.
Actual Result	

Figure 0.82 mobile application

	 *Figure 0.83 garden lights turn off time firebase console*
Conclusion	Working as expected

5.1.5.7 Test case for profile interface.

Table 0.21 test cases for profile interface

Test case	R01.1
Objective	Checking the customer image upload to the customer profile in their gallery or Drive.
Test data	Upload Picture in customer's Gallery
Expected Result	Show the toast message "image is uploading".
Actual Result	

Conclusion	Working as expected

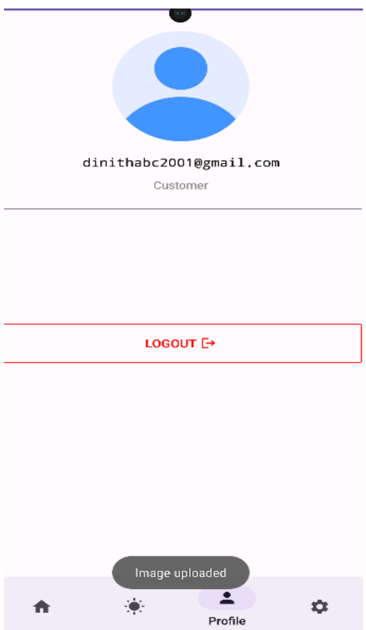
<table>
<tr><td>Test case</td><td>R01.2</td></tr>
<tr><td>Objective</td><td>Checking the customer image upload to the customer profile in their gallery or Drive.</td></tr>
<tr><td>Test data</td><td>Click “Profile “Upload Picture in customer’s Gallery</td></tr>
<tr><td>Expected Result</td><td>Completely uploading picture show the message “image uploaded”</td></tr>
<tr><td>Actual Result</td><td>


Figure 0.85 image successfully update interface
</td></tr>
</table>

Conclusion	Working as expected

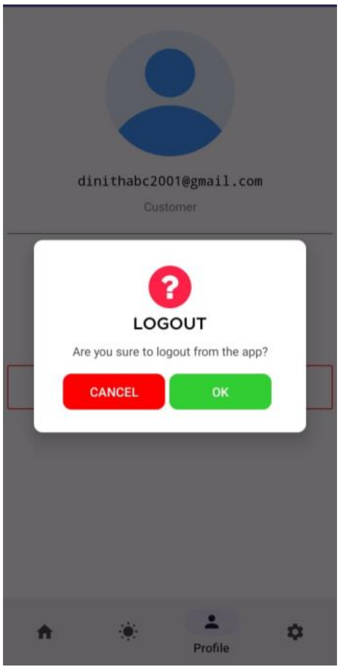
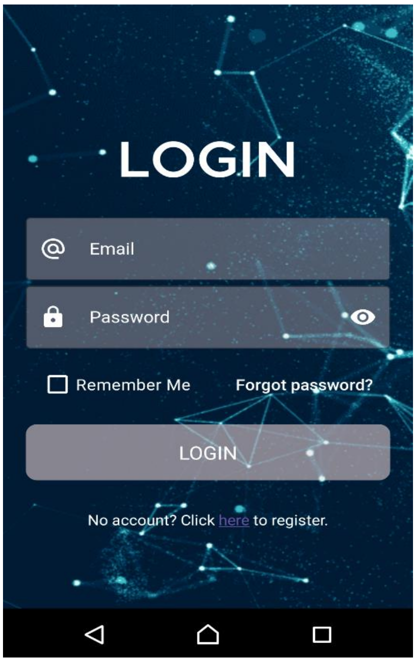
Test case	R02.1
Objective	Checking the log out function.
Test data	Click “Log out”
Expected Result	User click log out button show the message “are you sure to logout from the app” system gives the option “Ok or Cancel”
Actual Result	

Figure 0.86 logout notify interface

Conclusion	Working as expected

Test case	R02.2
Objective	Checking the log out function.
Test data	Click “Ok”
Expected Result	Login out the system and open Again login interface
Actual Result	 *Figure 0.87 After logout showing interface*

Conclusion	Working as expected

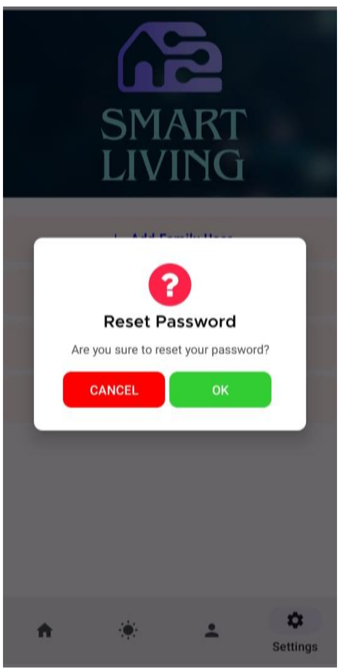
Test case	R02.3
Objective	Checking the log out function.
Test data	Click “Cancel”
Expected Result	Stay at current page.
Actual Result	 *Figure 0.88 Canceling logout showing interface*

Conclusion	Working as expected

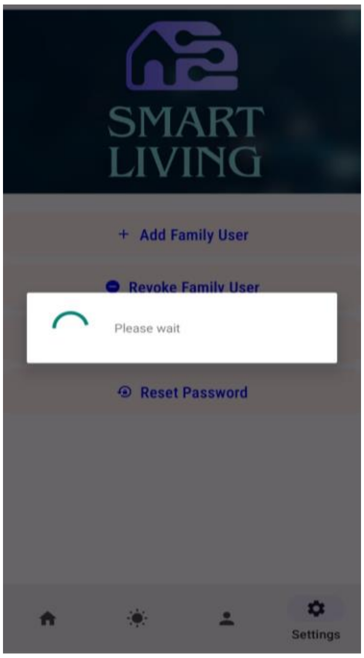
Test case	R03
Objective	Checking profile interface work
Test data	
Expected Result	Loading the profile interface.
Actual Result	 *Figure 0.89 profile interface*
Conclusion	Working as expected

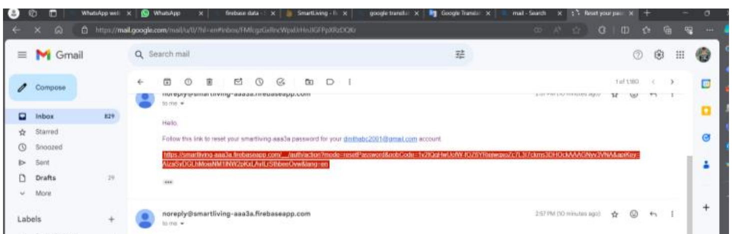
5.1.5.8 Test cases for password reset option.

Table 0.22 test cases for password reset option

Test case	R01.1
Objective	Checking password reset
Test data	Click password reset option
Expected Result	Show the message box “are you sure to reset password” and show “Ok” and cancel button
Actual Result	

Conclusion	Working as expected

Test case	R01.2
Objective	Checking password reset
Test data	Click “ok”
Expected Result	System show toast “please wait “and after show message “Password reset email sent your inbox”. And send email from firebase console.
Actual Result	 *Figure 0.92 please wait notify interface*  *Figure 0.91 password reset and mail sending notify interface*



Conclusion	Working as expected

Test case	R01.2
Objective	Checking password reset
Test data	Click “Cancel”
Expected Result	Can stay at current page.
Actual Result	

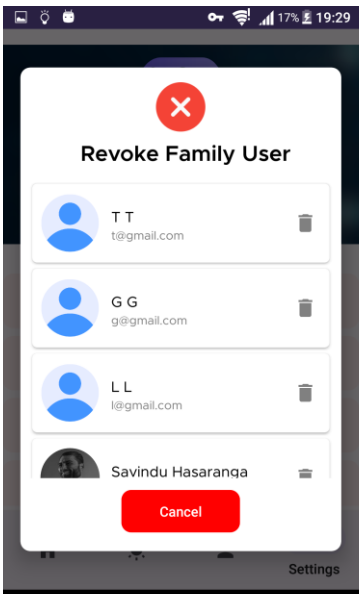
Figure 0.94 After cancel password reset showing interface

Conclusion	Working as expected

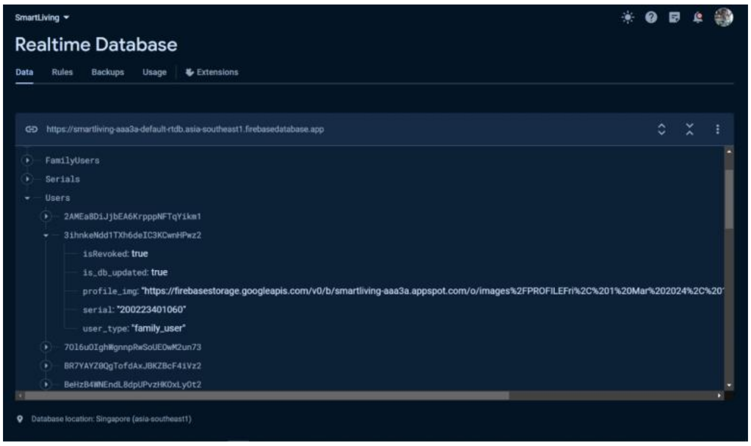
Test case	R03
Objective	Checking setting interface work
Test data	
Expected Result	Loading the setting interface.
Actual Result	 *Figure 0.95 setting interface*
Conclusion	Working as expected

5.1.5.9 Test Cases for the Revoke family users

Table 0.23 Test cases revoke family user

Test case	R01
Objective	Testing the revoke user function loading interface
Test data	
Expected Result	Loading revoke family user interface
Actual Result	

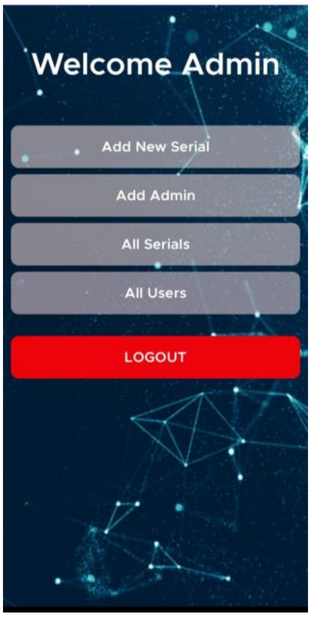
Conclusion	Working as expected

Test case	R01
Objective	Testing the revoke button in revoke family user in the system
Test data	
Expected Result	When the user clicks the revoke button, "is Revoked" variable in the Firebase database will become true.
Actual Result	
Conclusion	Working as expected

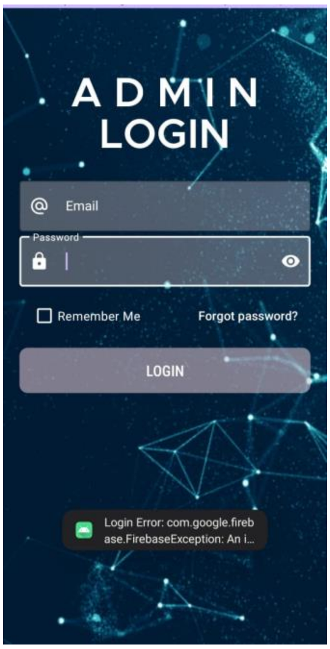
5.1.6. Test Cases Admin Mobile application.

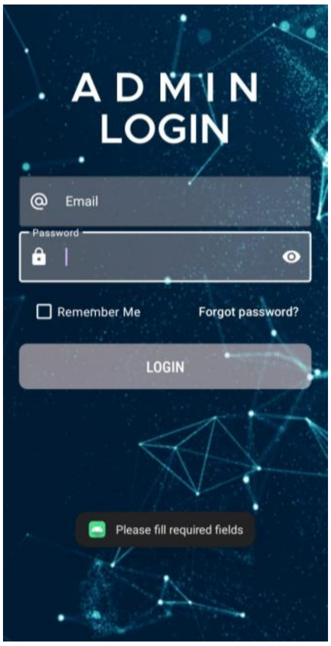
5.1.6.1. Admin login test cases

Table 0.24 Test cases for admin login

Test case	L01.1
Objective	To confirm the login function works fine with the correct credentials.
Test data	Email = admin@yahoo.com Password = qwerty
Expected Result	Because of the user type is "Admin", the user will be directed to "Admin Activity".
Actual Result	 *Figure 0.96 admin interface*

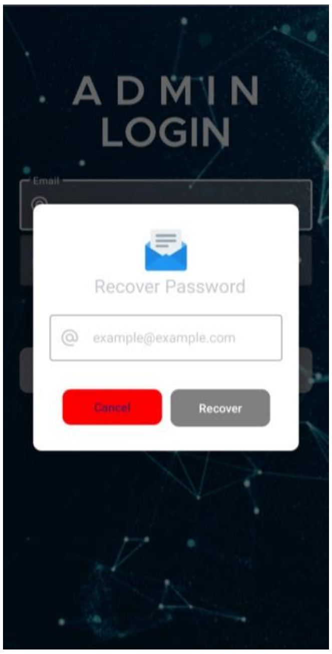
Conclusion	Working as expected

Test case	L01.2
Objective	To confirm the login function works fine with the incorrect credentials.
Test data	Email = fake@gmail.com Password = fake password
Expected Result	Display an error.
Actual Result	 *Figure 0.97 error message admin login interface*
Conclusion	Working as expected.

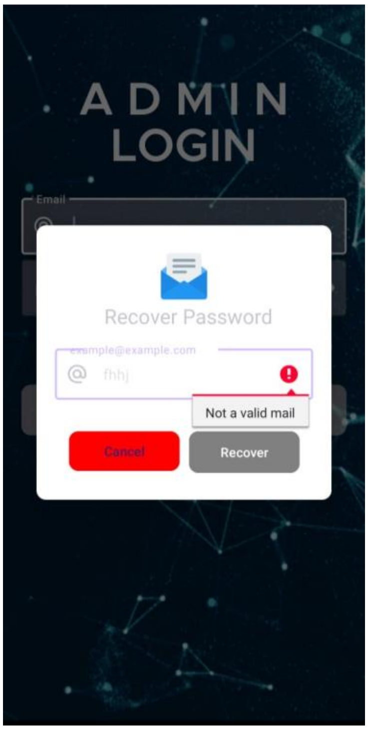
Test case	L01.3
Objective	To confirm the login function works fine with empty credentials.
Test data	Email = “” Password = “”
Expected Result	Error toast will be displayed.
Actual Result	 *Figure 0.98 please fill required field error message interface*
Conclusion	Working as expected

Test case	L02.1
Objective	Test the remember me function working fine
Test data	Remember me = true
Expected Result	Saves the data in checkbox.xml file
Actual Result	 *Figure 0.99 remember me true interface*
Conclusion	Working as expected

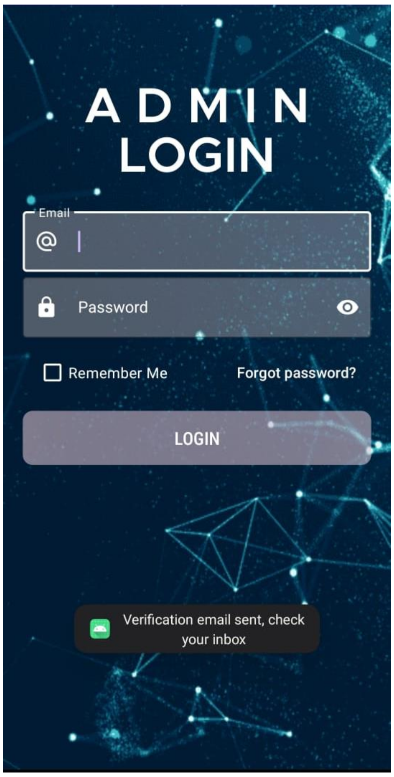
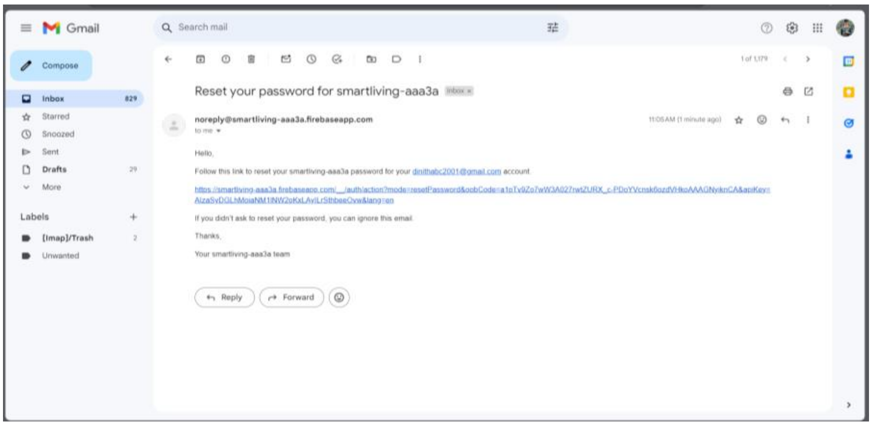
Test case	L02.2
Objective	Logout from the app to make sure that the data is written in the checkbox.xml correctly.
Test data	Logout
Expected Result	Saves the remember=false.
Actual Result	 *Figure 0.100 remember me interface (false)*
Conclusion	Working as expected.

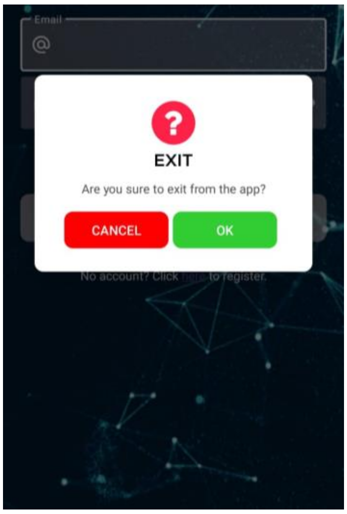
Test case	L03.1
Objective	Check the “forgot password” method working fine.
Test data	Click the forgot password button
Expected Result	Display the recover password window.
Actual Result	 *Figure 0.101 recovery password interface*
Conclusion	Working as expected

Test case	L03.2
Objective	Check the “forgot password” method working fine when a wrong email is entered.
Test data	Email = invalid email
Expected Result	“Not a valid mail” error will be displayed
Actual Result	

	 *Figure 0.102Not valid Error message interface*
Conclusion	Working as expected

Test case	L03.3
Objective	Check the “forgot password” method working fine when a valid email is entered.

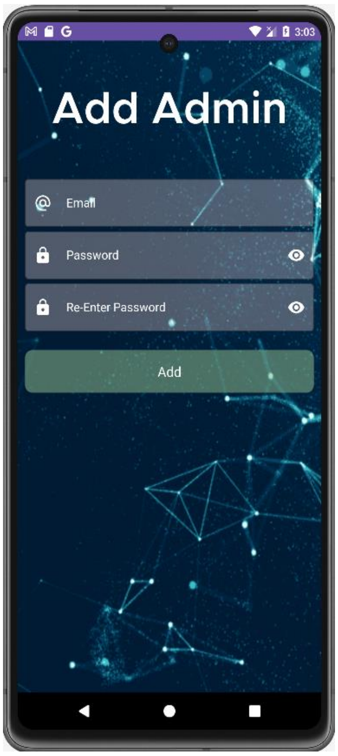
Test data	Email =dinithabc2001@gmail.com
Expected Result	Successful toast will be displayed
Actual Result	 *Figure 0.103 successful toast message result on phone*  *Figure 0.104 successful Gmail verification result*
Conclusion	Email is received, working as expected

Test case	L04.1
Objective	Test the back button
Test data	Click the back button
Expected Result	A dialog box will be displayed to get the confirmation from the user to exit from the app.
Actual Result	 *Figure 0.105 back button working interface*
Conclusion	Working as expected

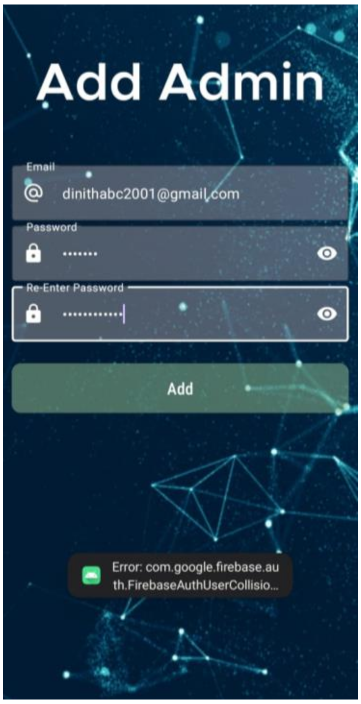
5.1.6.2. Add admin option.

Table 0.25 Test cases for add admin option

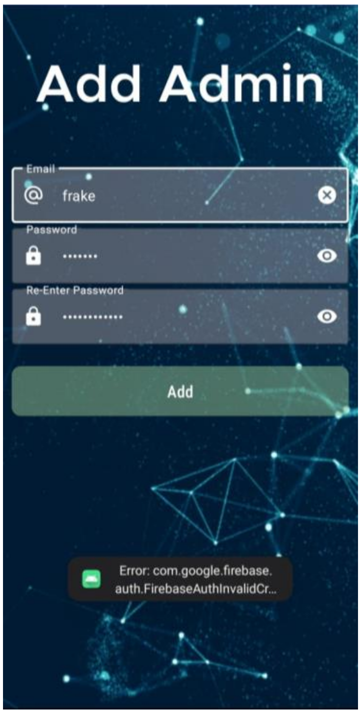
Test case	L01.1

Objective	Test the add admin button
Test data	Click the add admin button
Expected Result	Show add admin panel
Actual Result	 *Figure 0.106 add admin interface*
Conclusion	Working as expected

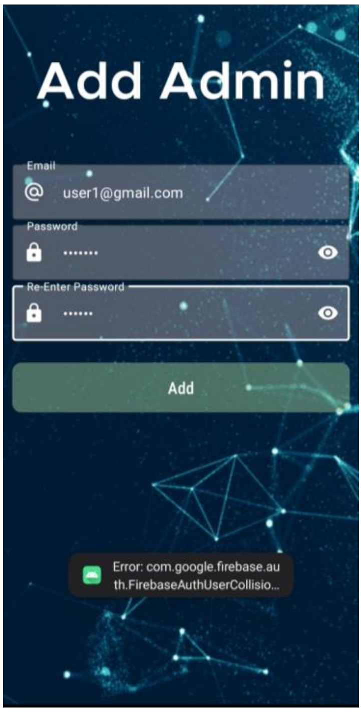
Test case	R02.1
Objective	Checking password field input random text.
Test data	Email= dinithabc2001@gmail.com Password= 123456

	Re type password=fake password
Expected Result	Show error message.
Actual Result	 *Figure 0.107 error message add admin interface*
Conclusion	Working as expected

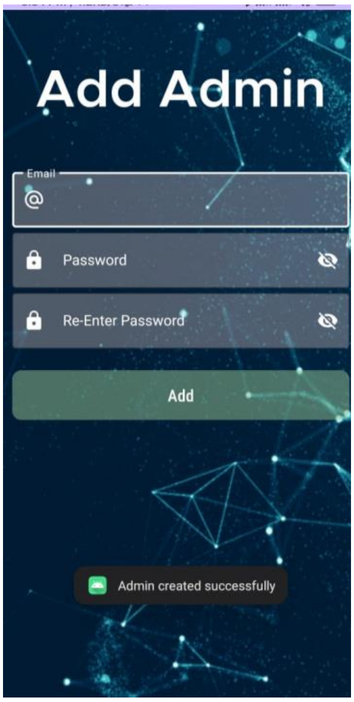
Test case	R03.1
Objective	Checking email field input random text.
Test data	Email= fake email
Expected Result	Show error message.

Actual Result	 *Figure 0.108 error message add admin interface*
Conclusion	Working as expected

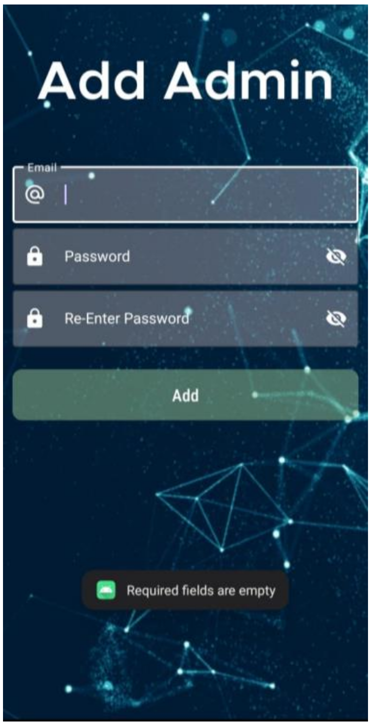
Test case	R03.2
Objective	Checking email field input random text.
Test data	Input already registered email
Expected Result	Show error message.

Actual Result	 *Figure 0.109 error message already registered interface*
Conclusion	Working as expected

Test case	R04.1
Objective	Checking add button field.
Test data	Email= User12@gmail.com Password=123456
Expected Result	Show Successfully message.

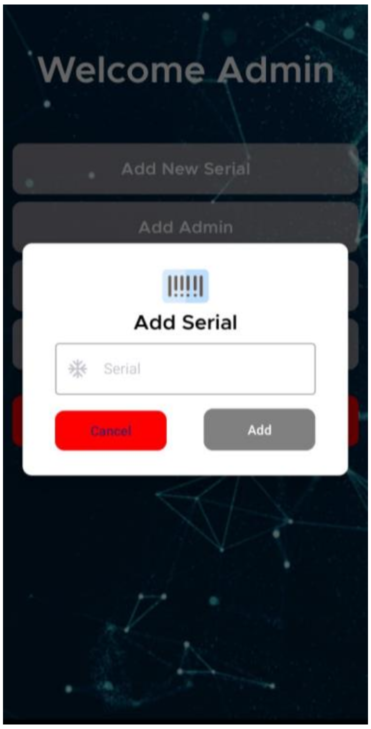
Actual Result	 *Figure 0.110 successful message admin panel*
Conclusion	Working as expected

Test case	R04.2
Objective	Checking add button field
Test data	Input Email= “” Password= “” Retype password= “”
Expected Result	Show error message.

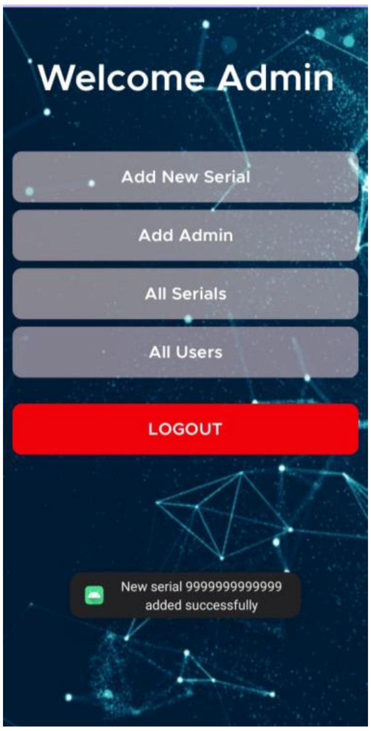
Actual Result	 *Figure 0.111 error message admin interface*
Conclusion	Working as expected

5.1.6.3. Test cases add new serial option.

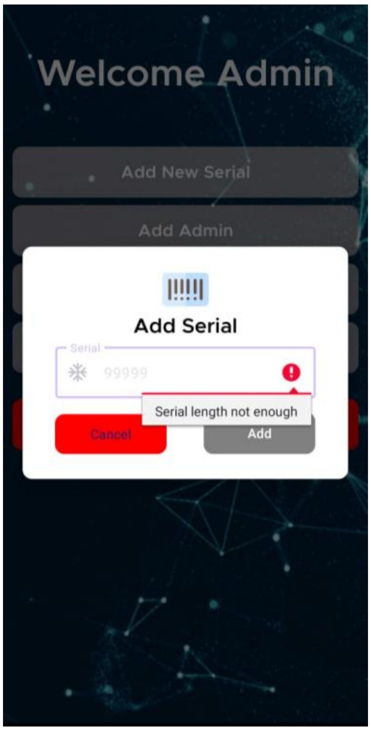
Table 0.26 test cases for add new serial option

Test case	R01.1
Objective	Checking add new serial button field
Test data	Click add new serial button
Expected Result	Show add serial interface
Actual Result	 *Figure 0.112 add serial interface*
Conclusion	Working as expected

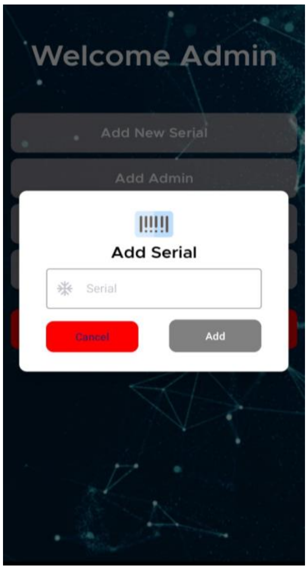
Test case	R02.1
Objective	Checking add button field
Test data	Input serial no=”999999999999999”
Expected Result	Show successful message

Actual Result	 *Figure 0.113 add serial successful interface*
Conclusion	Working as expected

Test case	R02.2
Objective	Checking add button field
Test data	Apply for entry number less than 10
Expected Result	Show message "Insufficient sequence length".

Actual Result	 *Figure 0.114 serial length error interface*
Conclusion	Working as expected

Test case	R03.1
Objective	Checking cancel button field
Test data	Click cancel button
Expected Result	Show admin panel again

<table>
<tr><td>Actual Result</td><td>


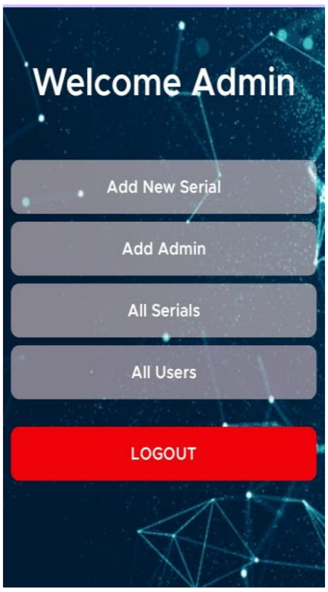


Figure 0.115 cancle button click result interface
</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

Test case	R04.1
Objective	Checking All serial button field
Test data	Click All serial button
Expected Result	Show all serial interface

Actual Result	 *Figure 0.116 All serial interface*
Conclusion	Working as expected

5.1.6.4. Test cases for the all user option

Table 0.27 test cases for all users' option

Test case	R01.1
Objective	Checking All User button field
Test data	Click All user button
Expected Result	Show all user interface

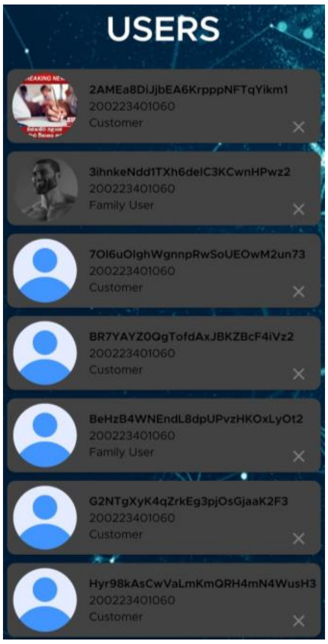
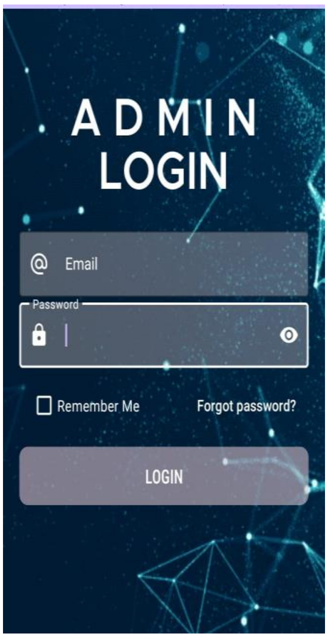
<table>
<tr><td>Actual Result</td><td>

Figure 0.117 all user interface</td></tr>
<tr><td>Conclusion</td><td>Working as expected</td></tr>
</table>

5.1.6.5. Test case for logout button

Test case	R01.1
Objective	Checking Log out button field
Test data	Click All log out button
Expected Result	Show logging interface

Actual Result	 *Figure 0.118 reloading login interface*
Conclusion	Working as expected

5.2 User manual

Product Name: SMART LIVING Arduino Home Automation System.

Model or type number: ESP8266

Intended use: This home automation system is designed to streamline and improve various household functions, including but not limited to lighting, climate control, automation systems, and security. It allows users to remotely monitor and control various aspects of their home environment, providing convenience, energy efficiency and security. With features such as scheduling, remote access and integration with smart devices, the system aims to simplify daily tasks and improve overall comfort and convenience in the home environment.

Features/accessories:

Features:

- **Remote Control:** Users can remotely control lights, thermostats and other connected devices from their smartphones or tablets.
- **Customizable settings:** Personalized settings allow users to create schedules for devices, set automatic routines, and adjust preferences according to their lifestyle.
- **Energy Management:** Monitor and manage energy consumption to optimize efficiency and reduce utility costs.
- **Security Integration:** Integration with security systems for door locks, alarms and controls.
- **Multi-platform compatibility**: compatibility with different platforms and operating systems, ensuring seamless integration with different devices and ecosystems.

Accessories:

- **Smart bulbs:** LED bulbs with built-in Wi-Fi or Bluetooth connectivity for remote dimming, color changing and scheduling.
- **Smart Plugs:** Plug-in modules that transform ordinary appliances into smart devices, enabling remote control and automation.
- **Smart Sensors:** Motion sensors, door/window sensors, and environmental sensors to monitor and automate actions based on detection conditions.
- **Smart doors:** Remote locking/unlocking capabilities and activation systems.
- **Smart Router:** Facilitate communication between different smart devices and unified control through a single interface.

Description of the main product elements:

Esp. 32 module

Figure 0.119 esp.32 module

ESP32 module is a compact and powerful microcontroller unit used in smart living home automation system. It serves as the central processing unit that facilitates communication and control between various smart devices in the home environment. Featuring built-in Wi-Fi and Bluetooth connectivity, the ESP32 module enables seamless integration with a wide range of smart devices, allowing users to control their home appliances, lighting, allowing remote monitoring and control of security systems and more. Its versatile design supports real-time data processing, making it ideal for applications that require fast response times and efficient handling of sensor inputs

Rain sensor Module

The rain sensor module is a critical Component of the smart living home automation System and is designed to detect the presence of Rain or moisture in the surrounding environment. This sensor uses various mechanisms such As conductivity or optical detection to determine The onset of precipitation. Once rain is detected, The sensor sends a signal to the automation system, Triggering predefined actions or adjustments to Improve comfort, safety and efficiency in the Home. In practice, the rain sensor module serves As a weather-sensitive input device, providing Real-time data on rainfall intensity or presence. Provides this information can be used in a Variety of ways within the home automation system. For example, motorized windows or skylights Can automatically close to prevent rainwater from Entering the home. Similarly, irrigation

Figure 0.120 rain sensor

Systems can be activated to conserve water
During rainy periods or outdoor lighting can be
Adjusted to improve visibility and safety.

Gas sensor module

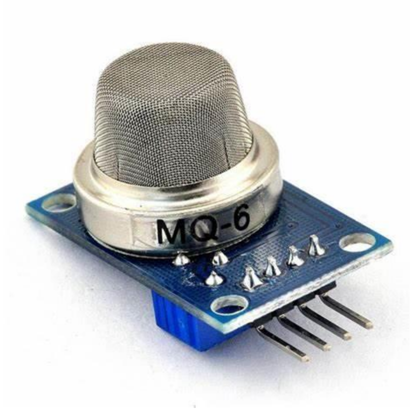


Figure 0.121 gas sensor

The gas sensor module is a crucial part of the smart living home automation system and it is designed and used to detect the presence of various gases in the environment inside the home. This module uses advanced sensor technology to monitor the concentration levels of specific gases such as carbon monoxide (CO), methane (CH4), propane (C3H8) and other combustible or toxic gases. This signal is processed by the circuit to determine the gas concentration level.

Servo motor

In the field of smart living home automation, Server Motor plays a key role in the automatic door system, ensuring seamless operation and enhanced convenience for users. This component acts as the driving force behind the automatic opening and closing of doors in the home environment. The servo motor is specially designed to provide precise and reliable movement, allowing for smooth and efficient operation of the automatic door system. Through integration with the home automation network, users gain the ability to remotely control the opening and closing of doors using their smartphones or other connected devices.

Really module / Jumper vi

Figure 0.122 server motor

Relay module:

Relay module is a critical component of smart living home automation system, especially for projects like

automatic door system. It acts as an electronically controlled switch to open or close circuits. In the context of the automatic door system, the relay module serves to activate the mechanism responsible for opening and closing the door. Through integration with the home automation system, users can remotely control the relay module to operate the door, providing convenience and improved accessibility.

Jumper Wire:

Jumper wires are essential for connecting Various components in the home automation System. They provide a means to make Electrical connections between modules, Sensors, actuators and other devices. In the Context of an automatic door system project, Jumper wires facilitate the integration of the Relay module with sensors such as motion Detectors or proximity sensors. This Integration allows the system to detect Movement or proximity and accordingly Activate the relay module to activate the door mechanism.

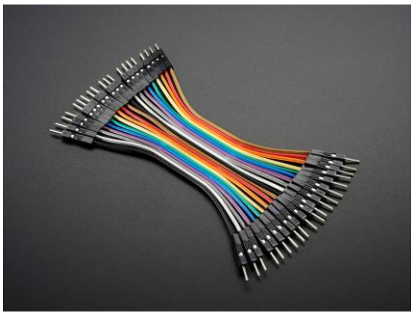


Figure 0.124 jumper wires

LED bulbs:

LED bulbs play a dual role in home automation projects, offering both light and smart functionality. In the automatic door system, LED bulbs can act as indicators or status lights, providing

visual feedback to users about the status of the door (e.g., whether it is locked or unlocked, opening or closing). Through integration with the home automation system, users can remotely monitor the status of the door based on the LED bulb's lighting pattern or color.

Project Board:

The project board serves as the central platform for assembling and organizing the various components of the home automation system, including relay modules, jumper wires, LED bulbs, and other peripherals. It provides a structured framework for connecting and configuring these components, simplifying the construction and deployment of the automatic door system project. In addition, features such as project board mounting points, power distribution circuits, and labeling can be included to ease installation, maintenance, and troubleshooting efforts for users.

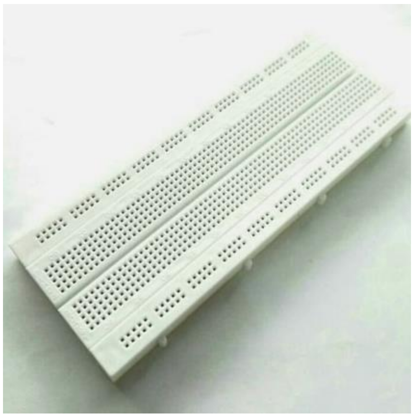
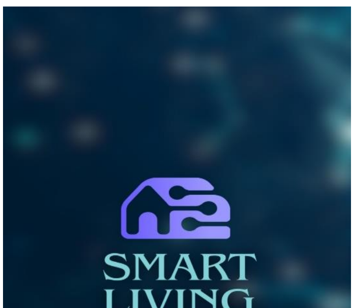


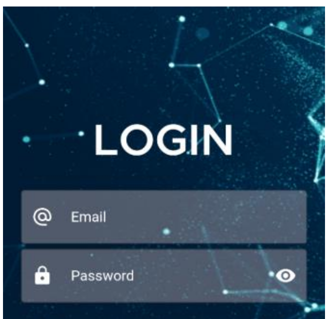
Figure 0.126 project Board

Description of the user interface:

Splash interface



Login interface



Registration interface

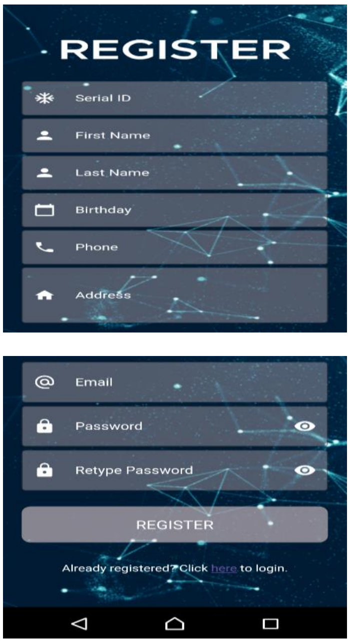


Figure 0.130 registration interface

Indoor interface

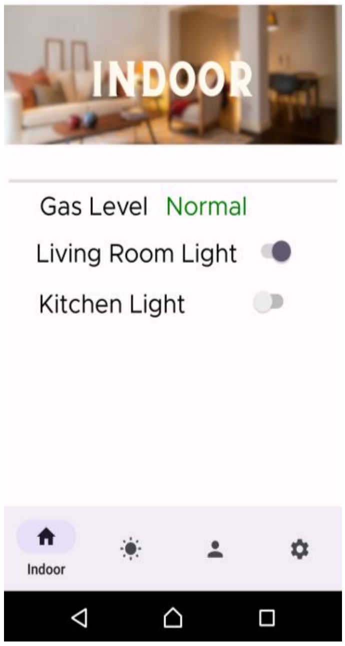
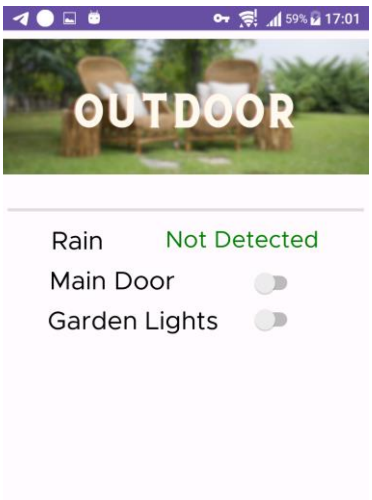
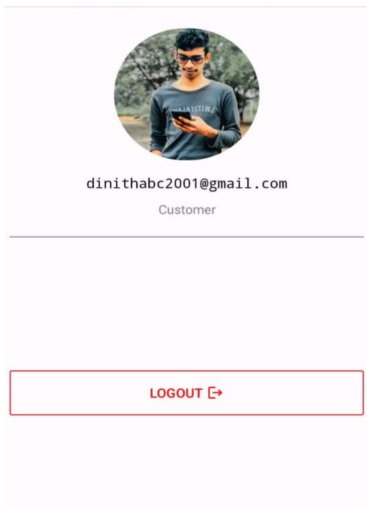


Figure 0.129indoor interface

Outdoor interface



profile interface



Setting interface

Add user interface

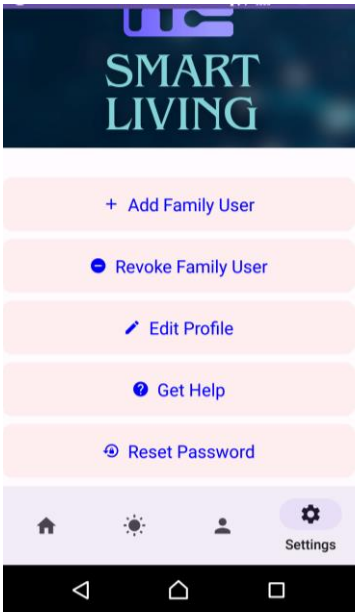


Figure 0.134 setting interface

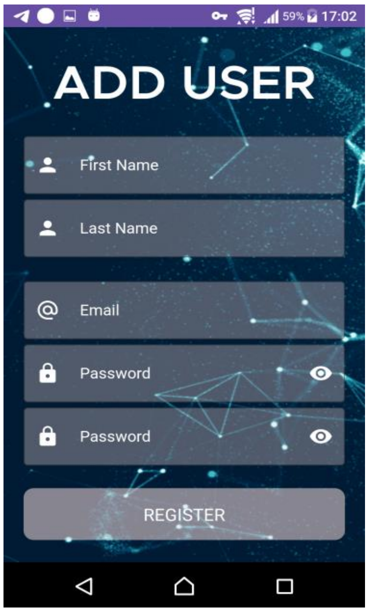
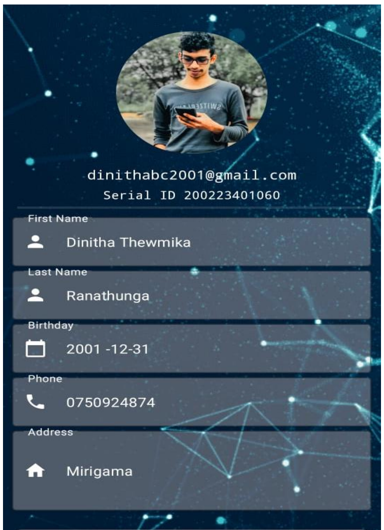
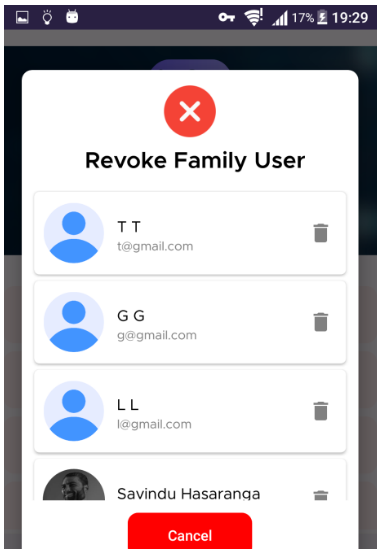


Figure 0.133 add user interface

Edit customer profile interface



revoke family user interface



Get help interface

Reset password interface

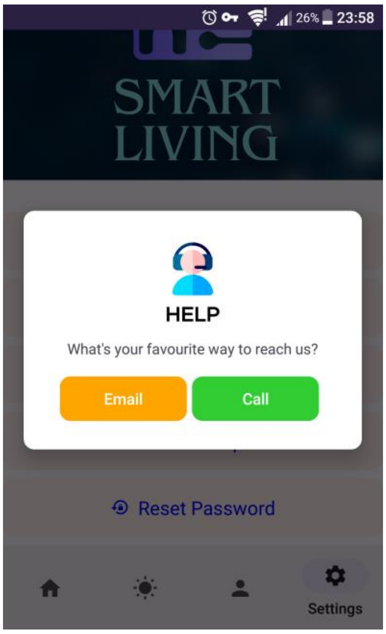


Figure 0.138 Get Hel interface

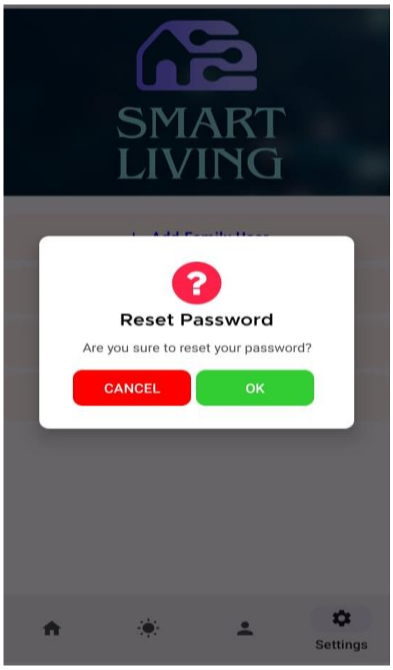


Figure 0.137 password reset interface

- **Electrical Hazards:**

Always turn off the power supply before installing, configuring, or servicing any part of the home automation system.

- Be careful when working with electrical connections and ensure proper insulation to avoid electric shock or fire hazards.

- Avoid overloading electrical circuits by adhering to the specified power ratings of devices and modules.

- **Fire Hazards:**

- Do not place any component of the home automation system near flammable materials or heat sources.

- Ensure proper ventilation and air flow around electronic components to prevent overheating and reduce fire risk.

- **Physical Hazards:**

- Securely mount components such as relay modules and project boards to prevent accidental removal or falling, especially in high-traffic areas.

- Keep cables, wires and cords away from walkways and areas where they may cause tripping hazards.

- **Security Risks:**

- Secure the home automation system against unauthorized access by implementing strong passwords, encryption and other security measures.

- Regularly update firmware and software to identify vulnerabilities and ensure system resilience against cyber threats

- **User Responsibility:**

-Users are responsible for understanding and adhering to all safety precautions and guidelines outlined in this manual.

- If unsure about any aspect of installation, configuration or operation, consult a qualified electrician or technician for assistance.

- **Children and pets:**

- Keep small components and batteries out of reach of children and pets to prevent ingestion or suffocation.

- Educate children about potential dangers associated with electrical devices and home automation systems.

- **Maintenance:**

- Regular inspection and maintenance of home automation system components to ensure proper operation and safety.

- Replace damaged or worn components promptly to avoid potential hazards or malfunctions.

Maintenance information

Regular inspections

- Schedule regular checkups for your home automation system. This can be weekly, monthly or quarterly depending on the complexity of your system.

- During inspections, check all system components including sensors, actuators, controllers and hubs.

Software updates

- Keep all software components of your home automation system up to date. This includes the firmware of the devices as well as the software running on the controllers and hubs.

- Check for updates from manufacturers or developers and apply them quickly.

Backup configuration

- Regularly back up your home automation system's configuration settings. This ensures that in case of system failure or data loss, you can quickly restore the system to its previous state.

- Store backups in a secure location, preferably offsite or in the cloud.

Network monitoring

- Keep an eye on your home network to make sure it's working optimally.

- Instantly troubleshoot any network issues to prevent interruptions in communication between devices.

Physical tests

- Periodically check the physical condition of your home automation system's components.

- Look for signs of wear, damage or environmental factors that may affect performance.

Security audits

- Conduct regular security audits of your home automation system to identify vulnerabilities.

- Implement security best practices such as using strong passwords, enabling two-factor authentication

Repair information

Troubleshooting Basics

Start by explaining the importance of troubleshooting and how it can help resolve issues quickly. Encourage users to perform basic troubleshooting steps before performing any repairs, such as checking power connections, rebooting devices, and ensuring proper network connectivity.

Common problems and solutions:

Provide a list of common problems users may encounter with their home automation system, along with step-by-step instructions for solving each problem.

Examples of common problems include:

- Device connectivity issues
- Sensor malfunction
- Unresponsive controllers or hubs
- Communication errors between devices

Diagnostic tools

Explain any diagnostic tools or features built into the home automation system that can help users diagnose and troubleshoot problems. Describe how to effectively use these tools to identify the root cause of problems.

Component-Specific Repair Instructions

For each component of the home automation system (E.g. sensors, actuators, controllers), provide specific repair instructions. Include detailed steps for diagnosing problems, disassembling components (if necessary), and repairing or replacing them. Warn users of potential risks or hazards associated with repairing certain components and provide safety precautions.

Contact information for support

Provide contact information for customer support or technical support, including phone numbers, email addresses, and online support portals. Encourage users to provide support if they run into problems they can't solve on their own.

Warranty Information

Remind users of warranty coverage for their home automation system and any limitations or exclusions that may apply to repairs. Explain the process for obtaining warranty service and the requirements for returning defective components.

User Responsibilities

Emphasize the importance of following manufacturer guidelines and instructions when attempting repairs. Advise users to avoid unauthorized modifications or repairs that may void the warranty or damage the system's safety and functionality.

Regular maintenance recommendations

Include recommendations for routine maintenance tasks that help prevent problems and extend the life of the home automation system. Examples include cleaning sensors, updating firmware, and replacing batteries.

Additional Resources

Provide links to additional resources such as online forums, knowledge bases, or instructional videos where users can find more information about troubleshooting and repairs.

Information on disposal of the product and packaging

Product Disposal

When it's time to dispose of your home automation system or any of its components, avoid simply throwing them in the trash. Check with local regulations regarding electronic waste disposal. Many areas have specific recycling programs or drop-off locations for electronic devices. Some manufacturers may offer take-back programs or recycling initiatives for their products. Contact the manufacturer

Packaging Disposal

The packaging materials used for your home automation system can often be recycled. Before removing the packaging, check for recycling symbols or signs. Cardboard boxes, paper inserts and plastic packaging can be recycled. Flatten cardboard boxes and separate materials for recycling according to local guidelines.

Hazardous materials

Some components of your home automation system may contain hazardous materials that require special handling. If you are unsure of the proper procedures, do not attempt to disassemble or dispose of these components yourself. Contact local authorities or environmental agencies for guidance on handling hazardous materials.

Manufacturer's recommendations

Refer to the user manual or contact the manufacturer for specific recommendations on product and packaging disposal. Manufacturers may provide detailed instructions or resources for environmentally responsible disposal of their products.

Environmental impact

Proper disposal of electronic devices and packaging helps reduce environmental impact by reducing waste and preventing harmful substances from entering landfills. By recycling or properly disposing of your home automation system and its packaging, you contribute to sustainability efforts and protects the environment for future generations.

Technical specifications

- **Model: ESP32 module.**

The ESP32 is a low-cost, low-power system-on-a-chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth capabilities. It was developed by Espressif Systems.

Processor:

The ESP32 module is equipped with a dual-core Xtensa 32-bit LX6 microprocessor that operates at up to 240 MHz frequency.

Memory:

ESP32 usually comes with different memory configurations:

RAM: 520 KB SRAM (internal memory for program execution and data storage).

ROM: 448 KB ROM (Internal memory for bootloader and firmware).

Flash memory: Depending on the module, external flash memory varies from 4 MB to 16 MB for storing program code and data.

Connection:

Wi-Fi: The ESP32 module supports 802.11 b/g/n Wi-Fi connectivity, allowing connection to wireless networks for communication and Internet access.

Bluetooth: It features Bluetooth v4.2 and Bluetooth Low Energy (BLE) capabilities, enabling communication with other BLE-enabled devices.

Power requirements:

Normally, the module works on a 3.3V DC supply voltage. Power consumption varies depending on factors such as clock frequency, active peripherals, Wi-Fi/Bluetooth usage, etc.

- **Model: Raindrop Sensor**

Processor: Not applicable (This sensor typically doesn't have a processor.)

Memory: Not applicable (These sensors usually don't have memory.)

Connectivity: Analog or digital output (depends on the specific model)

Power Requirements: Typically operates on a voltage range of 3.3V to 5V DC.

- **Model: MQ6 Gas Sensor**

Processor: The MQ6 gas sensor does not have a processor of its own. It is an analog gas sensor and does not require a processor for its operation.

Memory: Similarly, the MQ6 gas sensor does not have onboard memory.

Connectivity: The MQ6 gas sensor typically interfaces with microcontrollers or development boards such as Arduino, Raspberry Pi, or other embedded systems using analog or digital pins.

Power Requirements: The MQ6 gas sensor typically operates at 5 volts DC and consumes very little power, making it suitable for battery-powered applications. It usually requires a stable power supply within the range of 4.5V to 5.5V.

- ## Model :Relay Module

Processor: Relay modules typically do not have a dedicated processor. They act as switches controlled by external devices such as microcontrollers or home automation hubs.

Memory: Relay modules also generally do not have onboard memory as they are simple electromechanical devices.

Connectivity: Relay modules are often connected to other devices or systems via digital input/output pins. They can be controlled by microcontrollers, home automation hubs, or directly through manual switches.

Power Requirements: The power requirements for a relay module depend on its specifications and operating conditions. They typically operate at low voltages (e.g., 3.3V or 5V) for control signals and higher voltages (e.g., 120V or 240V AC) for switching loads. The power requirements should be in accordance with the relay module's data sheet and specifications provided by the manufacturer.

Model: Micro Digital Server Motor

Processor:

The specific processor model would depend on the manufacturer and the design of the motor. Generally, microcontrollers or specialized motor control chips are used as processors in such devices. Without specific information, it's challenging to provide exact details.

Memory:

Similarly, the memory specifications would depend on the design and features of the motor. Microcontrollers typically have built-in memory for program storage and data manipulation. Again, without specific details, it's hard to provide exact numbers.

Connectivity:

The connectivity options would depend on the application and requirements of the motor. Some common connectivity options for digital server motors include: Wired connectivity: USB, RS-232, RS-485, And Ethernet Wireless connectivity: Wi-Fi, Bluetooth, and ZigBee Connectivity options enable the motor to communicate with other devices or systems, such as controllers, computers, or other smart devices.

Power Requirements:

The power requirements specify the electrical input needed for the motor to function properly. This typically includes voltage, current, and sometimes power consumption. Example: Input Voltage: 12V DC, Current: 1AIt's crucial to adhere to the specified power requirements to prevent damage to the motor and ensure reliable operation.

Model: LED Bulbs:

Processor: LED bulbs typically do not have a traditional processor like a computer or smartphone. However, some smart LED bulbs may have a microcontroller or a small processing unit embedded within them to handle communication protocols and smart features.

Memory: LED bulbs generally do not have significant onboard memory. Any memory requirements are typically minimal and are used for storing settings or firmware updates temporarily.

Connectivity:

Wireless: Smart LED bulbs often connect wirelessly to a home automation system using protocols like ZigBee, Z-Wave, Bluetooth, or Wi-Fi.

Wired: In some cases, LED bulbs may connect directly to a hub or controller via a wired connection, although this is less common.

Power Requirements: LED bulbs are known for their energy efficiency. They typically require much less power compared to traditional incandescent bulbs. Specific power requirements may vary depending on the wattage and features of the LED bulb. Typical power requirements range from 5 watts to 15 watts per bulb.

Software requirement

Software requirements for mobile phones:

Format: Any smartphone or mobile device capable of running the required operating system and compatible applications to control the home automation system.

Operating system: Android, up to Android 6 (Marshmallow).

The mobile phone must be running Android version 6.0 Marshmallow or earlier to ensure compatibility with the home automation app.

Compatibility:

Ensure that the mobile phone meets the minimum system requirements specified by the home automation application.

Verify compatibility with any specific features or functionality offered by the home automation system.

Application:

Install the compatible home automation app from the Google Play Store.

The app should be designed to work seamlessly with Android versions up to 6.0 Marshmallow.

Permissions:

Grant the necessary permissions to the home automation app, such as access to location services, Wi-Fi network, and Bluetooth (if applicable).

Follow the prompts during the installation process to ensure proper configuration and access permissions.

Update:

Keep mobile operating system and home automation app up to date.

To ensure optimal performance and security, regularly check for updates on the Google Play Store and install any available updates.

Storage space:

Make sure the mobile phone has enough storage space to download and install the home automation app. (less than 50 MB)

Clear unnecessary files or applications if needed to free up space for installing and running the application.

Network connection:

Connect the mobile phone to a Wi-Fi network or mobile data network to communicate with the home automation system.

Ensure network connectivity is stable and reliable to ensure uninterrupted control and monitoring of the system.

Warranty information

1. **Warranty Coverage**:

Smart Living warrants the home automation system product to be free from defects in materials and workmanship under normal use for a period of one year from the date of purchase.

2. **Cover Details:**

- During the warranty period, Smart Living will, at its option, repair or replace any defective parts or components of the product, free of charge.
- This warranty extends only to the original purchaser of the product and is not transferable.

3. **Exclusions:**

- This warranty does not cover damage or defects caused by:
- Improper installation, misuse, abuse, neglect or accident.
- Modification or modification of the Product without Smart Living's permission.
- Acts of nature including but not limited to lightning, lightning, flood, or fire.
- Use of the Product with accessories, components, or software not provided or recommended by Smart Living.

4. **Limitations:**

- To the extent permitted by law. The remedies provide under this warranty are buyer's sole and exclusive remedies.
- Smart Living shall not be liable for any incidental, consequential, or indirect damages arising out of the use or inability to use the Product, including but not limited to loss of data, loss of revenue, or loss of profits.

5. **Liability Claims:**

- To make a warranty claim, the buyer must contact Smart Living within the warranty period and provide proof of purchase.
- Smart Living may require returning the defective product or parts for inspection or replacement.
- Buyer bears all shipping costs associated with returning the product or parts for warranty service.

6. **Disclaimer of additional liability:**

- Except for the express warranty provide herein, smart living.
- Disclaims all other warranties, whether express, implied or statutory, including but not limited to the implied warranties of merchantability and fitness for a particular purpose.

Contact details

- **Company Name:** Smart Living
- **Address:** No 6/A Maribiso Road, Gampaha
- **Phone:** 0110000022
- **Email:** SmartLiving@gmail.com
- **Website:** www.smartliving .lk

Chapter06

6.1 Limitation for the project

• Cost: The home automation system was significantly affected by the cost factor. The high cost and installation of the devices hindered widespread use. Cost was a barrier to entry for home automation, and advances and market dynamics made it inaccessible to average manufacturers.

• Limited time frame: The time frame affected the planning, implementation, and completion of a home automation project. Grants and deadlines pressured the team to rush through certain phases of the project, leading to compromises in quality or performance. Additionally, unexpected delays or setbacks further limited availability, making it challenging to meet project milestones or deliverables. Without sufficient time for thorough testing and troubleshooting, the risk of errors or system failures increased, ultimately leading to project failure.

• Lack of Team Collaboration: Collaboration and teamwork were essential to the success of any project, including home automation initiatives. Lack of cooperation among team members led to communication breakdowns, misunderstandings, and conflicts, hindering progress and productivity. Without the buy-in and support of all team members, securing the necessary approvals, funding, or resources became challenging.

• Technical complexity: Home automation projects often involved the integration of different technologies, devices, and systems, each with its own technical requirements and complexities. Designing and implementing an integrated and interoperable system was daunting, especially for teams with limited experience or expertise in home automation technologies. Technical challenges such as compatibility issues, software bugs, and configuration errors arose and required specialized knowledge and troubleshooting skills to resolve. Without access to adequate technical resources or support, team members struggled to overcome these obstacles, causing project timelines to be delayed and costs to increase.

• Resource constraints: Limited resources, including budget, manpower, and materials, limited the scope and scale of a home automation project. Without adequate resources, it was challenging to obtain the necessary equipment or allocate sufficient time and effort to project tasks. Resource constraints led to compromises in project quality, performance, or timelines that affected the overall success and viability of the project.

6.2. Lesson learned

Validated core functionalities

The validation of core functionalities focused on understanding the effectiveness of home automation systems and their strengths and weaknesses in an unmanned smart home environment.

Identified User Needs

User needs were identified to understand the desires and expectations of homeowners adopting home automation systems, with a focus on convenience, energy efficiency, and enhanced security.

Balanced benefits vs. costs

The financial implications of adopting home automation systems were identified, considering the initial investment required and potential benefits through reduced costs and improved quality of life.

Reflected on technology dependence

Risks associated with relying on technology to manage home automation systems, such as risks from power outages or cybersecurity threats, were considered.

Addressed privacy concerns

Investigation was conducted into ways to protect personal data collected by home automation systems and ensure secure connections between devices.

Simplified complexity

Emphasis was placed on designing easy-to-use interfaces and simple configurations for home automation systems to minimize the learning curve.

Explored social impacts

The potential impact of home automation systems on family dynamics, lifestyle choices, and social trends was analyzed.

Studied collaborative development

The processes by which specific application ideas emerged and evolved in the development of home automation systems were studied, highlighting the role of various stakeholders.

Anticipated long-term adoption patterns

Changes in consumer behavior and preferences over time were anticipated, recognizing that new technologies take years to establish themselves and generate new practices or perceptions.

Encouraged continuous improvement

Continuous innovation and adaptation within the home automation sector were encouraged, emphasizing the need for regular updates and improvements to meet changing demands and emerging challenges.

6.3. Future Recommendation.

Voice control and AI integration:

- Implementing voice control capabilities allows users to interact with their home automation systems using natural language commands, improving convenience and accessibility.
- By integrating AI algorithms, the system can learn user preferences, anticipate their needs, and intelligently automate routine tasks. For example, AI can adjust temperature settings or suggest energy-saving measures based on user behavior patterns.

Complex system design

- As home automation technology matures, there is an increasing demand for more complex and comprehensive systems that offer seamless integration of various devices and functions.

- Researchers and developers should focus on building modular and scalable architectures that can accommodate a wide range of devices, protocols and standards, enabling interoperability and future expansion.
- Advanced features such as predictive analytics, context-aware automation, and automated decision-making capabilities can further enhance the intelligence and efficiency of home automation systems.

Improved user interfaces:

- User interfaces play a critical role in the adoption and use of home automation systems. Future systems should prioritize easy to navigate and understand and aesthetically pleasing interfaces.
- Investing in user experience (UX) research and design helps identify user needs, preferences and pain points, leading to the development of more intuitive and user-friendly interfaces.
- Using responsive design principles and multi-modal interfaces (e.g. touchscreen, voice commands, and gesture control) can accommodate different user preferences and accessibility needs.

Improved mobile apps

- Mobile apps serve as the primary interface for controlling and monitoring home automation systems remotely. Future applications should offer advanced features and customization options to meet the diverse needs of users.
- Developers should focus on improving application performance, reliability and responsiveness, seamless connectivity and real-time updates.
- Incorporating innovative features such as augmented reality (AR) for virtual home tours, personalized dashboards and actionable insights can enrich the user experience and differentiate the app from competitors.

Emphasis on user experience (UX):

- User experience should be at the forefront of home automation system design and development. Future systems must prioritize simplicity, reliability and personalization to create delightful user experiences.
- Conducting usability testing, gathering user feedback, and iterating on design improvements are essential to refining and optimizing the user experience.

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Appendix

Plan Gantt chart

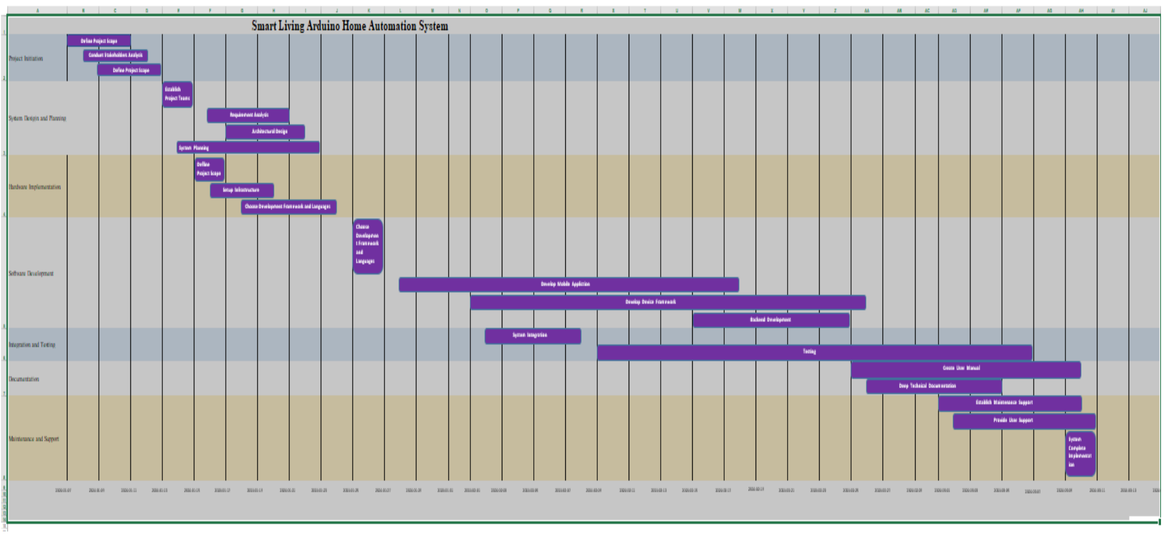


Figure 0.1 planned Gantt chart

Actual Gantt

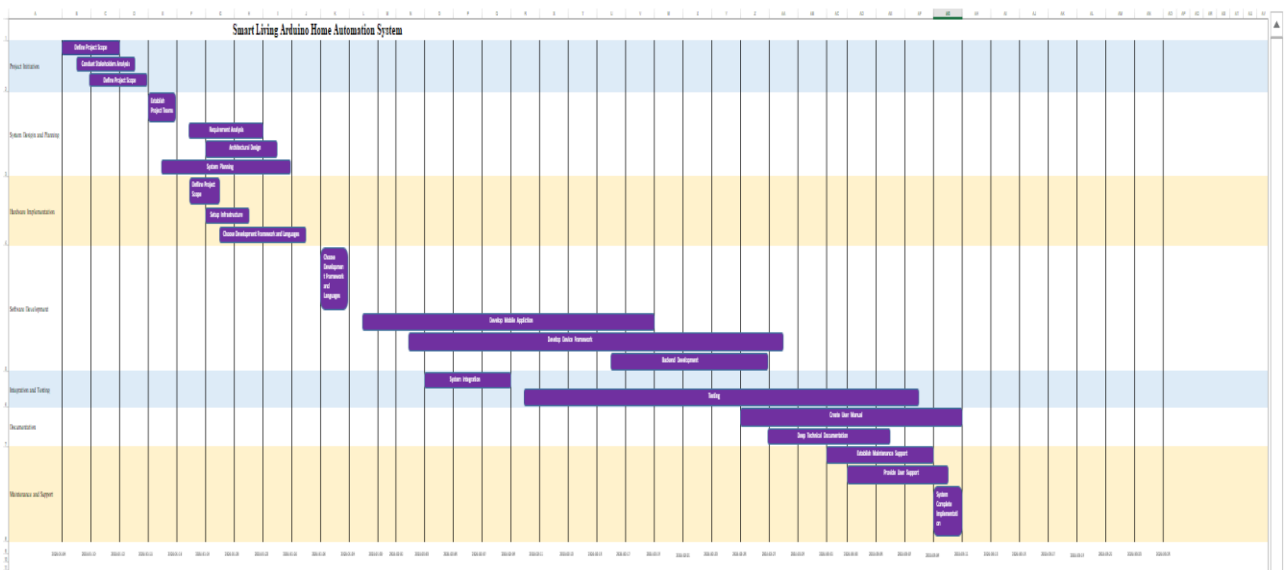


Figure 0.2 Actual Gantt chart

Requirement gathering evidences.

Objective 1: To identify the problems with IoT based home automation systems.

Questions.01

What common challenges do you experience with existing IoT-based home automation systems?

a) Connection problems between devices

b) Limited compatibility with various devices

c) Security and privacy issues

d) Unreliable performance and frequent interruptions

e) Other …………………………..

Questions.02

Can you describe a specific instance where an IoT home automation system failed to meet your expectations or caused an inconvenience?

a) Connection failure leading to loss of control

b) Devices that do not respond to commands

c) Breach of security or unauthorized access

d) Disruption of the system causes disturbances

e) Other ……………………………

Questions.03

How would you generally rate the reliability of IoT home automation systems?

a) Very reliable

b) Fairly reliable

c) Moderate

d) Somewhat unreliable

e) Very unreliable

Questions.04

What security concerns do you have with IoT home automation systems?

a) Unauthorized Access to Personal Data

b) Hacking or cyber threats

c) Lack of encryption for communication

d) Insecure device connections

e) Other ……………………

Questions.05

How do you think IoT home automation systems can be improved to better meet your needs?

a) Improved device compatibility

b) Enhanced security features

c) Better reliability and performance

d) More user-friendly interfaces and controls

e) Other …………………….

Objective 2: To analyze the needs of the customers of using home automation systems.

Questions.01

1. What made you consider using a home automation system?

a. Cost savings

b. Convenience

c. Security

d. Energy efficiency

e. Other ……………..

Questions.02

2. What specific tasks or activities do you think would be easier with a home automation system?

a. Lighting control

b. Managing the temperature controller

c. Security monitoring

d. Entertainment systems

e. Other …………….

Questions.03

3. How important is energy efficiency to you when considering a home automation system?

a. very important

b. important

c. neutral

d. not very important

e. Not important at all

Questions.04

4. What are your expectations regarding the convenience of a home automation system?

a. Extremely Convenient

b. Very Convenient

c. Moderately Convenient

d. Slightly Convenient

e. Not Convenient at All.

Questions.05

5. Can you describe a time when a home automation system would significantly benefit your daily life?

a. Improved Security

b. Enhanced Comfort

c. Time Savings

d. Energy Efficiency

e. Other ……………….

Objective 3: To implement a cost-effective mobile app with a user-friendly UI to control and monitor the home.

Question 1

What features do you consider essential in a mobile app for controlling and monitoring your home?

a. Security features:

A. Face recognition

B. Two-factor authentication

C. Intrusion Warnings

D. Secure remote access

b. Automation Capabilities:

A. Customizable schedules

B. Geofencing (location-based triggers)

C. Voice control

D. Integration with Third Party Devices

c. Energy Efficiency:

A. Smart thermostat control

B. Energy consumption monitoring

C. Smart lighting control

D. Instrument Energy Tracking

d. User Alerts and Notifications:

A. Real-time activity alerts

B. Push Notifications for Events

C. Emergency Notices

D. Customizable notification settings

Question 2

How important is the ease of use of a home control app's user interface to you?

a. extremely important
b. very important
c. moderately important
d. slightly important
e. Not important at all

Question 3

What are your preferences regarding the design and layout of a home control app?

a. Sleek and modern
b. Simple and intuitive
c. Colorful and vibrant
d. Clean and minimal

Question 4

Are there any particular challenges you anticipate when using a mobile app to control and monitor your home?

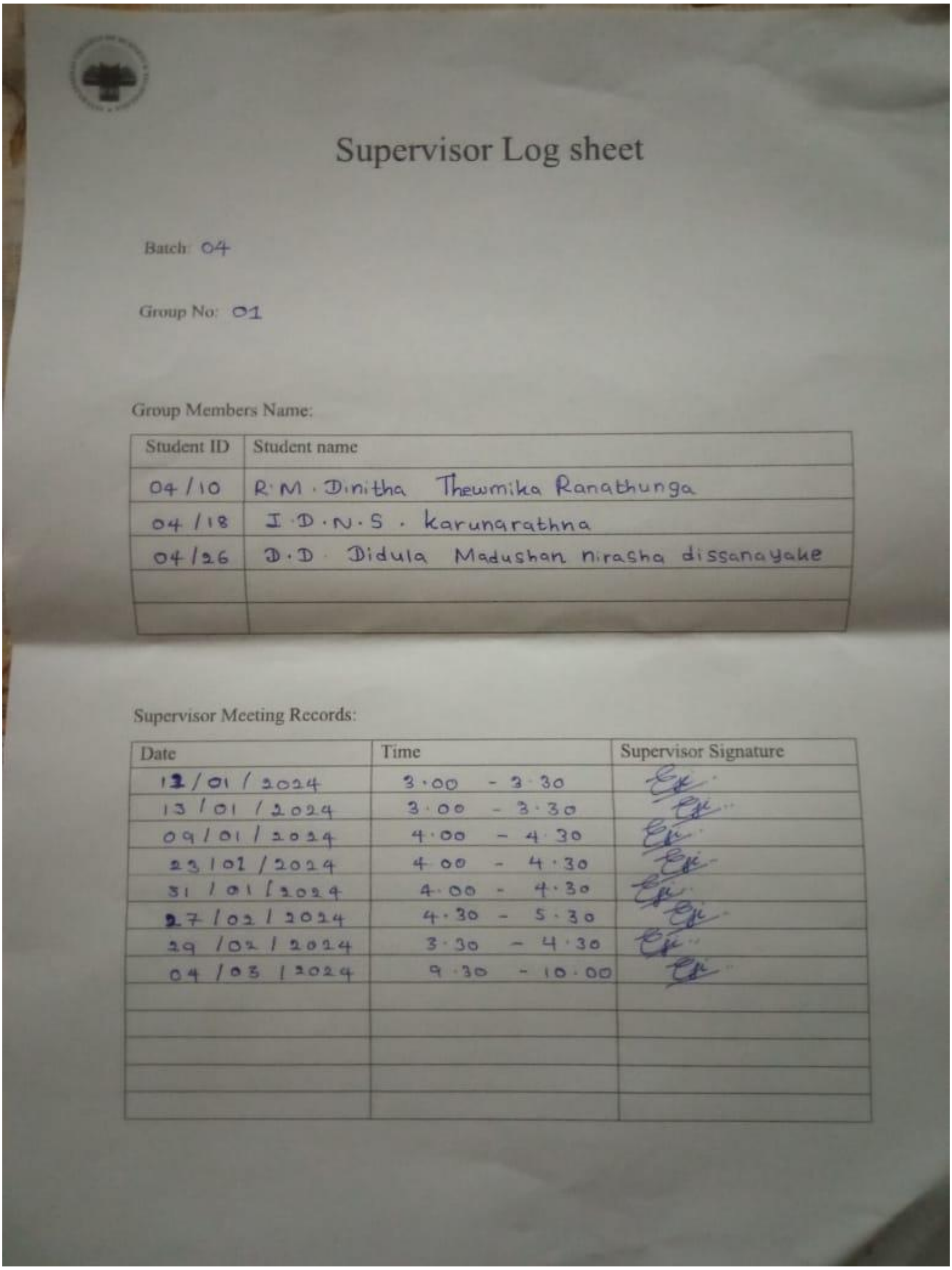
a. Connection problems
b. Difficulty navigating apps
c. Concerns about security and privacy
d. Compatibility issues with devices

Question 5

What do you consider a fair price for a mobile app that effectively controls and monitors your home?

a. free
b. $1 - $5
c. $6 - $10
d. $11 - $20
e. $21 or more

Supervisor Log sheet



Supervisor Log sheet

Batch: 04

Group No: 01

Group Members Name:

Student ID	Student name
04/10	R.M. Dinitha Thewmika Ranathunga
04/18	I.D.N.S. karunarathna
04/26	D.D Didula Madushan nirasha dissanayake

Supervisor Meeting Records:

Date	Time	Supervisor Signature
12/01/2024	3.00 - 3.30	
13/01/2024	3.00 - 3.30	
09/01/2024	4.00 - 4.30	
23/01/2024	4.00 - 4.30	
31/01/2024	4.00 - 4.30	
27/02/2024	4.30 - 5.30	
29/02/2024	3.30 - 4.30	
04/03/2024	9.30 - 10.00	