REPUBLIC OF TURKEY
ISTANBUL GELISIM UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

Department of Electrical Electronics Engineering

IOT CIRCUIT BOARD AND APPLICATION FOR SMART HOME SYSTEMS

Master Thesis

ALI AHMED MOHAMMED AMEEN

Supervisor
Asst. Prof. Dr. Yusuf Gürcan ŞAHIN

Istanbul – 2023

THESIS INTRODUCTION FORM

Name and Surname	**:**	ALI AHMED MOHAMMED AMEEN
Language of the Thesis	**:**	English
Name of the Thesis	**:**	IOT CIRCUIT BOARD AND APPLICATION FOR SMART HOME SYSTEMS
Institute	**:**	Istanbul Gelisim University Institute of Graduate Studies
Department	**:**	Electrical Electronics Engineering
Thesis Type	**:**	Master
Date of the Thesis	**:**	18.10.2023
Page Number	**:**	75
Thesis Supervisors	**:**	Asst. Prof. Dr. Yusuf Gürcan ŞAHIN
Index Terms	**:**	Smart Home, Coding, Circuit Design.

Turkish Abstract **:**

Ev otomasyonu şeklinde tanımlanan donanımlar, iletişim ve elektrik arayüzleri ağı, sıradan cihazları kablolu bağlantılar veya İnternet kullanan kablosuz cihazlar aracılığıyla birbirine bağlamaktadır. Bu otomosyon sayesinde ister evde ister binlerce kilometre uzakta olun, akıllı telefonunuzdan veya tabletinizden herhangi bir aygıtı sensörler ve internet bağlantısı ile kontrol edebilirsiniz. Bu çalışmada önerilen model ile kablolu ve kablosuz sistem üzerinden ev aletleri kontrolünün uygulanmasına yönelik uygulamalar odaklanılacaktır. Proje tasarlamanın ardındaki ana fikir, kullanıcı esnekliği, enerji verimliliği, erişim kolaylığı ve konfor sağlamaktır. Akıllı yaşam alanları olarak tanımlanan akıllı ev konceptinde herhangi bir odadaki ışığı, vantilatörü veya diğer herhangi bir elektrikli öğeyi kontrol etmek üzere Arduino ve Bluetooth modülü kullanmakla söz konusu kontroller kolaylıkla yapılabilmektedir. Bu tezde, kullanımı her geçen gün artan akıllı ev sistemlerinin akıllı uygulamaları için devre kartı tasarımı planlanmıştır. Tasarlanan devre kartında kullanılan işlemci programlanarak su (on-off), elektrik (on-off), gaz (on-off) gibi röleler ile çeşitli kontroller sağlandı. Işık, sıcaklık, fan, motorlar, invertörler vb. gibi sensörler kullanılarak ortam verileri elde edildi ve bu veriler kullanılarak tasarlanan devrede bluetooth veya GSM modülü ile haberleşme gibi kontrol birimlerinin gerçekleştirilmesi sağlandı. Tasarlanan devre kartının simülasyonu için Proteus programının kullanıldı. Tasarlanan devre kartının simülasyon testleri öncelikle Proteus programı ile yapıldı ve optimum sonuçlar elde edildikten sonra Ares programı kullanılarak fiziksel baskı devre kartı oluşturuldu. Ares çiziminde oluşturulan baskılı devre kartının üç boyutlu görüntüleri oluşturularak devre kartının daha iyi anlaşılmasını sağlandı. Giriş çıkış sayısına göre belirlenen işlemci için C++ dilinde yazılan kod ile devre simülasyon üzerinde çalıştırıldı. Kullanıcı kablolu modülünden veya telefondan cihaza (ON/OFF) komutu verildiğinde cihazın gerçek durumunu göstermek için A16x2 LCD modül tabanlı bir sistem devresi oluşturulmuş ve devreye alınmıştır.

Distribution List : 1. To the Institute of Graduate Studies of Istanbul Gelisim University

2. To the National Thesis Center of YÖK (Higher Education Council)

Signature

ALI AHMED MOHAMMED AMEEN

REPUBLIC OF TURKEY
ISTANBUL GELISIM UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

Department of Electrical Electronics Engineering

IOT CIRCUIT BOARD AND APPLICATION FOR SMART HOME SYSTEMS

Master Thesis

ALI AHMED MOHAMMED AMEEN

Supervisor
Asst. Prof. Dr. Yusuf Gürcan ŞAHIN

Istanbul – 2023

DECLARATION

I hereby declare that in the preparation of this thesis, scientific ethical rules have been followed, the works of other persons have been referenced in accordance with the scientific norms if used, there is no falsification in the used data, any part of the thesis has not been submitted to this university or any other university as another thesis.

ALI AHMED MOHAMMED AMEEN

…/…/2023

TO ISTANBUL GELISIM UNIVERSITY
THE DIRECTORATE OF GRADUATE EDUCATION INSTITUTE

The thesis study of Ali Ahmed MOHAMMED AMEEN titled as IoT Circuit Board and Application For Smart Home Systems has been accepted as MASTER in the department of Electrical-Electronic Engineering by out jury.

Director ______________________________

Asst. Prof. Dr. Yusuf Gurcan SAHIN

(Supervisor)

Member ______________________________

Asst. Prof. Dr. Sevcan KAHRAMAN

Member ______________________________

Asst. Prof. Dr. Kenan BUYUKATAK

APPROVAL

I approve that the signatures above signatures belong to the aforementioned faculty members.

... / ... / 20..

Prof. Dr. Izzet GUMUS

Director of the Institute

SUMMARY

A network of hardware, communication and electrical interfaces, defined as home automation, connects ordinary devices through wired connections or wireless devices using the Internet. Thanks to this automation, whether you are at home or thousands of kilometers away, you can control any device from your smartphone or tablet with sensors and internet connection. In this study, the application will be focused on the application of home appliance control over the wired and wireless system with the proposed model. The main idea behind the project design is to provide user flexibility, energy efficiency, ease of access and comfort. In the concept of smart home, which is defined as smart living spaces, these controls can be easily done by using Arduino and WiFi module to control the light, fan or any other electrical item in any room. In this thesis, circuit board design is planned for smart applications of smart home systems, the usage of which is increasing day by day. By programming the processor used in the designed circuit board, various controls were provided with relays such as water (on-off), electricity (on-off), gas (on-off). Light, temperature, fan, motors, inverters etc.

Environment data were obtained by using sensors depending on modern techniques such as Wifi, and in the circuit designed using these data, control units for those techniques or communication with GSM module were provided. Proteus program was used to simulate the designed circuit board.

Simulation tests of the designed circuit board were first performed with the Proteus program and after optimum results were obtained, the physical printed circuit board was created using the Ares program. Three-dimensional images of the printed circuit board created in the Ares drawing were created to provide a better understanding of the circuit board. The circuit was run on the simulation with the code written in C++ for the processor determined by the number of inputs and outputs. Arduino IoT Cloud Remote App has been created and commissioned to show the actual status of the device when the (ON/OFF) command is given to the device from the user wired module or telephone.

Keywords: Smart Home, Coding, Circuit Design.

ÖZET

Ev otomasyonu şeklinde tanımlanan donanımlar, iletişim ve elektrik arayüzleri ağı, sıradan cihazları kablolu bağlantılar veya İnternet kullanan kablosuz cihazlar aracılığıyla birbirine bağlamaktadır. Bu otomosyon sayesinde ister evde ister binlerce kilometre uzakta olun, akıllı telefonunuzdan veya tabletinizden herhangi bir aygıtı sensörler ve internet bağlantısı ile kontrol edebilirsiniz. Bu çalışmada önerilen model ile kablolu ve kablosuz sistem üzerinden ev aletleri kontrolünün uygulanmasına yönelik uygulamalar odaklanılacaktır. Proje tasarlamanın ardındaki ana fikir, kullanıcı esnekliği, enerji verimliliği, erişim kolaylığı ve konfor sağlamaktır. Akıllı yaşam alanları olarak tanımlanan akıllı ev konceptinde herhangi bir odadaki ışığı, vantilatörü veya diğer herhangi bir elektrikli öğeyi kontrol etmek üzere Arduino ve Wifi modülü kullanmakla söz konusu kontroller kolaylıkla yapılabilmektedir. Bu tezde, kullanımı her geçen gün artan akıllı ev sistemlerinin akıllı uygulamaları için devre kartı tasarımı planlanmıştır. Tasarlanan devre kartında kullanılan işlemci programlanarak su (on-off), elektrik (on-off), gaz (on-off) gibi röleler ile çeşitli kontroller sağlandı. Işık, sıcaklık, fan, motorlar, invertörler vb.

Wifi gibi modern tekniklere bağlı olarak sensörler kullanılarak ortam verileri elde edilmiş ve bu veriler kullanılarak tasarlanan devrede bu teknikler için kontrol üniteleri veya GSM modülü ile haberleşme sağlanmıştır.

Tasarlanan devre kartının simülasyonu için Proteus programı kullanılmıştır. Tasarlanan devre kartının simülasyonu için Proteus programının kullanıldı. Tasarlanan devre kartının simülasyon testleri öncelikle Proteus programı ile yapıldı ve optimum sonuçlar elde edildikten sonra Ares programı kullanılarak fiziksel baskı devre kartı oluşturuldu. Ares çiziminde oluşturulan baskılı devre kartının üç boyutlu görüntüleri oluşturularak devre kartının daha iyi anlaşılmasını sağlandı. Giriş çıkış sayısına göre belirlenen işlemci için C++ dilinde yazılan kod ile devre simülasyon üzerinde çalıştırıldı. Kullanıcı kablolu modülünden veya telefondan cihaza (ON/OFF) komutu verildiğinde cihazın gerçek durumunu göstermek için Arduino IoT Cloud Remote App oluşturulmuş ve devreye alınmıştır.

Anahtar kelimeler: Akıllı Ev, Kodlama, Devre Tasarımı

TABLE OF CONTENTS

ABBREDIVATIONS

IOT	**:**	Internet of Things
OS	**:**	Operating System
WIFI	**:**	Wireless Fidelity
LCD	**:**	Liquid Crystal Display
GSM	**:**	Global System for Mobiles
WLAN	**:**	Wireless local area network
LU	:	Lamp Unit
CC	:	Control Center
LoRa	**:**	Longe Range Communication Network
HTML	**:**	HyperText Markup Language
WSN	**:**	Wireless Sensor Networks
RTC	:	Real Time Click
SLS	:	Smart lighting systems
LCU	:	Load Control Units
CC	**:**	Control Center
PLC	**:**	Power Line Communications
RFID	**:**	Radio Frequency Identification
RSSI	:	Received Signal Strength Indicator
CSI	:	Channel State Information
BDD	**:**	Binary Decision Diagram
CSVD	:	Class Estimated Basis Space Singular Value Decomposition
NMF	:	Nonnegative Matrix Factorization

LIST OF FIGURES

PREFACE

Throughout the process of preparing and writing this thesis, I express my gratitude to Asst. Prof. Dr. Yusuf Gürcan ŞAHIN for the support rendered and to the members of the Thesis jury for their valuable comments and suggestions that assisted in managing and advancing the thesis. Last but not least, my sincere appreciation goes to my family for their support.

INTRODUCTION

Circuit boards play a vital role in connecting and controlling devices and systems within smart homes (Serda, 2013). In the past few years, the usage of circuit boards in smart homes has gone up a lot and now plays a crucial part in offering better features and saving energy. Circuit boards are applied to operate and monitor an array of devices like lighting systems, heating and cooling apparatus, and appliances in a smart home system. Moreover, they play an important part in communication between various smart home devices, promoting seamless and efficient operation of the entire system. As smart homes gain more popularity, there is a correlated surge in the need for circuit board analysis and simulation for smart home systems. The assessment and modeling of circuit boards are critical in the creation of intelligent home systems, ensuring the efficacy and dependability of these components before their integration. This process incorporates software and computer-based methods, simulating the actions and capabilities of circuit boards and their constituent parts, detecting and resolving defects before they become problematic in the functioning system. Circuit board analysis and simulation should assess critical factors such as power consumption, thermal management, reliability, and electromagnetic compatibility that optimize design and performance. Despite the various advantages of circuit board analysis and simulation, challenges like the complexity of circuit boards' design, its numerous components and interconnections, pose operational limitations. This research offers an extensive study of the obstacles and prospects linked to circuit board analysis and simulation, and highlights the latest advancements and patterns in this area. In summary, this research presents a detailed summary of circuit board analysis and simulation for intelligent applications in residences.

CHAPTER ONE

PURPOSE OF THESIS

1.1. Literature Review:

Extensive investigation has been devoted to utilizing circuit board analysis and simulation to enhance the performance and reliability of smart home systems by modeling and testing their circuits prior to physical implementation. A Smart Home System, referred to as assistive domestics, for disabled people capitalizes on Wifi wireless technology for easy control of electrical appliances. The software application renders appliance control wireless via Wifi that can be run on mobile devices running Android OS. The system is useful in hospitals, home care for the elderly, and facilities for disabled users as it can control switches within a 25-meter radius from the main controller, as the study has found. In a similar vein, an algorithm for managing household energy consumption is introduced in another paper as part of a smart grid. The algorithm prioritizes household appliances and ensures power usage remains below a particular level. A simulation tool is also developed to exhibit the algorithm's effectiveness in managing demand response at the appliance level, which serves as a foundational step in comprehending the demand response potential for residential customers (Pipattanasomporn et al., 2012; Ramlee et al., 2012).

A smart control system based on Internet of Things technology has been proposed to manage and control the increasing number of appliances in a home (Wang, Zhang, Zhang, Zhang, & Li, 2013). The system utilizes a smart central controller to set up a wireless sensor and actuator network. Control modules have been developed for the network to directly control various home appliances, and communication between the central controller and application servers, client computers, and other devices is made possible through a Wi-Fi interface.

A Smart Home system was created to help disabled individuals, utilizing various technologies to create an advanced and self-learning home, featuring two neural networks. A prototype has already been created, with potential future plans to develop it into a functional home. The objective is to make a cost-effective Smart Home that is also user-friendly, centered on a WLAN network creating an Arduino microcontroller for monitoring and controlling household appliances. After evaluation, the system was deemed effective. A survey on construction techniques for an energy-efficient IoT-enabled home was conducted, reviewing IoT, context awareness, and ambient intelligence (Aqeel-ur-Rehman & Khursheed, 2014; Che-Bin & Hang-See, 2016). The study focuses on the context-aware application for smart homes in terms of thermal comfort and energy optimization based on occupancy. The review discusses intelligent techniques that can provide an ambient intelligent home with an IoT sensor network, providing a functional mapping for solving the problems of thermal comfort and energy awareness in constructing a smart house.

With the pressing need to conserve energy, the inability to remotely control appliances contributes to energy waste (Palaniappan et al., 2015). A web or mobile application has been developed to send instructions to these systems, using various communication methods like Wi-Fi, GSM, Bluetooth, and ZigBee. This survey paper examines the different control devices and configurations available in existing systems used in various applications.

(Li & Lin, 2014)explores the use of Wireless Sensor Networks (WSNs) and Power Line Communications (PLCs) to create a smart home control network that reduces the impact of wireless interference and energy consumption. Each room in the home has a WSN with a coordinator integrated into the PLC transceiver to transfer environmental parameters to the management station. The control messages for home appliances are directly sent through PLCs, which reduces the impact of wireless interference. The smart home control network saves energy by using a smart control algorithm for lighting systems and reducing electricity consumption by at least 40% on sunny or cloudy days. A prototype of the proposed system was tested and demonstrated to be practically feasible and effective.

In (Zhang et al., 2015) ,a new smart home system is designed and developed by incorporating ARM and ZigBee technologies. The traditional data transmission security model is modified with security considerations. The system allows for control by the server and access to residential and municipal services such as weather information. The use of ZigBee as the household network eliminates the need for internet-connected devices and complex wiring, making it a more cost-effective solution. Future research will include numerical testing and gathering feedback for further improvement.

The article (Hoque & Davidson, 2019) outlines an architecture for a low-cost smart door sensor system for home automation and security. The system utilizes sensors such as motion sensors, temperature sensors, smoke sensors, and web cameras, which connect to a home gateway for Internet connectivity. The utilization of an Arduino-compatible microcontroller board and a Raspberry Pi board enables communication with a web server via a RESTful API. Limitations and applications of the architecture, including potential interference from other radio frequency devices, are carefully considered and discussed while employing multiple programming languages. The Android application is notified of door-open events via the sensor. The exploration executed by Latif et al. (2019) emphasizes the vital function performed by IoT tech in boosting the standard of living within clever homes. The key intention is to design a further competent structure that not just presents convenience but also diminishes power usage. To simulate an IoT-based architecture diagram, a Porteous simulator is employed. By incorporating RFID technology, the system can monitor household appliances such as water faucets, washing machines, kitchens, and gas cylinders, transmitting data to an Android device. The system features cost savings, energy efficiency, and improved functionality, highlighting the benefits of IoT in smart homes.

A smart home system incorporating LoRa technology is proposed to monitor room temperature and manage electronic devices. The communication module used is the LoRa Dragino 915 MHz module, which acts as the connection between the LoRa Client and the LoRa Server. The created prototype operates effectively in real-time temperature monitoring and electronic device control (Lianda & Amri, 2023). The signal range between the LoRa Client and the LoRa Server was found to have a maximum reach of 183 meters (approximately 600.39 ft) in semi-open spaces, but is reduced to 63 meters in obstructed spaces.

(Stolojescu-Crisan et al., 2021) introduces a home automation system called qToggle that interconnects sensors, actuators, and other data sources, it leverages the power of a flexible API for simple and common communication. The devices used by qToggle are mostly based on ESP8266/ESP8285 chips and Raspberry Pi boards and a smartphone application has been developed for users to control home appliances and sensors. The system is user-friendly, flexible, and can be further developed with different devices and add-ons.

(Daş & Ababaker, 2021) discusses the use of IoT technology in controlling various home appliances like doors and lights. The system uses various sensors like IR, DHT22, and ultrasonic to monitor the status of the doors, windows, temperature, humidity, and measure distances. The system uses NodeMCU ESP8266, relay module, and Arduino Uno as its main components. The system can be monitored and controlled from any location, and the data from the sensors can be accessed using Ubidots IoT platform and Blynk application. During transmission, the Wi-Fi information is encrypted to ensure data protection using the AES method, with decryption and decoding taking place at the data's destination. A research paper (Anh Khoa et al., 2020) discusses information security in smart homes' role in smart cities, emphasizing the significance of big data, mobile networks, cloud computing, and IoT. The work calls for using Secure Hash Algorithm 256 (SHA-256) as an authentication mechanism to strengthen security efficiency amid equipment failure. The framework presented can be used for various smart home systems such as burglar alarms, guest attendance monitoring, and light switches and integrates well with smart city systems.

The implementation of the SHA-256 monitoring system is found to be successful in achieving real-time control that is secure. With the use of a microcontroller linked to an Arduino Uno board, the prototype enables remote management of home devices via the Internet of Things (IoT). The BTDisplay app allows users to gain access to the system and enables control through their mobile devices. The user can monitor the appliances and receive notifications if any changes go beyond the set range. The hardware, software, and test design are discussed in the paper (Jenal et al., 2022).

In (Wang et al., 2022) the study focuses on the reliability of Smart Home Sensor Systems (SHSSs) that incorporate ZigBee and Bluetooth devices and sensors connected to the network through gateways is of concern, as a gateway failure could lead to the failure of the entire SHSS, especially if it occurs prior to failures propagated from the connected sensors. To mitigate this, a new method based on advanced Binary Decision Diagrams (BDDs) is proposed to analyze the reliability of SHSSs that experience competing failures. This method is more efficient and precise compared to the conventional method that involves multiple reduced fault trees. The effectiveness and accuracy of the proposed method is demonstrated through an example of a SHSS.

1.2. Problem Statement

The evaluation and simulation of circuit boards has become increasingly important for smart homes. Predicting the efficacy of contemporary boards is challenging due to the scarcity of precise component data. The advancement of smart home systems necessitates the enhancement of circuit board analysis and simulation tools and techniques to ensure the dependability, effectiveness, and proficiency of said systems. The objective is to establish and enforce efficient circuit board analysis and simulation procedures for crafting and refining smart home systems, as well as to improve their reliability, productivity, and energy conservation. This endeavor will guarantee that smart home systems satisfy the specifications and aspirations of residential consumers and bolster the expansion and prosperity of the smart home industry.

1.3. Study Objectives

The project's goals are to assess the smart home system's present circuit boards and discover any potential complications. It aims to simulate the circuit boards to find the best possible design that enhances efficiency and performance. Moreover, suggest using advanced materials and components to augment the circuit board's functionality, durability and secure it from any attack.

1.4. Thesis Organization

A total of six chapters can be found within the thesis.

- **First chapter**: It gives a simple prologue to the proposed framework and includes general and important data, a proclamation of the issue and the purpose of theory.
- **Second chapter** in this chapter, provides an overview of the relevant theories, concepts, and systems used in previous.
- **Third chapter:** includes the methodology, the general structure of the proposed system, the systematic diagrams, and the proposed system code algorithm.

- **Fourth chapter:** includes the implementation and simulation results.
- **Fifth chapter:** includes conclusions and future work concerning a continuation of this work.

CHAPTER TWO

THEORETICAL BACKGROUND

2.1. Internet of Things (IOTs)

The term IoT refers to a network of physical objects that are enhanced with electronics, software, sensors, and network connectivity ('What Is the Internet of Things? How Does IoT Work? | Built In', n.d.), figure 1. These IoT devices collect and exchange data, leading to an automated and efficient world. The magnitude of IoT expansion is significant, with prognostications indicating that over seventy-five billion IoT devices will exist by 2025. These instruments access the internet and employ detectors and electronics to communicate data between themselves and their environment, facilitating automatic decision-making and heightened automation.

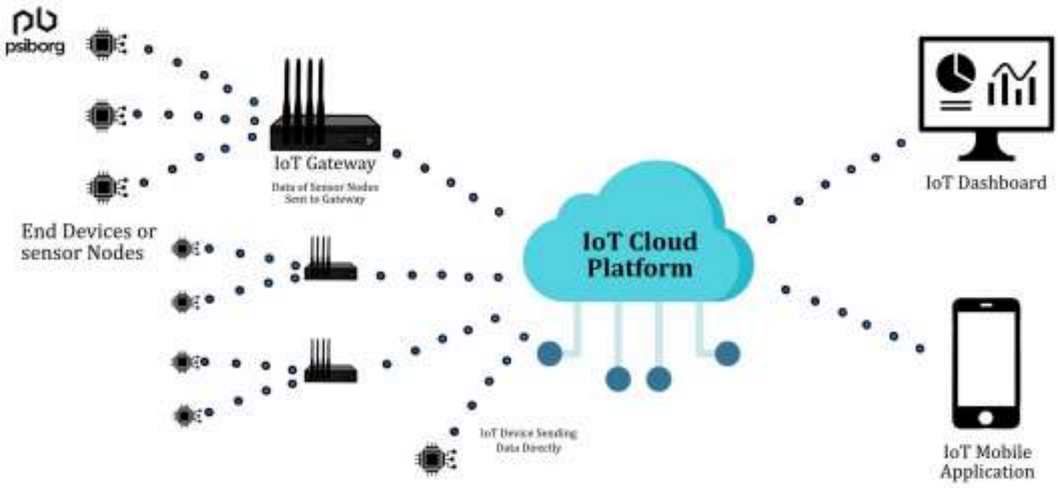

Figure 1. Overview of IOT

('IoT Platform and IoT Gateway- PsiBorg', n.d.).

The potential for increased efficiency is one of the benefits of the Internet of Things (IoT). For example, homeowners can regulate temperature via smartphone apps from any location and before arriving home. This can increase comfort and energy efficiency. The IoT can also promote productivity and lessen downtime in businesses via equipment performance monitoring. Gathering and analyzing large amounts of data is another advantage. This data enables valuable insights into topics ranging from consumer behavior to environmental factors. In cities, for instance, air quality can be observed with IoT devices to differentiate areas in need of improvement. The IoT has the capability to alter numerous industries, amongst them, healthcare and manufacturing. Within healthcare, IoT technology can track patients' vital signs for easy remote access. This promotes early detection and expedites response times to maximize positive patient outcomes and limit hospital stays. In manufacturing, IoT devices can be utilized to supervise equipment performance and detect issues before they result in downtime, ultimately leading to improved efficiency and productivity.

The proliferation of IoT also creates fresh quandaries. The chance of being hacked or attacked increases as more machines link up to the internet, particularly those controlling important power grids or medical machines. This could be catastrophic if vulnerable. Furthermore, there is a concern about personal data being collected and employed by IoT items. To combat potential threats and difficulties arising from the swiftly advancing IoT area, designing security and privacy into device architecture is essential. IoT design should include robust security measures, such as encryption and secure transmission protocols for internet data. Furthermore, clear and transparent policies for collecting and utilizing personal data, along with granting users' control over their data, are imperative. Despite the potential innovative and transformative benefits of IoT technology, it's crucial to address and manage associated risks by prioritizing security and privacy measures.

2.2. Smart Home System

Home-based crime attacks, dangerous thefts, and unexpected burglary are all on the rise. This has demonstrated the necessity for increased and enhanced levels of security for homes, properties, and individuals. The increase in the industrial development of smart home automation systems, as well as the rate of research effort in the field, provide confidence that the field will be used to solve security challenges that arise in smart home environments.

The Internet of Things (IoT) is the linking technique of various and available physical devices, different network connectivity, and communication mediums to convey desired information between various devices and/or between devices and humans. IoT technologies have enabled these devices, used sensor, and appliance connectivity, interaction, and employed data exchange (Taiwo et al., 2022).

Smart home systems have become more accessible and affordable due to IoT technology as figure 2. Such systems offer remote access and control for various appliances like thermostats, locks, cameras, and lighting. Individuals who own houses can easily control their residences through a mobile device or tablet from any place, resulting in a more enjoyable and environmentally friendly home.

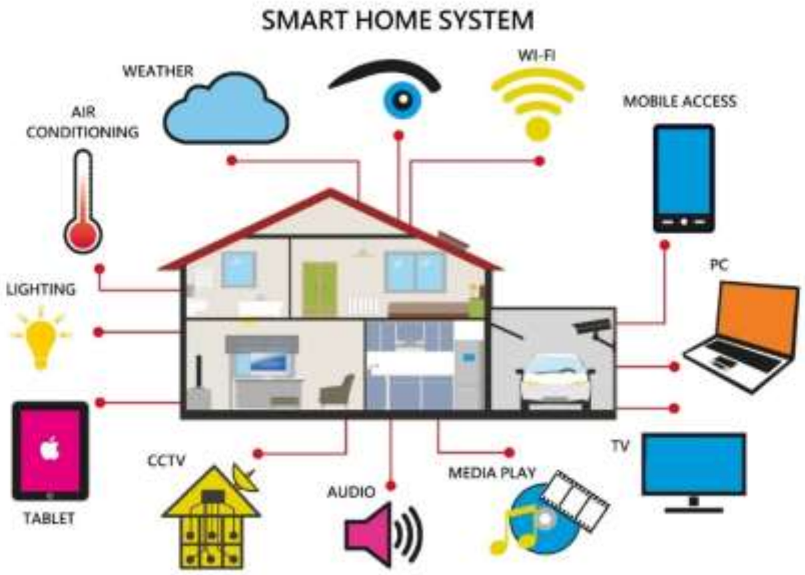

Figure 2. Smart Home System.

('Visioforce Automation Hong Kong- Smart Home, home automation', n.d.)

A smart home system lets homeowners manage devices remotely via smartphones, programmable to adjust based on schedules or location. This helps reduce bills, improve comfort, and enhance security through smart locks and cameras. Nevertheless, worries about data privacy and compatibility are present, underscoring the importance of picking trustworthy makers with robust encryption and harmonious devices. Commencing with one gadget and gradually including additional ones is a superb approach for proprietors to acclimate themselves with the technology.

2.2.1. Smart Electrical Systems

Incorporating intelligent technology into the domestic network and household machinery pertains to intelligent electrical arrangements. Such setups allow occupants to handle and observe energy expenditure in order to economize on energy usage and expenses. Smart electrical systems offer improved energy efficiency by allowing homeowners to monitor their energy usage in real-time and identify areas requiring energy reductions. A smart plug can monitor an appliance's energy consumption, usage durations, and times. The details can be utilized to form learned determinations regarding power usage, such as the ideal time to shut off electric devices, therefore decreasing power consumption.

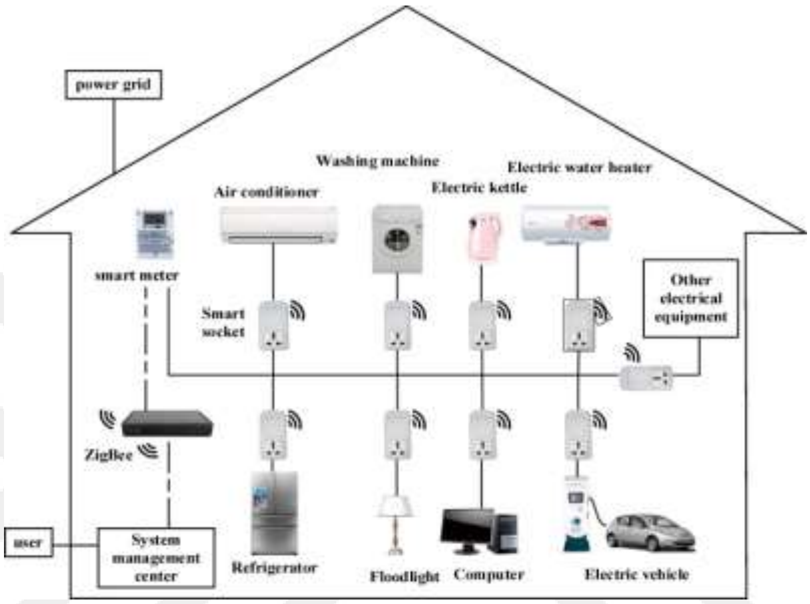

Figure 3. Smart Home (with electrical system)

(Lu et al., 2022)

Improved convenience is a notable advantage of smart electrical systems. Control and automation of appliances, lighting, and other electrical systems using smart devices allows homeowners to manage their homes effortlessly from anywhere and anytime (‘25-32-eng’, n.d.) figure 3. For instance, with smart lighting systems, homeowners can set schedules for when lights should turn off and on or power up lights remotely using their smartphones. This saves time and reduces energy consumption because homeowners don't need to physically adjust light switches.

Cultivating home safety is another compelling feature of smart electrical systems. For example, through the utilization of clever plugs, property holders can remotely power down gadgets to evade a blaze or in case of an electrical surge.

Additionally, brilliant lighting setups have the capability to program lighting to activate when there is a power outage, serving as an emergency light source.

Smart electrical systems have the corporate potential to improve the overall efficiency of the electrical grid. Monitoring energy consumption in real-time can help energy companies optimize energy production and minimize waste. (>>) wanted to monitor an electrical system utilizing the internet of things with smart current electric sensors, where the electric current was measured with a current sensor SCT 013-000, shown on the LCD, and sent a notice to Telegram, this measurement being taken straight from the power meter. If the electric current exceeds the breaker's maximum capacity, the user will receive information by telegram, and users can also cut off the power via telegram. This implementation received a percentage with iron load of 3,29%, Dispenser loading of 0,20%, and MagiCom load of 1,07%. There is a 6.81% improvement from iron load testing, MagicCom, and Dispenser, as well as the delay time of relay with an average ignition time of 1.50 seconds and when turning off 0.78 seconds, and then the delay time in the telegram application with an average of 6.2 seconds. The tool's design should be built so that those who see it are interested in applying it and find it simple to understand. A real-time clock and a microSD card to store RTC data are required (Hajar et al., 2018).

Although this huge developement, security concerns remain a significant hurdle for smart electrical systems.

Collecting and transmitting sensitive information, such as energy usage, increases vulnerability to hacking and cyberattacks. Therefore, it is imperative to purchase devices from reputable manufacturers that use strong encryption and reliable protocols for secure data transmission.

One potential problem with smart electrical systems is their compatibility with other devices. As the smart home device market expands, it may become difficult to find devices that work with both each other and pre-existing home technology. To avoid any issues related to compatibility, it is crucial to choose devices from a single manufacturer or from cooperatives between multiple manufacturers. All in all, smart electrical systems can decrease energy use and costs, and grant homeowners more controls over their energy utilization. The inclusion of smart technology into the electrical grid and devices also ameliorates convenience and home safety.

Homeowners can guarantee that their smart electrical system fits their needs and delivers desired benefits by selecting devices from respectable manufacturers and keeping the consistency with their home technology.

2.2.2. Smart Lighting Systems

Smart lighting systems (SLS)s involve incorporating intelligent technology into a residence's lighting system, providing owners with the ability to direct and automate their lights using a mobile device or tablet. Compared to typical lighting systems, these methods have multiple advantages, such as improved convenience, amplified energy efficiency, and boosted safety,figure 4 .

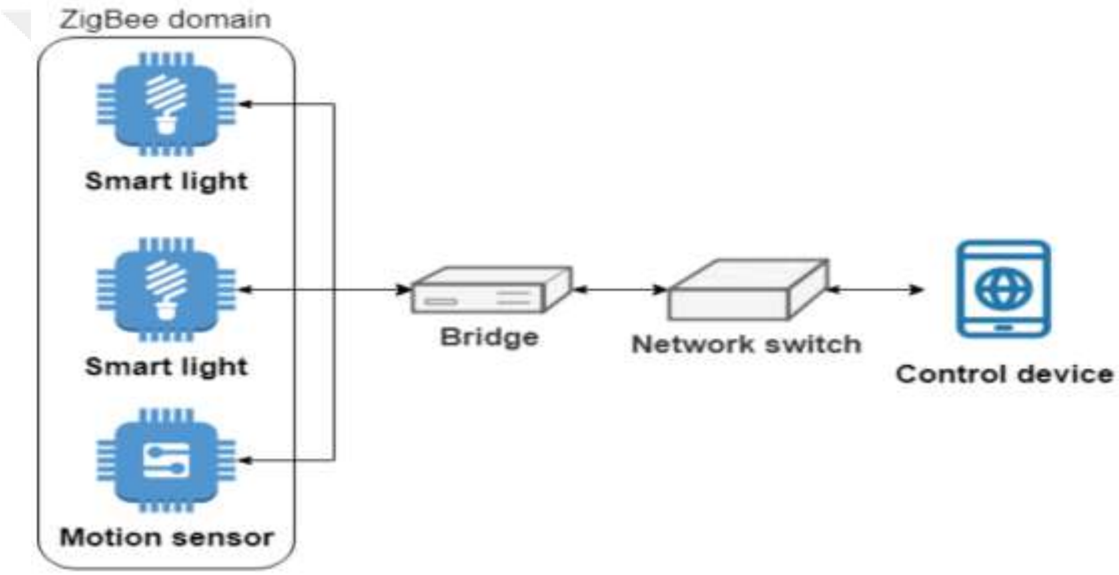

Figure 4. Prototype Of Smart Lighting System

('Reference architecture of smart lighting systems. | Download Scientific Diagram', n.d.).

Smart lighting offers the advantage of convenient control from mobile devices, allowing homeowners to manipulate lights at any location and time. Users can operate several settings such as brightness and color with ease. The feature proves worthwhile in the absence of homeowners, creating the illusion of occupation.

Smart lighting also boasts an essential benefit of energy efficiency. Homeowners can define schedules for the automatic on-off cycle of lights, which efficiently reduces energy consumption, further promoting sustainability.

In addition, smart lighting systems offer additional safety through remote control of lights, ensuring that these remain functional even while homeowners are away.

The characteristic might cause a sense of safety and stop trespassers from entering. Also, they can switch on the lights during a power cut, working as a backup lighting. Intelligent lighting arrangements permit adjusting various lighting modes for different occasions and times, hence allowing house owners to adjust the ambiance of their homes. Additionally, these systems improve energy efficiency, encourage security, and suggest diverse lighting options for various cases. Homeowners can create a "reading scene" with soft, warm lighting or a "party scene" with bright, colorful lighting. This allows for a tailored ambiance for any event.

Through integration with voice assistants such as Amazon Alexa or Google Home, the power to manage lighting needs can now be centralized and simplified to merely vocal commands, hence enhancing convenience.

The following are explanations of the two different IoT-enabled Smart Lighting System communication protocols:

Long-range Communication: In the context of SLS, long-range communication mainly refers to information sharing between Load Control Units (LCUs) and CC, as well as between LCUs. SLS typically consists of numerous LCUs and one central CC in a major urban region. After gathering data from LUs, LCUs located around the area communicate the information to a CC. LCUs, once again, communicate information with one another. Distances between LCUs and between LCUs and CC can be long (from a few hundred meters to a few hundred kilometers) because LCUs are placed proportionally around the city. As a result, a long-distance communication protocol is required to create a communication channel between LCUs and CC. Protocols such as Wi-Fi, Ethernet, and so on which are utilized to establish communication channels between LCUs and CC.

Short-range communication: Short-range communication is typically defined as communication between devices in direct line of sight. Distances between LUs and related LCUs in an SLS are modest (less than 100 meters). Short-range protocols are used to communicate primarily between LCUs and LUs in an SLS. Short-range protocols can be wired (for example, DALI) or wireless (for example, ZigBee, JenNET-IP, 6LoWPAN) (Sikder et al., 2018).

2.2.3. Heating, Cooling, Air Conditioning and Ventilation Systems

The integration of advanced technology into HVAC Systems allows for easy control and automation using mobile devices such as smartphones or tablets. This advancement in technology increases energy efficiency, comfort, and control, making it more beneficial compared to traditional HVAC systems (‘Understanding Building Automation and Control Systems -KMC Controls’, n.d.-a).

One considerable advantage of intelligent HVAC systems is their improved energy efficiency. The implementation of remote temperature control and scheduled adjustment of heating and cooling systems enables homeowners to cut back on their energy consumption by turning off the heating or cooling when it is unnecessary. This helps to decrease energy expenses and foster a sustainable future. Another substantial benefit of intelligent HVAC systems is increased comfort. Individuals are able to manipulate the temperature of their household from a remote location, which guarantees that it is heated or cooled to their preference even during absence. This enables individuals to schedule the heating to activate in the morning, so that they wake up to a warm residence. Additionally, the systems can be programmed to turn on and off automatically based on homeowner preferences, making it even more convenient to manage house temperature.

Furthermore, intelligent HVAC systems provide enhanced control. Homeowners can control the temperature and ventilation in their homes remotely to optimize air quality. For example, they can turn on ventilation while cooking to improve air quality or turn off heating and cooling while away from home to save energy.

Integrating intelligent HVAC systems with other smart home devices, such as lighting and security systems, can enhance energy efficiency and reduce waste ('Understanding Building Automation and Control Systems -KMC Controls', n.d.-b). Voice control is another useful feature that enables homeowners to regulate HVAC systems with ease. However, compatibility issues and security concerns pose potential challenges and risks. To mitigate these issues, it is advisable to select devices from the same manufacturer or those that follow established security protocols.

2.2.4 Smart Curtain, Shutter Systems

Innovative home automation technologies known as Smart Curtain and Shutter Systems allow homeowners to control the amount of light and privacy in their home through voice commands or by pressing a button. These systems offer benefits such as increased convenience, enhanced security, and improved energy efficiency in comparison to traditional curtains and shutters.

Increased convenience is one of the key benefits provided by smart curtain and shutter systems. Because the curtains and shutters can be remotely controlled, homeowners can adjust lighting and privacy levels from any location, at any time. This feature can be especially helpful for managing natural light entering a room during the day or making sure the curtains are closed before sleeping. Certain smart curtain and shutter systems can also be programmed to automatically open and close at specific times, making it easier to manage lighting and privacy levels.

The implementation of intelligent curtains and shutter systems have the potential to increase energy efficiency by controlling the light levels in a room, leading to a lowered requirement for artificial lighting. This outcome can further reduce energy bills. Moreover, such systems can regulate a room's temperature by blocking excessive cold or heat, hence contributing towards improving the comfort within a household.

Improved overall security is another benefit of smart curtain and shutter systems. With remote control features, homeowners can create the illusion that someone is home, even if they are away, discouraging potential burglars. Integration with other smart security systems, such as cameras and alarms, can increase peace of mind for homeowners.

2.2.5 Intelligent Security Systems

Advanced security solutions are achieved by combining sophisticated technologies and intelligent algorithms. Through the incorporation of data, machine learning, and artificial intelligence, these systems offer real-time monitoring, predictive analysis, and threat detection capabilities.

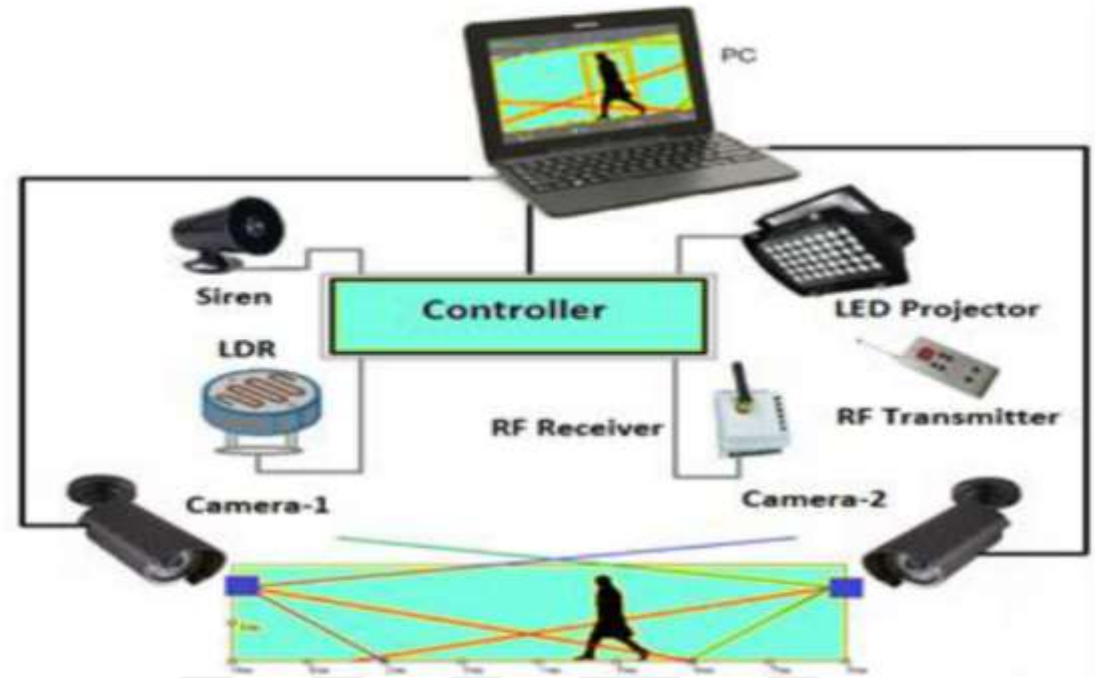

Figure 5. Intelligent Smart System

('Smart Security System | Download Scientific Diagram', n.d.).

Intelligent security systems tackle these challenges by employing a proactive and adaptable approach to security, figure 5. This involves data analysis from various sources to detect and expel threats as quickly as possible. The use of machine learning algorithms for analyzing data and predicting potential threats, AI technology for automating security processes, and integration with other security solutions like intrusion detection or SIEM allow for a comprehensive view of security incidents and efficient response to threats. Nevertheless, there exist certain obstacles linked to the implementation of intelligent security systems.

In conclusion, intelligent security systems represent a new era in the evolution of security solutions. These systems offer improved defense against online security risks and enable organizations to safeguard their belongings and information more effectively. By investing in appropriate skills and technology, businesses can enjoy the advantages of these systems and better insulate themselves from constantly-changing threats.

2.3. Wifi Based Security Systems

Adding WiFi to security systems allows for faster data transmission and allows the user to remotely monitor and operate the equipment.

In (.>>) a newly redesigned security system was released that merges sensor alerts with video surveillance techniques using Raspberry Pi and NodeMCU (IoT/WiFi module). The Raspberry Pi is a low-cost, low-power single-board computer that can perform various functions like a standard computer. This system's main characteristics are intrusion and fire detection. This technology is entirely reliant on WiFi connectivity. Instead of Zigbee, a WiFi module is employed for wireless communication in this case. Any technology that has WiFi connectivity has an advantage. Data can be retrieved from anywhere and moved to the cloud for storage and monitoring. It also has a long range and a high bandwidth, making it ideal for streaming video and delivering emails. Furthermore, the IoT module makes the system affordable, compact, globally controllable, and accessible. The goal of the project is to build and execute a low-cost, dependable, energy-efficient, long-range, worldwide accessible, storage-efficient surveillance system using the Raspberry Pi SBC, GSM Modem, and NodeMCU (IoT Module) (Sruthy & George, 2017).

It has recently been discovered that passenger mobility influences WiFi signals to some extent. Based on this insight, researchers are able to describe human activities using the Received Signal Strength Indicator (RSSI) and Channel State Information (CSI). When compared to alternative approaches, WiFi-based technology has three advantages:

1) First and foremost, it is designed for practical implementation as a ubiquitous system. The indoor coverage of wireless networks has grown increasingly common as the WiFi method has advanced. As a result, no special sensors or RF links are required.

2) Second, WiFi-based techniques use pattern extraction of wireless signals in the physical layer, which eliminates privacy concerns.

3) Finally, it can provide relatively accurate sensing while requiring minimum infrastructure, which is a reasonable trade-off between availability and performance.

When WiFi-based technologies are used in practice, various obstacles remain, such as platform scalability and a lack of wireless signal resolutions, among others.

These difficult difficulties are addressed in (>>>), which presents a revolutionary technique that employs commercial off-the-shelf (COTS) Wi-Fi enabled IoT devices for occupancy sensing in smart homes. In the wireless link between the transmitter (Tx) and receiver (Rx), our technology uses fine-grained CSI data from the physical layer. It is intended for high scalability and performance occupancy sensing and is made up of three parts: an innovative IoT platform for sensing, a cloud server for compute, and a user end for alerting. First, Improve the OpenWrt system to enable it to report excellent CSI on IoT devices. The data can then be handled in either a coarse or fine-grained manner depending on the application. Then create and implement two hard applications, namely occupancy detection and human activity recognition, to illustrate the performance of our system. Use CSI curve similarity to meet the purpose of coarse sensing applications such as occupancy detection. It is fully implemented on IoT devices. For fine-grained sensing applications such as activity detection, Extract activity features using Class Estimated Basis Space Singular Value Decomposition (CSVD) and subsequently classify them using Nonnegative Matrix Factorization (NMF). The evaluation in typical interior situations reveals that two applications attain reasonable real-time performance (Yang et al., 2018).

2.4. Protocols Based Security Systems and IoT

IoT Applications are numerous and are used to provide answers to a wide range of challenges. Though IoT has a lot of potential in the digital world, it runs into various challenges during deployment, such as device heterogeneity, device identity, device administration, secure device-to-device communication (D2D), and so on. Architectures such as Ubiquitous Sensor Network (USN), Sensor Web Enablement (SWE), and others are proposed to facilitate the integration and administration of heterogeneous IoT devices. Device security (such as identity theft and data integrity), D2D connectivity, and other issues are not properly addressed here. Furthermore, the majority of the privacy and security measures provided by them remain in their early stages.

Current solutions, while providing fundamental security primitives for D2D communications, do not address the protocol level. Constrained Application Protocol (CoAP, UDP based), Message Queue Telemetry Transport (MQTT, TCP based), MQTT-SN (UDP based), and other communication protocols used for IoT at various tiers have minimal or no security protections. As a result, these protocols must handle IoT security concerns.

Furthermore, MQTT and MQTT-SN are more widely used than CoAP and have applications in social networks, vehicle-to-vehicle communication (V2V), and sensor networks (M. Singh et al., 2015).

2.4.1. Secure MQTT for Internet of Things (IoT)

IoT devices and systems are extremely complex, and study into the communication protocols of each network layer is at the heart of the Internet of Things. And MQTT, as the application layer protocol of the Internet of Things, is widely utilized in data exchange. MQTT's security issue is quite important. Because of its subscription and release mode, the MQTT (Message Queue Telemetry Transport, MQTT) protocol has become a de facto data transfer standard in the field of Internet of Things. Andy Stanford-Clark of IBM and Arlen Nipper of Arcom proposed MQTT in 1999, and it became an OASIS standard in 2013. The MQTT protocol can theoretically support encrypted communication using SSL/TLS, although this solution has clear drawbacks on resource-constrained IoT devices. In reality, many present MQTT systems have no security settings at all. The primary cause of this scenario is the sophisticated use of SSL/TLS and resource consumption.

Intrusion Detection Systems (IDS) and authentication (authentication) have long been used for MQTT security protection, with good results under certain settings. However, due to too restricted criteria and too complicated implementation, it is difficult to be extensively used (Chen et al., 2020).

2.4.2. IoT Security, Challenges, and Solutions

IoT promises a world in which smart and intelligent communication from most devices is possible via the Internet everywhere, at any time, with as little human intervention as feasible. However, security and privacy are important problems for IoT, which may have an impact on its long-term development (Mohanty et al., 2021).

In the network, the MQTT protocol supports two entity models: Client and Broker. Broker realizes data decoupling and data one-to-many service mode for the client, which includes publishers and subscribers.

In-depth examination of the security dangers that MQTT may encounter, as well as research on associated solutions, are critical to MQTT's wider applicability and application in vital domains. MQTT is mostly used for data transmission in Internet of Things edge node networks.

Traditional security measures are difficult to apply due to the limited resources of MQTT host equipment, the complicated working environment, and the variable system and structure. On the contrary, because of these qualities, many network attack methods are easier to implement. At the same time, users have not paid close attention to MQTT security, exposing MQTT applications to serious dangers. As a result, numerous academics have conducted study into MQTT security mechanisms as well as offensive and defense measures (Chen et al., 2020).

CHAPTER THREE

METHODOLOGY

A domicile management network comprises of supervising and administering electrical gadgets, illumination, security systems, and other related utilities. The domicile management bazaar is experiencing remarkable growth. This is attributed to the reason that people incline towards automatic systems over manual ones at home, to alleviate their everyday chores and concentrate better on their interests. Diverse techniques of domicile automation are available, and each has its distinct tactics of execution, advantages and disadvantages.

Without using the internet, a home automation system that is wireless or wired may be accessed from anywhere. Elderly and disabled persons would benefit greatly from the proposed home automation system since they may issue orders by just pushing a key. The end-users' ability to monitor and control home appliances was made easier by the integration of mobile phones with home automation technologies like Wireless because they were no longer required to carry specialised equipment for the task, which also helped to lower the cost of investing in that specialised equipment. Our proposed system consists of sensors and appliances connected to the Arduino IDE processor (Galadima, 2014). Have a keypad so by pressing specific key one can turn on/off fans, lights, lamps, water motor and regulate the temperature through looking at the temperature of room. Through Wireless module one can connect it with through phone and do the same task. Figure 6 give the generalized overview of our proposed system.

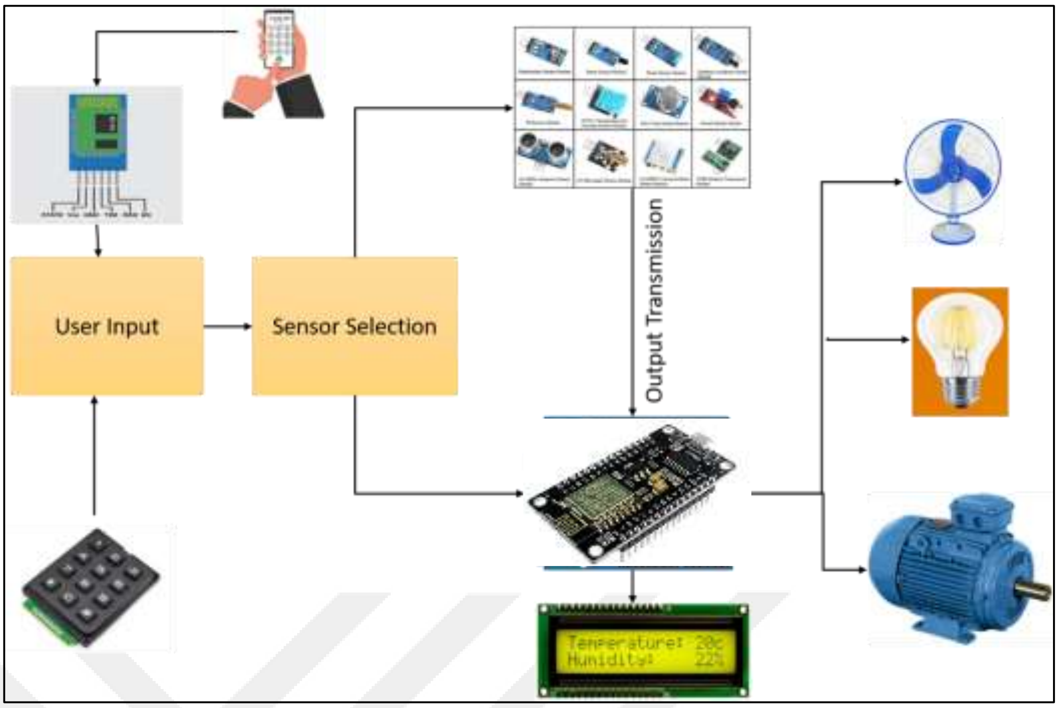

Figure 6. Block diagram of proposed model

There are several operational strategies for home automation. These could be based on Manual control, Bluetooth, GPRS, mobile, or the internet. The methodologies used for implementing Home Automation System are discussed below: (Galadima, 2014).

1. Wired Communication (Keypad)
2. Wireless Communication (Wifi)

3.1. Wired Communication(Keypad)

Home automation has raised the bar for ease, allowing you to do everything from lock the door remotely with your keypad to dim the lights in the room. The circuit for this particular project consists of multiple components such as an Arduino, keypad module, servo motor, temperature sensor, and LCD. The integration of technology within smart homes has become increasingly popular, offering a plethora of manually installed applications (Herrero, 2019). Despite its advantages, individuals are reluctant to embrace this trend due to uncertainty regarding the necessary installation and maintenance expenses. The study are concentrating on creating unique automation solutions that exactly match customers as a result of this design approach. Based on client preferences, the study offer workable solutions that make the system useful, easy to use, and convenient.

3.2. Wireless Communication(Wifi)

Embedded Wifi technology allows for the connection, monitoring, and control of household equipment. It is less expensive, has a wide operating range, and uses a lot of electricity. Its encryption is mature. The majority of the hardware is composed of a smartphone and ESP8266 NodeMCU WiFi, figure 7. The ESP8266 itself is a self-contained WiFi networking solution offering as a bridge from existing micro controller to WiFi and is also capable of running self-contained applications (Herrero, 2019) .

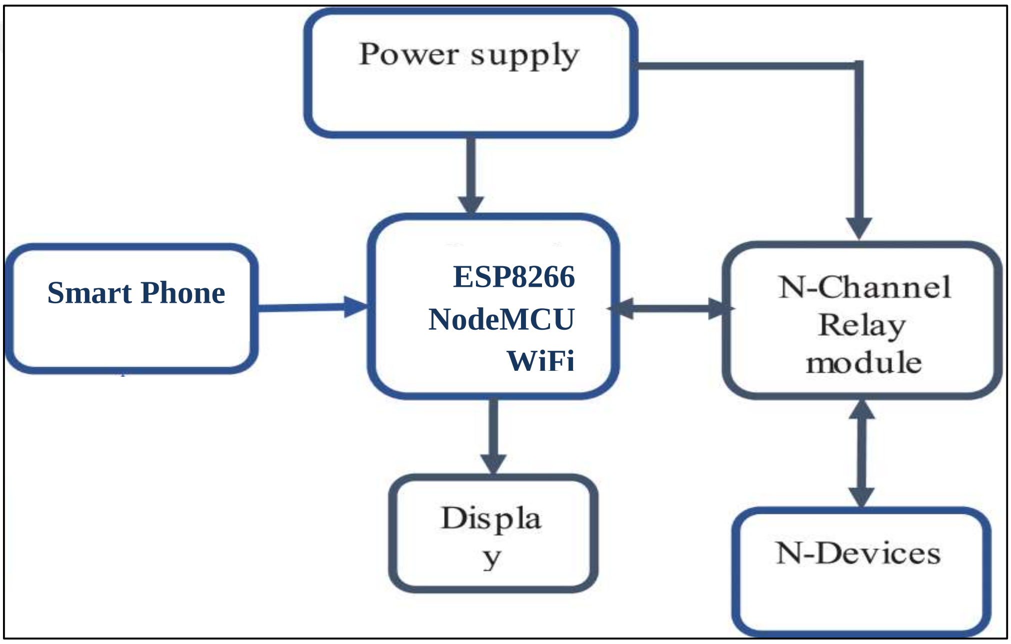

Figure 7. Showing the input and output of the data

3.3. Data Reception

Data acquisition is done by the use of two protocols either worked in wired communication by interfacing keypad or wireless communication by the use of ESP8266 NodeMCU. Wifi is used to link the automation system with the smartphone. The smart phone uses a Wifi interface to send control signals to an Android app, which turns on or off household appliances (Amoran et al., 2021).

Appliances are connected to the ESP8266 NodeMCU board through a relay. Data received though mobile or through keypad is fed to ESP8266 NodeMCU for processing, figure 8.

Figure 8. Receiver side

3.4. Flowchart of Code

The flowing shows the flowchart of code used in the posposed system,figure 9.

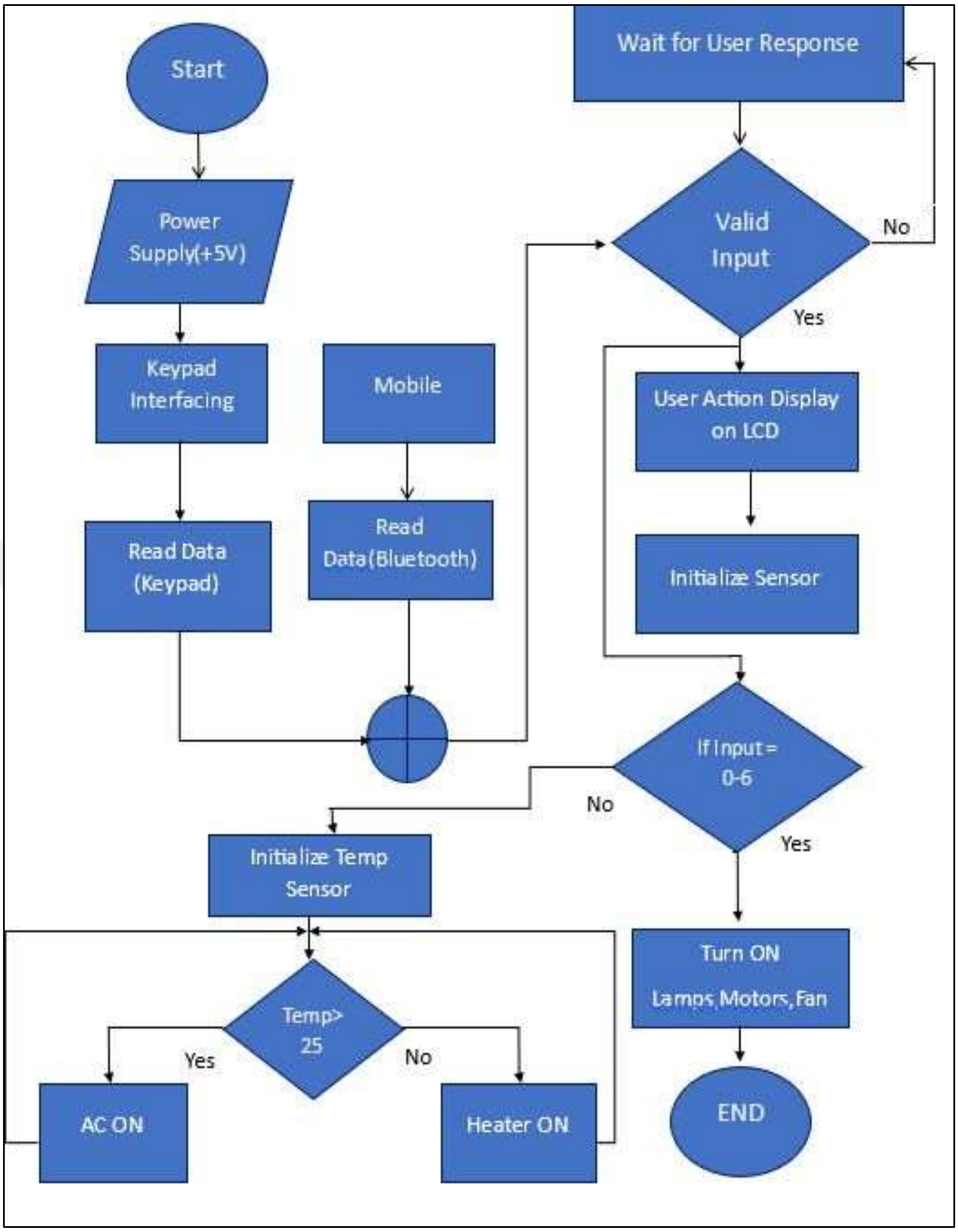

Figure 9. Flowchart

(It is developed by the researcher)

3.5. Overall Working

An algorithm is a detailed collection of instructions created to carry out a certain,figure 10.

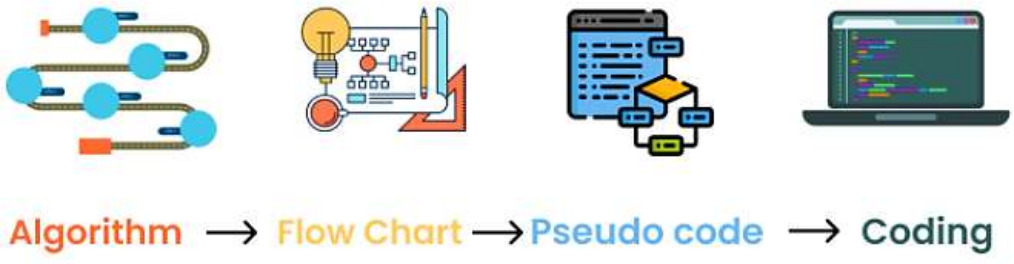

Figure 10. Overall Working Algorithm

(It is developed by the researcher)

1. Initialize the system by providing power source of 5V.
2. Fetch input from user and analyze whether input coming from keypad or mobile through ESP8266 NodeMCU.
3. Download and install IOT app from Google Play Store for proper connectivity of wifi with mobile.
4. Interface distinct peripherals with ESP8266 NodeMCU embedded platform.
5. Download Arduino IDE for writing sketch for whole system design in C/C++.
6. Compile the sketch and enable output generated machine code hex file for simulation purposes.
7. Implement all scenarios for home automation system utilizing keypad and Wifi inputs.
8. Interconnect 220V power relays for switching and running high power loads with ESP8266 NodeMCU.
9. Interlink the user output devices such as motors, lamps and fans with output pins of ESP8266 NodeMCU.
10. Interface LM35 temperature sensor with ESP8266 NodeMCU Hardware for analyzing room temperature.
11. Temperature for ideal environment is set to 25° Celsius.If temperature rises higher than this range AC will turn on automatically and heater vice versa.
12. Goto step 1 for sensing user input in next moment.

3.6. Hardware Components

Components used in the project are selected based on availability in the market. Through literature review component selected are following:

- NodeMCU ESP8266
- 4-channel Relay Module (5V)
- Tower Pro SG90 RC Mini Servo Motor
- LM35 temperature sensor
- Pushbuttons
- Jumper wires
- Arduino IDE
- Proteus
- Smartphone (iOS OR Android)
- Arduino IoT Cloud Remote app
- Arduino IDE

3.6.1. ESP8266 NodeMCU

The microcontroller known as the ESP8266 as Figure11 was created by Espressif Systems. The ESP8266 is a self-contained WiFi networking system that can run standalone programs and serves as a bridge between WiFi and current micro controllers. This module includes a built-in USB connector as well as a wide range of pin-outs. Similar to Arduino, you can easily flash the NodeMCU devkit by connecting it to your laptop using a micro USB wire,figure 11. Additionally, it is right away breadboard friendly (*HandsOn Tech – Open Source Electronics Platform*, n.d.).

Figure11. ESP8266 NodeMCU WiFi Development Board

3.6.2. LM35 temperature sensor

The LM35 is a useful tool that gauges temperature in various industries. The capacity to gauge temperatures from negative fifty-five degrees Celsius to one hundred and fifty degrees Celsius is made possible through the use of a device, which functions accurately depending on the environment conditions. By generating an analog voltage output, the device corresponds with an increase in temperature, and, through a simple formula, the output can be converted to a temperature value. It is critical to apply the device within an energy range from four to thirty volts, as the gadget uses a low output impedance and minimal current figure 12. This sensor is frequently used for temperature control and measurement in many settings, such as HVAC, medical, automotive, and consumer electronics industries, as well as in industrial automation (H. Singh et al., 2018).

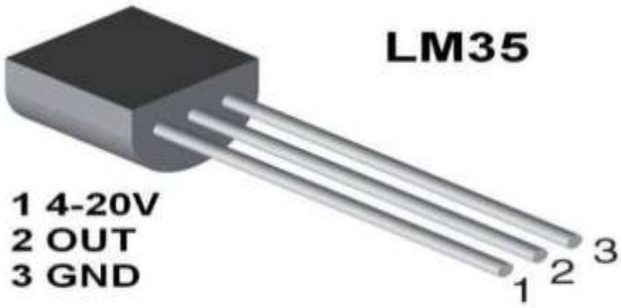

Figure 12. LM35 temperature sensor

3.6.3. Tower Pro SG90 RC Mini Servo Motor

The consumption of power by motors in devices is regulated with PWM, resulting in no unused current being burned as heat. An older option was the use of a transistor circuit that adjusted current by modifying resistance,figure 13. Manipulating the input voltage can control the pace of a DC motor, generally done through the utilization of PWM, which entails the transmission of a series of ON-OFF signals to adjust the average input voltage (H. Singh et al., 2018).

Figure 13. Tower Pro SG90 RC Mini Servo Motor

3.6.4. 4-channel Relay Module (5V)

An electromagnetic device that functions as an electrical switch is known as a relay. Within control systems, it is frequently employed to control high-power circuits using a low-powered control signal. The relay's construction is composed of wire coils that, when charged by an electric current, generate a magnetic field that pulls the armature or switch to make or break the circuit connection,figure 14 (H. Singh et al., 2018).

The management of different electrical mechanisms might be efficiently executed through relays. These function as protection by supplying isolation between the controlling circuit and the managed device, stopping any potential threat of electrical interruption and enhancing comprehensive security. Employing relays also provides meaningful advantages, including the handling of circuits with elevated current or voltage through a decreased-power controlling signal, simplifying the controlling system designing process. Furthermore, they are recognized for their long life and reliability, rendering them perfect for industrial and business applications (Amoran et al., 2021).

Figure 14. 4-channel Relay Module

CHAPTER FOUR

IMPLEMENTATION AND PRESENTATION OF RESULTS

In today's world, technology has the potential to improve people's lives. Technology advances decade after decade. Automation was once considered science fiction, but not anymore. We can create an amazing home by combining cutting-edge technology and home design. We can create a home automation system that can operate devices automatically using microprocessors, microcontrollers, resberryPi and the world leading Arduino Boards.As discussed earlier the firm known as Arduino creates and produces single-board microcontrollers and microcontroller kits for the construction of digital devices and interactive objects that can sense and control items in both the real and virtual worlds (ÖZTÜRK & NAİMİ, 2017).

Currently, technologies created with the help of the Internet of Things are starting to find more and more uses in order to improve human existence. It will be highly helpful to employ simulation tools before prototyping for the best technology selection in Internet of Things solutions, which include many various sorts of new technologies. IoT-based smart home design applications have been created and examined in this study (Sethi & Sarangi, 2017).

Physical realization of all these systems requires high cost, simulation tools are used effectively at this imtermediate stage. When trying something out in the real world would be difficult, expensive, impractical, or simply impossible, simulation is utilised. Simulated experiments provide experimenters greater control over the parameters and better understanding of the outcomes. It lowers the expense of experiments and enables the use of systems that do not yet exist physically. Lead times are shortened, and product quality is increased. In a way, Employ simulation and virtual systems because they're better than reality. Simulations are tools that can be used to comprehend how the real world operates in situations where doing so in the real world might be risky or difficult (Sivagami et al., 2021). The first proof of concept for the research life cycle is created using simulations. They are also highly helpful tools that let you adjust parameters to examine a system's behaviour while removing different extra duties that are not directly related to the goal in the real world. Working with simulation software prior to prototyping while creating IoT solutions helps to avoid wasting time and foresee potential error scenarios. Widely used Simulations softwares depending upon desired outcomes for different scenarios are shown figure 15.

Figure 15. Embedded Systems Software Development

To build a communication platform or embedded system that enables communication between systems connected to home automation in a single view, industry-leading simulation software (Proteus) is being used.Have put in place home automation simulation systems, that is, systems that function exactly like real-world home automation systems do, together with the hex files generated by the machines in those systems. In this part, the concept of "problemdomainanalysis" is used to further analyse home automation systems. Following analysis, a thorough simulation study is offered. In this context, distinct scenarios for the creation of smart Home automation systems have been created in the widely used Proteus simulation environment along with the hardware design with eye catching PCB 3D Design. The use of tools has been illustrated with examples based on the various situations (Jumini et al., 2020).

Home Automation System is designed on proteus software for simulations purposes and machine code is generated for transferring model to hardware.Different peripherals are attached with embedded ESP8266 board for proceesing at desired inputs and run specified systems.A 4x4 keypad is used as input tool and output devices are operated such as home lights,fan, motors. ESP8266 module can be connected to mobile mobile phone and whlole system can be tackled wirelessly.Arduino IDE is used for writing programming code in order to operate whole scenario.C\C++ language is opted for implementing Home Automation System in Arduino IDE (Galadima, 2014).

4.1 Proteus

An exclusive tool set for automating electronic design is called the Proteus Design Suite. The program is primarily used by technicians and electronic design engineers to develop schematics and electronic prints for printed circuit board production. Proteus is a program for virtual system modelling and circuit simulation. To enable co-simulation of full microcontroller-based designs, the suite combines animated components, animated SPICE circuit simulation, and microprocessor models. Proteus can also replicate the communication between a microcontroller's software and any linked analogue or digital components. It mimics all of the peripherals found on each supported processor, including input/output ports, interrupts, timers, USARTs, and more (Albertini et al., 2022).

Proteus VSM fills the void in the design life cycle between schematic capture and PCB layout for embedded engineers. It allows you to build your firmware, apply it to a compatible microcontroller on the schematic, and then simulate the program in tandem with the circuit in a mixed-mode SPICE simulation that takes MCU peripherals into account. Many debugging tools, like as breakpoints, single stepping, and variable display for both assembly code and high level language source, are also available with Proteus VSM.

Proteus schematic design for home automation system is shown in figure 16 with all peripherals included.

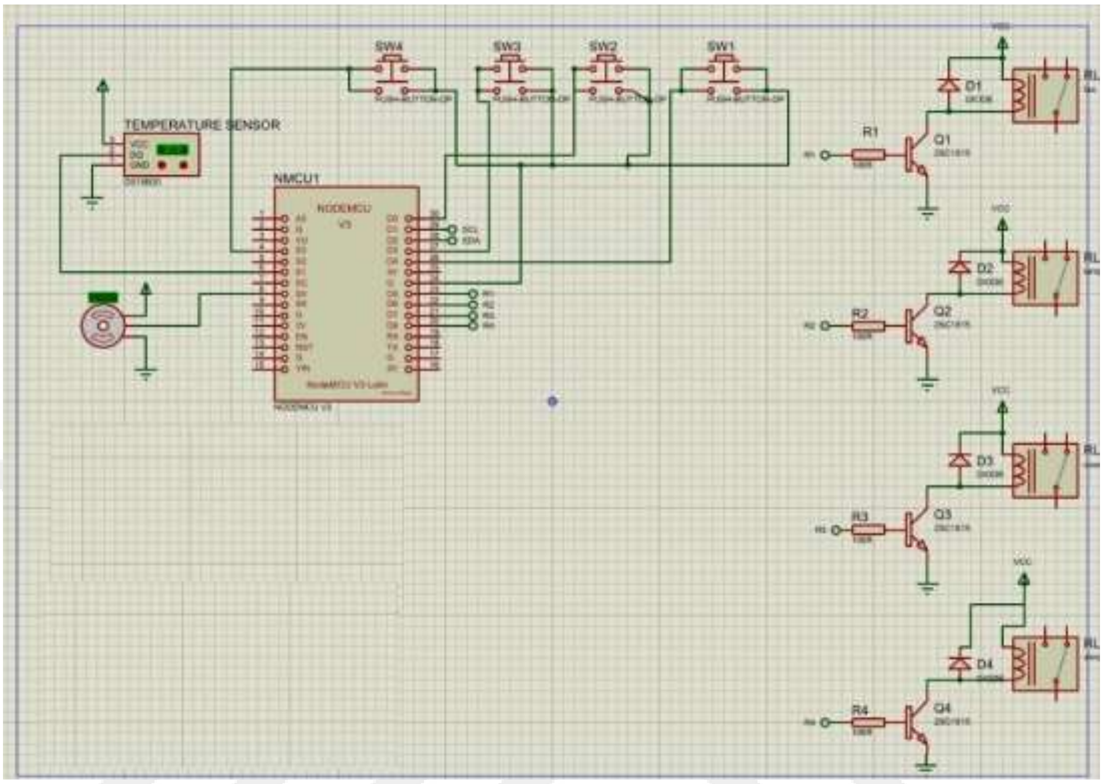

Figure 16. ESP8266 NodeMCU based schematic diagram

LM35 temperature sensor is used for visualizing temperature behaviour in real time environment. The LM35 is a thermometer with an analogue output voltage that varies with temperature. It gives output voltage in degrees Celsius (Celsius). No additional calibrating circuitry is needed. The LM35 is 10 mV/degree Celsius sensitive. Output voltage increases along with temperature. Upon increasing and decreasing temperature either AC or Inverter will turn on and will keep room temperature at 25 degree Celsius.Four relays operating at 220V are used in circuit design to operate high power load of home automation (Albertini et al., 2022).

4.2 Arduino IDE

In addition to a text editor for writing code, a message area, a text console, a toolbar with buttons for frequently used operations, and a number of menus, the Arduino Integrated Development Environment, sometimes known as the Arduino Software (IDE), is also available (Galadima, 2014). In order to upload programmes and communicate with them, software communicates to the Arduino hardware. Sketches are computer programmes created using the Arduino Software (IDE). These drawings are created in a text editor and saved as files with the.ino extension. The editor offers functions for text replacement and text searching. When saving and exporting, the message section provides feedback and shows errors. The console

shows text generated by the Arduino Software (IDE), including error messages in their entirety and other data. The configured board and serial port are visible in the window's bottom right corner. You may create, open, and save sketches, validate and upload programmes, open the serial monitor, and more using the toolbar buttons are shown figure 17.

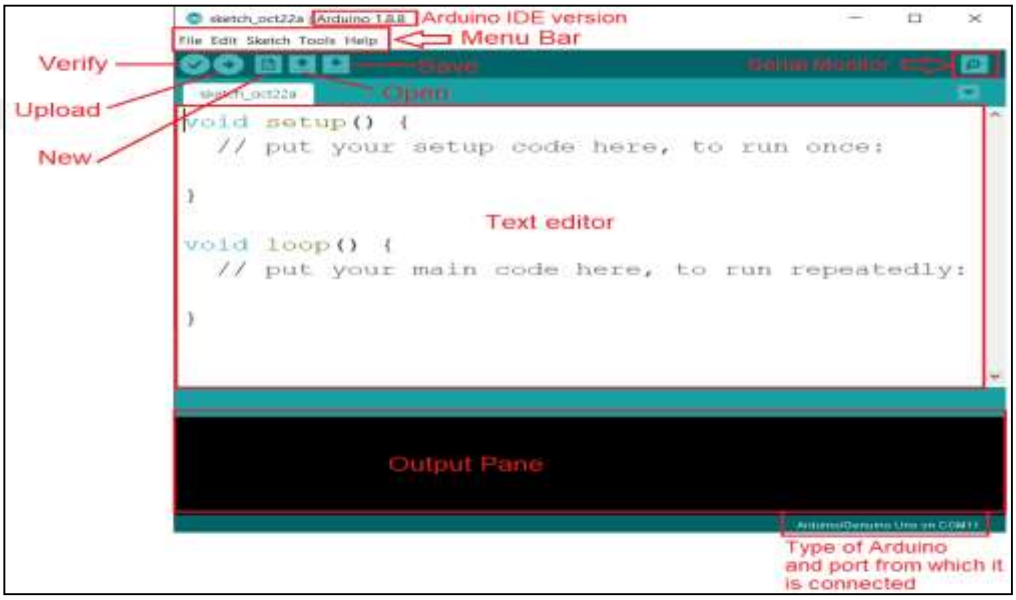

Figure 17. Arduino IDE

4.3 Arduino Proteus Library

Around 50,000 libraries are included with Proteus as standard. Each schematic component is bundled with one or more IPC-7351 compatible PCB footprints. Furthermore, the majority of the parts provide property definitions, such as stock code numbers that can be used in the bill of materials report. But it still lacks Arduino support. In order to make Arduino board functional we have to create/add custom Arduino Libraires in Proteus This Proteus Arduino Library is the first of its type,figure 18. Arduino library added in Proteus supports following Arduino boards (Galadima, 2014).

- Arduino UNO

- Arduino Mega 2560
- Arduino Mega 1280
- Arduino Nano
- Arduino Mini

-

Figure18. C\C++ Arduino based code file

4.4 Proteus Routing Diagram

All editions of Proteus' professional PCB Design software include with a shape-based autorouter that is completely integrated and included at no extra cost. With all versions of Proteus, the router uses cutting-edge cost-based conflict reduction algorithms that have been shown to maximise completion rates on even the most densely packed boards (Albertini et al., 2022). The router can only be used interactively or with the creation of unique router scripts by users who have access to the sophisticated feature set (PCB Design Level 2 or higher).

The router looks for a routing solution that conforms to the natural flow of the nets using a multi-pass cost-based conflict reduction technique. The most efficient method for achieving high completion rates is presently thought to be adaptive routing algorithms, which also frequently produce outcomes that are difficult to distinguish from manual routing. Router Diagram for designed home automation system is attached as figure 19;

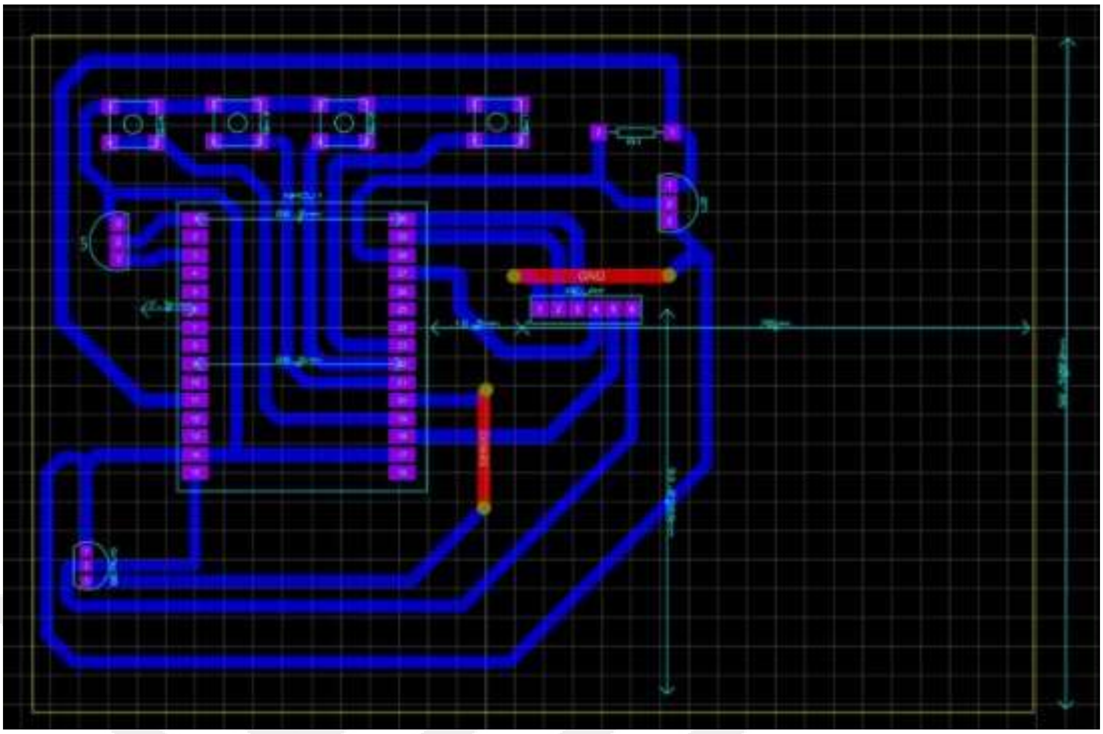

Figure 19. Routing Diagram

4.5 Proteus 3D Visualizor

PCB development is integrated into the Proteus workflow when used in conjunction with their leading PCB design tools (optional). By doing this, you may be sure that your simulated project is ready for manufacture from beginning to end, just as it was when it was successfully simulated. The last touch before your board is built and populated is a 3D visual of the PCB.Whatever PCB design software you use, you'll almost probably be able to launch it and visualise the board in three dimensions. Very frequently, this is disregarded as a pre-sales tool that looks nice rather than a feature that the engineer will actually utilise.Will examine the top three applications for the Proteus Design Suite's 3D Viewer in this post and make the assumption that the outcomes would be consistent across the sector (Albertini et al., 2022).

4.6 IOT Based Home Automation by Using ESP8266 (NodeMcu)

After this project is successfully completed, you will be able to use your smartphone to operate home's appliances, including your television, fans, lights, motors, refrigerators, and door locks, from anywhere in the globe. Esp8266, a wifi module, is essential to an IOT-based project for home automation.

Smartphone will send commands wirelessly via the internet to a Esp8266 module. An app needed to execute this work in order to encode the orders on a smartphone and send them to the ESP8266. There are several applications available, but we're just going to pick the best one, Android devices. Since already know that IOT is completely dependent on internet access, this project requires streamless internet connectivity. In MQTT, each client can publish/subscribe to any topic. The topic is like a channel, which can be used to send/receive data through the MQTT broker show figure 20. In this project, NodeMCU & "Arduino IoT Cloud Remote" (mobile) will act as MQTT clients and Arduino IoT is an MQTT broker show figure 16. I used Arduino IoT Cloud as an MQTT broker figure 21. l got the **username, password, Network_ID, Device_ID,** from Arduino IoT Cloud.I could also use any other MQTT broker, I just have to update the details in the code.

Here, I have created the topic "**switch1**" to control the relay-1, and the topic "**switch1_status**" to get the feedback.

The NodeMCU (MQTT client) will subscribe to the "**switch1**" topic and publish data on the "**switch1_status**" topic.

In this project, when NodeMCU received "**0**" on the "**switch1**" topic, it will turn on the relay-1, and for "**1**", it will turn off the relay-1.

After turning ON/OFF the relay-1, the NodeMCU will publish the status ("0″/"1") on "**switch1_status**" topic. The "Arduino IoT Cloud Remote" app will receive the feedback sent by NodeMCU on the "**switch1_status**" topic.

Thus can control the relay-1, and monitor the real-time status in the "Arduino IoT Cloud Remote" app (mobile).

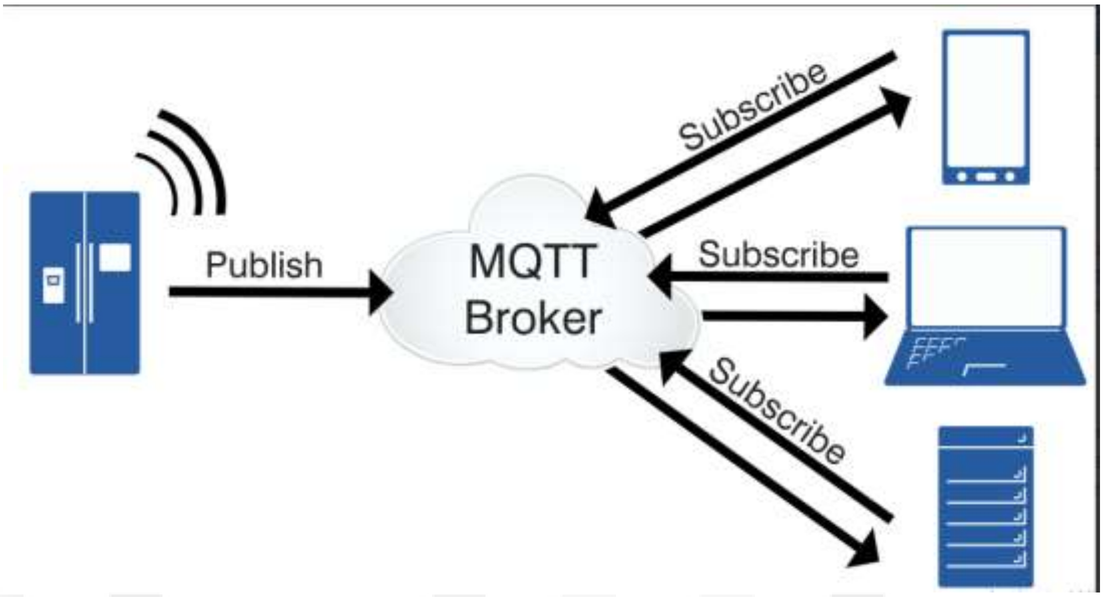

Figure 20. MQTT protocol works

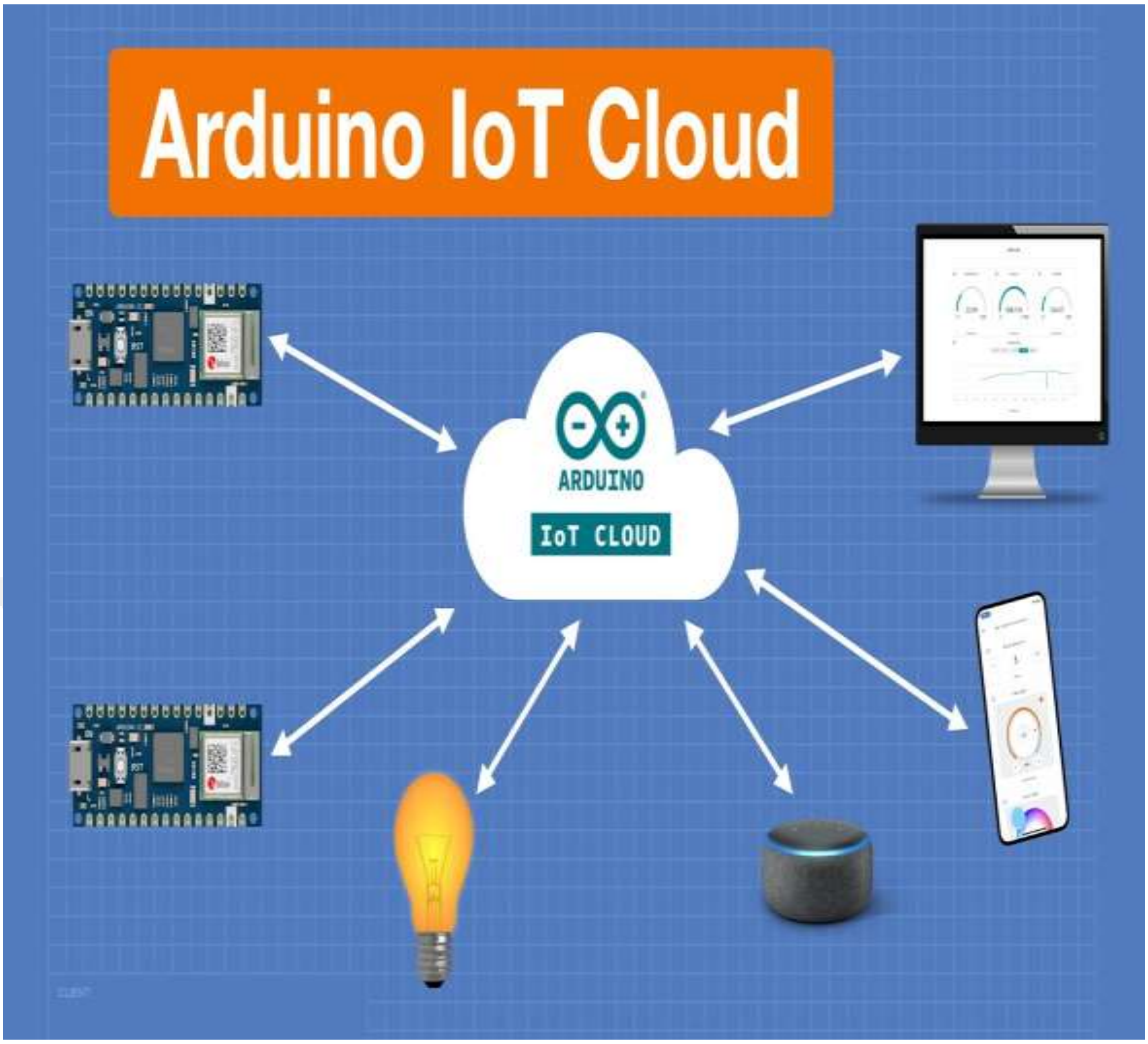

Figure 21. Arduino IoT Cloud

The " Arduino IoT Cloud Remote" app figure 22 or any other MQTT client can be used to control household appliances if the NodeMCU is WiFi-connected. Although you can use any other programs, I've chosen Arduino IoT Cloud as a MQTT broker and the " Arduino IoT Cloud Remote" app as a MQTT client in this example.The appliances can also be managed by various smartphones. You must connect to the same MQTT broker for that. All cellphones will function as MQTT clients in this fashion. Relays can be managed and their status tracked in real time from anywhere in the world.

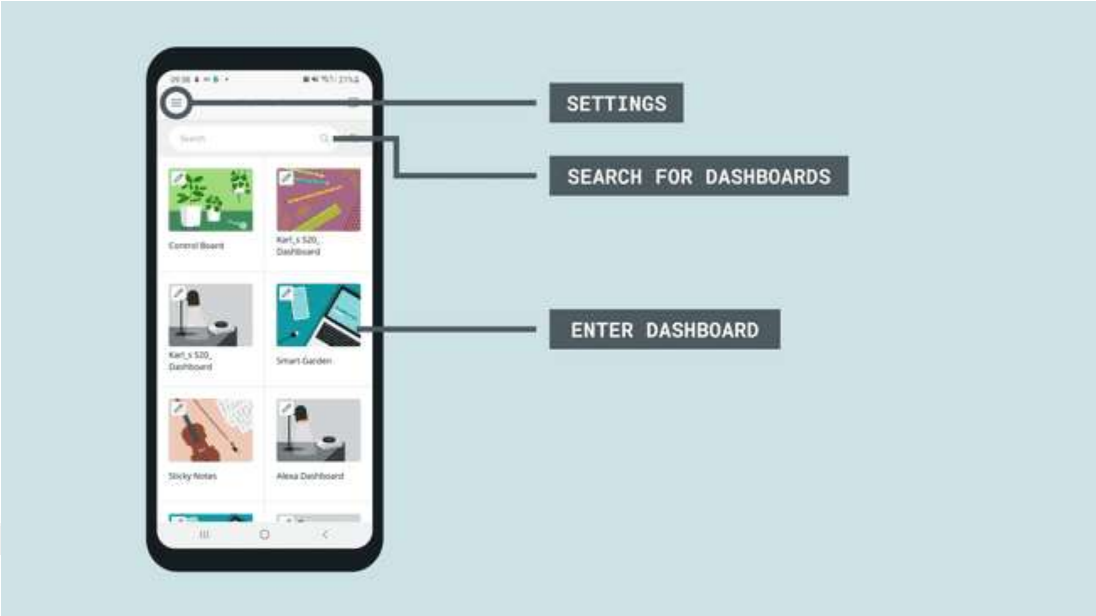

Figure 22. Arduino IoT Cloud Remote

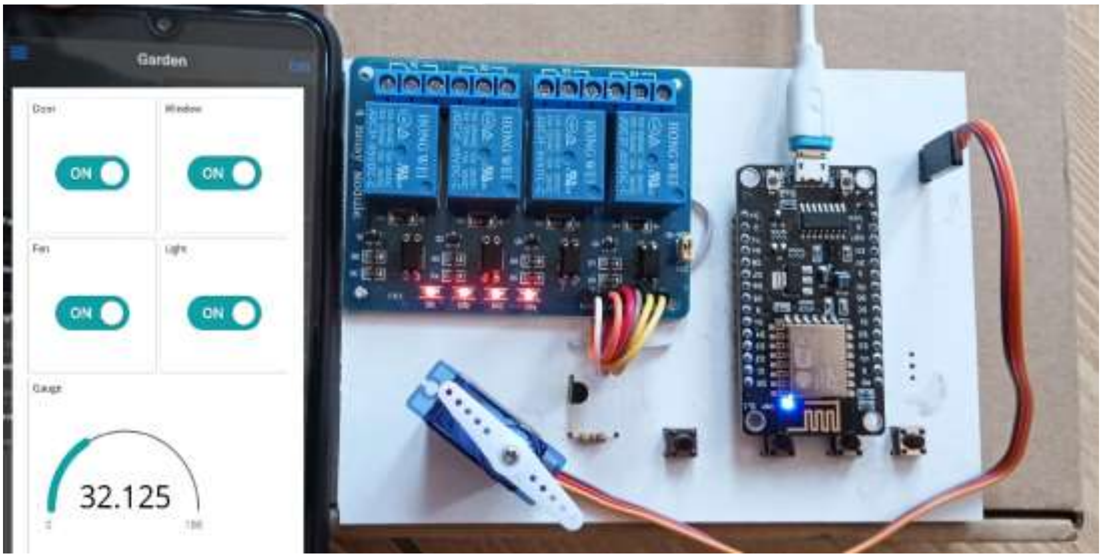

Figure 23. Finally, the Smart Home System

CONCLUSION AND RECOMMENDATIONS

The subject matter of this dissertation is the generation and execution of smart home automation systems with emphasis on the significance of the simulated findings. Our research substantiates that elevate security measures, and further user satisfaction. Nevertheless, the challenges of interoperability, data privacy, and user acceptance remain to be tackled.

The outcomes of our analysis of the smart home automation system offer meaningful comprehension into its efficiency and usefulness. We evaluated the system's ability to save energy, enhance security, and provide user satisfaction. The study revealed noteworthy enhancements when compared with conventional homes. The performance of the system was impacted by an array of elements, including the devices used, network topology, and user behavior. Our study emphasizes the significance of considering such factors when creating and executing smart home automation systems.

Furthermore, our investigation found a number of obstacles which require attention to guarantee the prosperous uptake and execution of intelligent home automation systems. Compatibility remains a substantial complication as gadgets from various manufacturers and platforms necessitate seamless communication. Confidentiality of data is also a worry, as intelligent home automation systems engender copious amounts of private data that necessitate safeguarding. Lastly, acceptance by users continues to be a crucial element, as users must be informed about the advantages of intelligent home automation and how to utilize it proficiently.

To summarize, smart home automation technology has the capability to revolutionize our lifestyle and interaction with technological devices in our households. Nonetheless, we must address various obstacles to ensure the smooth introduction and execution of such systems. To improve the performance and ease of use of smart home automation systems, upcoming analyses should prioritize producing solutions against these obstructions. The expanding scope of technology indicates that smart home automation will likely become a routine aspect of our daily lives in the immediate future.

Future work

Future enhancements for Proteus could include implementing voice and hand gesture recognition for more intuitive use, integrating with smart grids for real-time energy monitoring, utilizing AI to improve system intelligence and personalization, prioritizing user experience with more user-friendly interfaces, and increasing focus on energy efficiency and renewable energy integration in response to climate change.

REFERENCES

Albertini, N., Baldini, J., Dal Pino, A., Lazzari, F., Legnaioli, S., & Barone, V. (2022). PROTEUS: an immersive tool for exploring the world of cultural heritage across space and time scales. *Heritage Science*, *10*(1), 71.

Amoran, A. E., Oluwole, A. S., Fagorola, E. O., & Diarah, R. S. (2021). Home automated system using Bluetooth and an android application. *Scientific African*, *11*, e00711.

Aqeel-ur-Rehman, R. A., & Khursheed, H. (2014). Voice controlled home automation system for the elderly or disabled people. *Journal of Applied Environmental and Biological Sciences*, *4*, 55–64.

Che-Bin, F., & Hang-See, O. (2016). Research Article A Review on Smart Home based on Ambient Intelligence, Contextual Awareness and Internet of Things (IoT) in Constructing Thermally Comfortable and Energy Aware House. *Research Journal of Applied Sciences, Engineering and Technology*, *12*(7), 764–781.

Chen, F., Huo, Y., Zhu, J., & Fan, D. (2020). A review on the study on MQTT security challenge. *2020 IEEE International Conference on Smart Cloud (SmartCloud)*, 128–133.

Daş, R., & Ababaker, T. (2021). Design and Application of A Smart Home System Based on Internet of Things. *European Journal of Technique (EJT)*, *11*(1), 34–42.

Galadima, A. A. (2014). Arduino as a learning tool. *2014 11th International Conference on Electronics, Computer and Computation (ICECCO)*, 1–4.

Hajar, I., Hafizd, M., Dani, A. W., & Miharno, S. (2018). Monitoring of electrical system using internet of things with smart current electric sensors. *Sinergi*, *22*(3), 211–218.

HandsOn Tech – Open Source Electronics Platform. (n.d.). https://handsontec.com/

Herrero, R. (2019). Analytical model of IoT CoAP traffic. *Digital Communications and Networks*, *5*(2), 63–68.

Hoque, M. A., & Davidson, C. (2019). Design and implementation of an IoT-based smart home security system. *International Journal of Networked and Distributed Computing*, *7*(2), 85–92.

Jumini, S., Trisnowati, E., & Dahnuss, D. (2020). Proteus as a virtual simulation to improve readiness and process skills in laboratory experiment. *Journal of Physics: Conference Series*, *1517*(1), 12074.

Li, M., & Lin, H.-J. (2014). Design and implementation of smart home control systems based on wireless sensor networks and power line communications. *IEEE Transactions on Industrial Electronics*, *62*(7), 4430–4442.

Lianda, J., & Amri, H. (2023). Application Cosmic Lora Ray for the Development of Peatland Forest Fire Prevention System in Indonesia. *International Journal of Intelligent Systems and Applications in Engineering*, *11*(2), 864–869.

Lu, Q., Guo, Q., & Zeng, W. (2022). Optimization scheduling of home appliances in smart home: A model based on a niche technology with sharing mechanism. *International Journal of Electrical Power & Energy Systems*, *141*, 108126.

Mohanty, J., Mishra, S., Patra, S., Pati, B., & Panigrahi, C. R. (2021). IoT security, challenges, and solutions: a review. *Progress in Advanced Computing and Intelligent Engineering: Proceedings of ICACIE 2019, Volume 2*, 493–504.

Öztürk, A., & Naimi, S. (2017). Akıllı Ev Sistemlerinde Kullanılan Yöntemlerin Farkları, Avantajları Ve DEZAVANTAJLARI. *İstanbul Aydın Üniversitesi Dergisi*, *9*(4), 115–125.

Palaniappan, S., Hariharan, N., Kesh, N. T., & Vidhyalakshimi, S. (2015). Home automation systems-A study. *International Journal of Computer Applications*, *116*(11).

Pipattanasomporn, M., Kuzlu, M., & Rahman, S. (2012). An algorithm for intelligent home energy management and demand response analysis. *IEEE Transactions on Smart Grid*, *3*(4), 2166–2173.

Ramlee, R. A., Tang, D. H. Z., & Ismail, M. M. (2012). Smart home system for disabled people via wireless bluetooth. *2012 International Conference on System Engineering and Technology (ICSET)*, 1–4.

Serda, M. (2013). *Synteza i aktywność biologiczna nowych analogów tiosemikarbazonowych chelatorów żelaza*.

Sethi, P., & Sarangi, S. R. (2017). Internet of things: architectures, protocols, and applications. *Journal of Electrical and Computer Engineering*, *2017*.

Sikder, A. K., Acar, A., Aksu, H., Uluagac, A. S., Akkaya, K., & Conti, M. (2018). IoT-enabled smart lighting systems for smart cities. *2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC)*, 639–645.

Singh, H., Pallagani, V., Khandelwal, V., & Venkanna, U. (2018). IoT based smart home automation system using sensor node. *2018 4th International Conference on Recent Advances in Information Technology (RAIT)*, 1–5.

Singh, M., Rajan, M. A., Shivraj, V. L., & Balamuralidhar, P. (2015). Secure mqtt for internet of things (iot). *2015 Fifth International Conference on Communication Systems and Network Technologies*, 746–751.

Sivagami, P., Jamunarani, D., Abirami, P., Pushpavalli, M., Geetha, V., & Harikrishnan, R. (2021). Smart home automation system methodologies-a review. *2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)*, 1386–1390.

Sruthy, S., & George, S. N. (2017). WiFi enabled home security surveillance system using Raspberry Pi and IoT module. *2017 IEEE International Conference on*

Signal Processing, Informatics, Communication and Energy Systems (SPICES), 1–6.

Stolojescu-Crisan, C., Crisan, C., & Butunoi, B.-P. (2021). An IoT-based smart home automation system. *Sensors*, *21*(11), 3784.

Taiwo, O., Ezugwu, A. E., Oyelade, O. N., & Almutairi, M. S. (2022). Enhanced intelligent smart home control and security system based on deep learning model. *Wireless Communications and Mobile Computing*, *2022*, 1–22.

Wang, C., Liu, Q., Xing, L., Guan, Q., Yang, C., & Yu, M. (2022). Reliability analysis of smart home sensor systems subject to competing failures. *Reliability Engineering & System Safety*, *221*, 108327.

Yang, J., Zou, H., Jiang, H., & Xie, L. (2018). Device-free occupant activity sensing using WiFi-enabled IoT devices for smart homes. *IEEE Internet of Things Journal*, *5*(5), 3991–4002.

Zhang, Y., Huang, W., & Shi, Y. (2015). Research on the Design and Implementation of Smart Home System based on ARM and ZigBee Techniques with the Analysis of Data Transmission Security Enhancement Model. *3rd International Conference on Management Science, Education Technology, Arts, Social Science and Economics*, 870–874.

APPENDIXES

Code the project

/*

CloudLight door;

CloudLight fan;

CloudLight light;

CloudLight window;

CloudTemperatureSensor temperature;

Variables which are marked as READ/WRITE in the Cloud Thing will also have functions

which are called when their values are changed from the Dashboard.

These functions are generated with the Thing and added at the end of this sketch.

*/

#include "thingProperties.h"

/*

Sketch generated by the Arduino IoT Cloud Thing "Untitled"

https://create.arduino.cc/cloud/things/3ac804f2-200a-464a-a8f0-511683bf6b4b

Arduino IoT Cloud Variables description

```
The following variables are automatically generated and updated when changes are made to the Thing

  CloudLight door;
  CloudLight fan;
  CloudLight light;
  CloudLight window;
  CloudTemperatureSensor temperature;

  Variables which are marked as READ/WRITE in the Cloud Thing will also have functions
  which are called when their values are changed from the Dashboard.
  These functions are generated with the Thing and added at the end of this sketch.
*/

#include "thingProperties.h"

#include <OneWire.h>
#include <DallasTemperature.h>
#include <Servo.h>

#define RelayPin1 D0  //D0
#define RelayPin2 D1  //D1
#define RelayPin3 D3  //D3
#define RelayPin4 1   //TX
```

```
// Switches
#define SwitchPin1 D5   //D5
#define SwitchPin2 D6   //D6
#define SwitchPin3 D7  //D7
#define SwitchPin4 3   //RX

//WiFi Status LED
#define wifiLed    D4   //D4
Servo servo_m;

int toggleState_1 = 1; //Define integer to remember the toggle state for relay 1
int toggleState_2 = 1; //Define integer to remember the toggle state for relay 2
int toggleState_3 = 1; //Define integer to remember the toggle state for relay 3
int toggleState_4 = 1; //Define integer to remember the toggle state for relay 4

float tempC = 0;
#define ONE_WIRE_BUS D2
// Setup a oneWire instance to communicate with any OneWire devices (not just Maxim/Dallas temperature ICs)
OneWire oneWire(ONE_WIRE_BUS);
// Pass our oneWire reference to Dallas Temperature.
DallasTemperature sensors(&oneWire);

void setup() {
  // Initialize serial and wait for port to open:
```

```
Serial.begin(9600);
// This delay gives the chance to wait for a Serial Monitor without blocking if none is found
delay(1500);

sensors.begin();
pinMode(RelayPin1, OUTPUT);
pinMode(RelayPin2, OUTPUT);
pinMode(RelayPin3, OUTPUT);
pinMode(RelayPin4, OUTPUT);

pinMode(SwitchPin1, INPUT_PULLUP);
pinMode(SwitchPin2, INPUT_PULLUP);
pinMode(SwitchPin3, INPUT_PULLUP);
pinMode(SwitchPin4, INPUT_PULLUP);
pinMode(wifiLed, OUTPUT);
 sensors.begin();
servo_m.attach(D8);
 servo_m.write(0);
// Defined in thingProperties.h
initProperties();

// Connect to Arduino IoT Cloud
ArduinoCloud.begin(ArduinoIoTPreferredConnection);
```

```
  setDebugMessageLevel(2);
  ArduinoCloud.printDebugInfo();
}

void loop() {
  ArduinoCloud.update();
  temp_read();
  // Your code here
  manual_control();
   if (ArduinoCloud.connected()){
    digitalWrite(wifiLed,LOW);
  }
  else{
    digitalWrite(wifiLed,HIGH);

  }


}



/*
  Since Fan is READ_WRITE variable, onFanChange() is
  executed every time a new value is received from IoT Cloud.
*/
void onFanChange()  {
```

```
  if(fan == 1)     // Add your code here to act upon Fan change
  {
    digitalWrite(RelayPin1,LOW);


  }
  else
  {
    digitalWrite(RelayPin1,HIGH);


  }
}

/*
  Since Door is READ_WRITE variable, onDoorChange() is
  executed every time a new value is received from IoT Cloud.
*/
void onDoorChange()  {


  if(door == 1)     // Add your code here to act upon Fan change
  {
    digitalWrite(RelayPin2,LOW);


  }
  else
```

```
  {
    digitalWrite(RelayPin2,HIGH);


  }



}


/*
  Since Light is READ_WRITE variable, onLightChange() is
  executed every time a new value is received from IoT Cloud.
*/
void onLightChange()  {


  if(light == 1)     // Add your code here to act upon Fan change
  {
    digitalWrite(RelayPin3,LOW);


  }
  else
  {
    digitalWrite(RelayPin3,HIGH);


  }
}
```

```
/*
  Since Window is READ_WRITE variable, onWindowChange() is
  executed every time a new value is received from IoT Cloud.
*/
void onWindowChange()  {

  if(window == 1)     // Add your code here to act upon Fan change
  {
    digitalWrite(RelayPin4,LOW);
    servo_m.write(180);
  }
  else
  {
    digitalWrite(RelayPin4,HIGH);
    servo_m.write(0);
  }

}

void temp_read()
{
  sensors.requestTemperatures();
  tempC = sensors.getTempCByIndex(0);
      Serial.println(tempC);
      temperature = tempC;
    // dtostrf(tempC,7,3, temp);
```

```
}
void manual_control()
{
  if (digitalRead(SwitchPin1) == LOW){
    delay(200);
    if(toggleState_1 == 1){
      digitalWrite(RelayPin1, LOW); // turn on relay 1
      toggleState_1 = 0;
      fan = 1;

      }
    else{
      digitalWrite(RelayPin1, HIGH); // turn off relay 1
      toggleState_1 = 1;
      fan = 0;

      }
   }
   else if (digitalRead(SwitchPin2) == LOW){
    delay(200);
    if(toggleState_2 == 1){
      digitalWrite(RelayPin2, LOW); // turn on relay 2

      toggleState_2 = 0;
    door = 1;
```

```
    }
  else{
    digitalWrite(RelayPin2, HIGH); // turn off relay 2
    toggleState_2 = 1;
    door = 0;

    }
}
else if (digitalRead(SwitchPin3) == LOW){
  delay(200);
  if(toggleState_3 == 1){
    digitalWrite(RelayPin3, LOW); // turn on relay 3
    toggleState_3 = 0;
 light = 1;

    }
  else{
    digitalWrite(RelayPin3, HIGH); // turn off relay 3
    toggleState_3 = 1;
    light = 0;

    }
}
else if (digitalRead(SwitchPin4) == LOW){
     delay(200);
  if(toggleState_4 == 1){
```

```
      digitalWrite(RelayPin4, LOW); // turn on relay 4
      toggleState_4 = 0;
    window = 1;
    servo_m.write(180);
      }
     else{
      digitalWrite(RelayPin4, HIGH); // turn off relay 4
      toggleState_4 = 1;
     window = 0;
     servo_m.write(0);
      }
    }

}
```