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# Design and Implementation of an IOT based smart home automation system in real world scenario

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## Abstract

INTRODUCTION: Automation developments have significantly increased general convenience in modern technology. Our study focuses on developing and deploying an Internet of Things (IoT)–enabled smart home automation system that maximizes energy efficiency and improves convenience in residential settings. Our technology provides homes with an intelligent environment by smoothly combining several sensors, actuators, and communication protocols. We explore the challenges of creating a reliable and useful smart home system that works well in everyday situations. We investigate the difficulties, architectural issues, communication protocols, and security features specific to these systems.

OBJECTIVES: This project aims to use a database server and Wi-Fi module to develop an effective and reasonably priced smart home automation system. It improves accessibility and convenience by enabling smartphone voice control of household appliances.

METHODS: This project was developed using various implementation techniques, including wireless home automation via GSM technology, speech recognition-based systems, Blynk, and the Internet of Things. These techniques added up to a reliable and effective smart home system.

RESULTS: Although it improved user routines, the IoT-based smart home system had latency problems. Interoperability issues are still present. Improvements were guided by user input. Using Blynk, our software manages loads remotely.

CONCLUSION: A home automation system that is inexpensive and locally supplied can effectively operate household appliances. It is adaptable, scalable, and a component of future smart homes. IoT applications in real life revolutionize convenience and efficiency in living environments.

**Keywords:** Home Automation, Node MCU ESP-8266 Module, Wi-Fi Module, IoT, Voice-Controlled

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## 1. Introduction

In both daily experience and in relation to the global economy today, automation is an essential part of everyday life. The desire for an easy life is a hot topic nowadays since we live in an era of rapid technological advancement and minute-by-minute developments. Engineering industries concentrate on initiatives that progress and help their clients live comfortably and securely. In this paper, we suggest a system for the design and implementation of home automation.

This system can monitor and operate the house; it only takes a few seconds to update the data system. Because of this, an individual with worries or concerns can act quickly. Numerous methods can operate the system, including voice control, the Internet, and mobile devices. Our suggested approach includes a low-cost design, a user-friendly interface, and is easy to install in a home. By properly monitoring and managing, the user can reduce electrical power wastage with IoT technology.

## 2. Literature Survey

This study [15] presents the cheapest wireless medium for constant communication with the installed GSM (Global System for Mobile Communication) handset using a field programmable gate array (FPGA). This study [13] addresses the limitations of discrete features, low mobility, restricted updating capabilities, and reliance on personal computers by introducing IoT (Internet of Things) and ZIGBEE technologies via a 3G connection. The topic of this study [4] is wireless sensor networks (WSNs), which have gained prominence recently because of their capacity to handle situational data in real-time for a wide range of innovative uses. Zi SAS is an intelligent and self-adjusting ZigBee sensor.

An integrated micro-web server with IP connectivity powers the home management and monitoring system utilized in this study [12], giving Android users remote access to and control over appliances and smartphone apps. Compared to earlier solutions, the recommended method eliminates the need for a dedicated server PC. This study discusses an affordable smart home system based on an Android app that connects to a micro-web server to give functionality beyond simple switching [7]. The system's overall cost is kept low by using voice activation for switching operations and doing away with the need for a personal computer (PC).

Smart Home Automation technique using Raspberry Pi employing IoT is introduced in this study [11], which incorporates integrating cameras and motion sensors into a web application. We created this system with a Raspberry Pi module and computer vision algorithms. This allows us to control household appliances linked to an internet-based monitor. The Raspberry Pi operates and keeps track of motion using motion sensors and cameras. This paper [5] claims that residential energy usage can be easily accessed by improving it with PLC (Power Line Communication). A PLC- and Zigbee- based renewable energy gateway is also recommended to track the generation of renewable energy. It is suggested that an intelligent distribution of power management system be created using the ACS and DDEM algorithms to sustain the power supply for home networks.

The remote-control home automation system with the smartphone gives a very modern choice in this article [1]. A GUI application on the phone transmits commands to the receiver, while a Bluetooth module at the receiving end connects to the Arduino board. This study [17] focuses on a system that can be easily operated using IoT and offers home automation features. In addition, it offers notification-based home security and a camera module. In this project [8], design control is used in conjunction with IoT to make ordinary household appliances into smart and intelligent devices. Utilizing IoT connectivity, an energy-efficient system enables remote access to the smart home. The proposed system uses IFTTT to identify voice commands and the Node MCU as a microcontroller.

This study [18] suggests a way to reduce processing overheads in contemporary smart home systems that use various encryption algorithms, such as AES, ECHD, hybrid, and so on. These systems connect many sensors through the use of an intermediate gateway. This study [9] proposes merging sensors, actuators, and other data sources to achieve multiple home automation. The foundation of a popular and simple communication method is an Application Programming Interface (API), which serves as the foundation for the Toggle system. The Smart Home Automation System in this article [6] offers fully functional voice-based ways to interface with home appliances using various technologies, including GSM, NFC, and others. It utilizes the Internet of Things, artificial intelligence, and natural language processing (NLP).

## 3. Motivation

Much has been written about how everything is being regulated by the Internet of Things (IoT). More sophisticated and clever solutions have been used in the home automation space. Consequently, the end user may interact with appliances with ease since they can learn from him or her and respond to their requests without requiring a button push. Because of this, wireless sensor nodes have become more significant and are now necessary for the effective use of home automation. One of the main benefits of automating household appliances is energy savings. Therefore, the consumer must be informed about how much energy the automated appliances use. Excellent energy conservation and comfort at affordable prices and increased e ciency are essential in emerging nations like India, where people lead hectic lives.

## 4. Objective

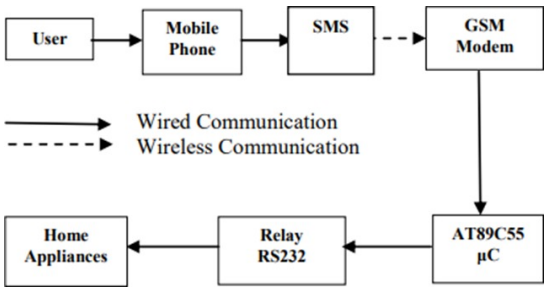
The major objective of this project is to employ readily available components to design, develop, and implement an economical and effective smart home

automation system with the help of a database server and a Wi-Fi module. With the advancement of technology, homes are growing modern. Smarter homes are cautiously switching to automated controlled systems from the ordinary switches. Currently, the old-fashioned wall switches are positioned all over the home in different p ositions, m aking t he user move closer to the switch to operate those. For physically disabled persons, it can be even more challenging to operate those switches and perform these types of operations. To switch from these operations and to make our lifestyle more effective, o ur project comes into play. Our project assists in controlling all home gadgets with our own voice through a smartphone, thus making life smoother and more progressive. The gadget is manufactured using a methodology such that it can be easily handled, installed and configured, and even in the cases of application and maintenance, it is very easy for those not from a technical background. Home automation involves the introduction of several electronic and electrical gadgets that are used in our daily life in our living places. It also includes a water tank, pump control system, as well as any other electrical appliances. A Node MCU ESP-8266 module is connected through a live database server to achieve near unlimited connectivity with your home appliances to reach the objective. The smartphone consists of a GUI App with an ON/OFF command. These commands send information to the server where the loads are controlled. When touching a particular position on the GUI, the loads are turned ON or OFF remotely with this technology's help.

## 5. Methodology

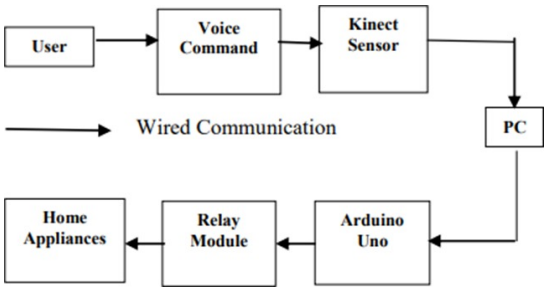
### 5.1. Wireless Home Automation System Using GSM Technology

Global Systems supports Home Automation through Mobile Communication [3]. Some of the characteristics of GSM are that it runs mostly on the mobile network and is battery-operated. The microcontroller and the GSM modem make up its two main parts. The Home Automation System (HAS) and the end user are connected through the GSM modem. Actuators and sensors, among other domestic equipment, are connected to the GSM via a microcontroller. Mobile phone numbers are the primary means of identifying users. The GSM modem receives SMS messages sent by authorized users using their mobile phones via the GSM network. The AT89C55 microcontroller may receive and interpret orders by connecting to the GSM modem. The GSM modem and the AT89C55 microcontroller may communicate serially thanks to the usage of Relay RS232. After that, these relays are connected to actuators and sensors, enabling the devices to be controlled and monitored.




### 5.2. Home automation system based on speech recognition

Nowadays, we use speech recognition in many applications like iPhone voice assistant SIRI, Google Voice Search, Amazon Alexa etc. This is designed for centralized controlling [14]. A Kinect v2 sensor was used to provide such control. The sensor uses voice signal, with audio quality is improved by removing any background music. Sound is divided into 24 frames and the central controller receives this sound. After receiving the sound, the whole thing is processed by the controller. In this case, system accuracy is 95% and distance between user and sensor is 4m.

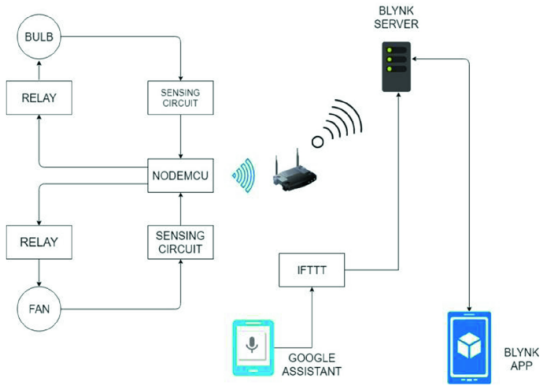



### 5.3. Home automation system based on Blynk

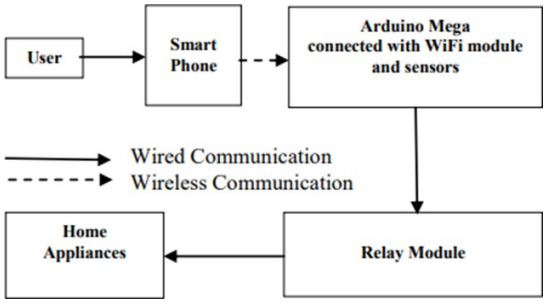
The Blynk app controls a home automation system that uses a 4-channel relay module and a NodeMCU ESP8266 to remotely control various equipment. Blynk may transmit commands to the NodeMCU module by connecting it to the internet using Wi-Fi. The 4-channel relay serves as a switchboard, controlling various appliances. Blynk provides a user-friendly interface for real-time monitoring and control of connected devices. Users can customize the Blynk app to create virtual buttons, sliders, or timers for each connected device. The NodeMCU, acting as a bridge, interprets Blynk app commands and triggers the corresponding relays, automating home devices seamlessly.

### 5.4. Home automation system based on IOT

Actuators and sensors acquire data from the surrounding environment. Subsequent to this, additional processing is done on the data to produce information [16]. Due to the data acquired via this method, users may even utilize the appliances away from home.




The microprocessor provides input to the relay board. On the household appliances, users may observe this activity [10]. The hardware interface module appropriately allies the home automation system's sensors and actuators [2]. The end user can access the server by using the same technology [4].




## 6. Proposed Method

The Blynk Cloud is the core repository for the Blynk real-time database, where data is structured and arranged using the JSON language. This dynamic database ensures seamless and rapid updates across all interconnected clients, including Android, iOS, and online applications. The Blynk Cloud allows users to easily share and synchronize their databases across several platforms.

### 6.1. Offline Accessibility

The Blynk Cloud's excellent offline support is one of its distinguishing features. Even without an internet connection, the Blynk-powered application has full access to the data saved in the Blynk real-time database. This offline feature ensures that users may interact with and alter data on their mobile devices or online apps even when not connected to the internet.

### 6.2. Automatic Synchronization

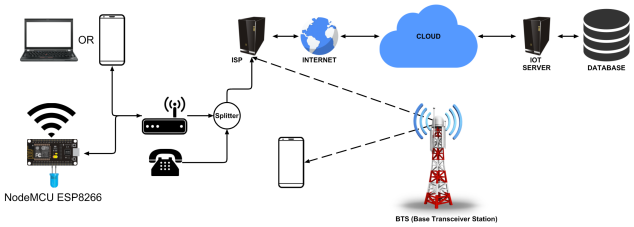
The Blynk Cloud manages data update synchronization flawlessly, guaranteeing that any changes performed in offline mode are automatically synced with the Blynk Cloud whenever the device reconnects to the internet. This real-time synchronization technique functions in milliseconds, ensuring that the most recent information is always available across all connected devices.

### 6.3. Multi-Platform Accessibility

The Blynk Cloud's adaptability extends to various client devices, including mobile (Android and iOS) and online apps. Users can interact with the Blynk real-time database using their preferred platform, offering a uniform and accessible experience across various devices.

### 6.4. Security

The security of the Blynk home automation software is critical, assuring the protection of sensitive user data and the integrity of connected devices. With strong encryption algorithms, Blynk secures communication between the app and devices, preventing unauthorized access. Two-factor authentication adds extra protection and regular software updates fix problems as they arise. Secure APIs and token-based authentication techniques strengthen the platform's defences against cyber threats. Continuous monitoring and adherence to industry security standards help to build a resilient home automation ecosystem, ensuring users a safe and dependable smart home experience.




## 7. Design and Development

### 7.1. Hardware Components

The NodeMCU ESP8266 is a small, multifunctional development board with the ESP8266 Wi-Fi module. The ESP8266 chip makes wireless communication and Internet of Things applications possible. The NodeMCU ESP8266, which has an inbuilt Wi-Fi module, GPIO connectors, and a 32-bit Tensilica microcontroller, is a popular choice for IoT project development and prototyping due to its low cost and simple interface. Firmware and data have plenty of room on the NodeMCU ESP8266, which has 4MB of flash memory for program storage. Its built-in USB-to-Serial converter

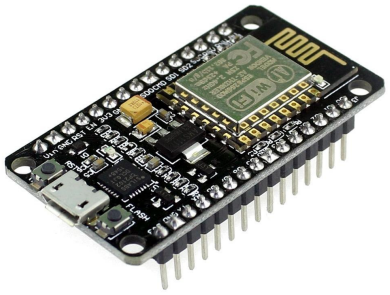


**Figure 1.** NodeMCU ESP8266

and wide voltage range (3.3V) make programming and troubleshooting simple.

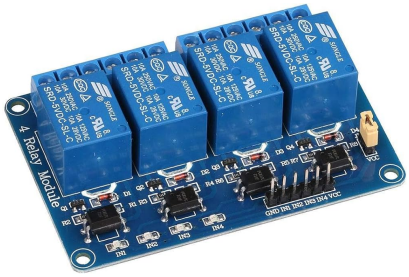



**Figure 2.** 4 Channel Relay Module

A 4-channel relay module is a versatile electronic component that can control several high-power devices. Each channel normally provides a switching voltage of 250V alternating current and a current of 10A, making it appropriate for a wide range of applications. The module is frequently powered by a low-level input signal (5V) and includes isolation to safeguard sensitive control circuits. Its four independent relay channels provide an easy-to-use solution for controlling and automating various electrical loads in applications, including robotics, industrial control, and home automation.

A breadboard is a versatile prototype tool in electronics that is used to make temporary circuit connections without soldering. It is often made up of a grid of interconnected metal clips that allow components to be inserted and easily connected. It promotes rapid experimentation and testing of electronic circuits due to consistent spacing for DIP (dual in-line package) components. Because of the breadboard's design, engineers and hobbyists can quickly prototype and change circuits for efficient electrical development.

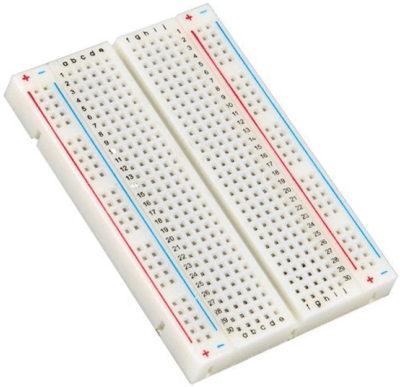


**Figure 3.** Breadboard


**Figure 4.** Arduino IDE 2.2.1

## 7.2. Software Components

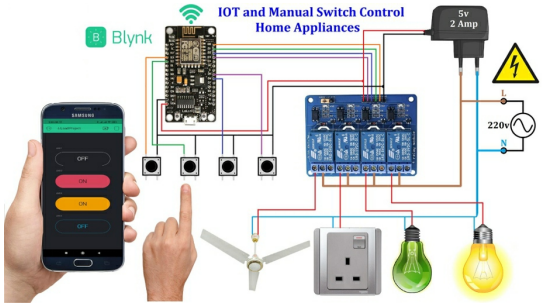
The Arduino IDE (Integrated Development Environment) provides a straightforward programming tool for Arduino microcontrollers. It features a simplified C/C++ syntax, which makes code production easier for newcomers. Its simple interface enables smooth code uploading to Arduino boards via USB. The IDE also has a large library of pre-built functions, making integrating various hardware components and sensors into applications easier. This project used the Arduino IDE version 2.2.1.


**Figure 5.** Blynk Application

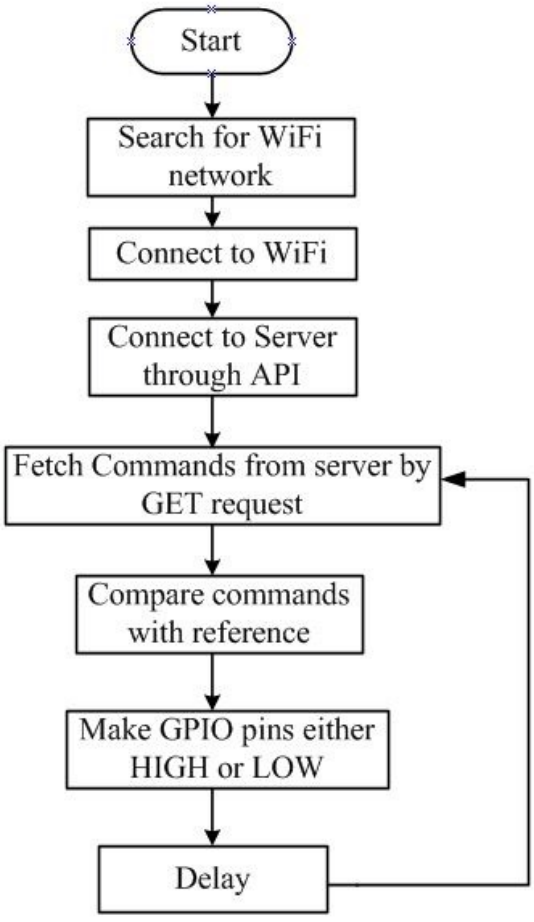
The Blynk app, built for home automation in this project, provides a dynamic platform for easy management of smart devices. It is compatible with various microcontrollers and IoT hardware, allowing users to create customized dashboards for monitoring and controlling connected devices. Blynk simplifies the construction of personalized automation interfaces by providing an easy interface with drag-and-drop capabilities. Furthermore, it offers real-time data visualization, push notification features, and easy connection with top IoT platforms, solidifying its

position as a powerful tool for developing successful and engaging smart home solutions.

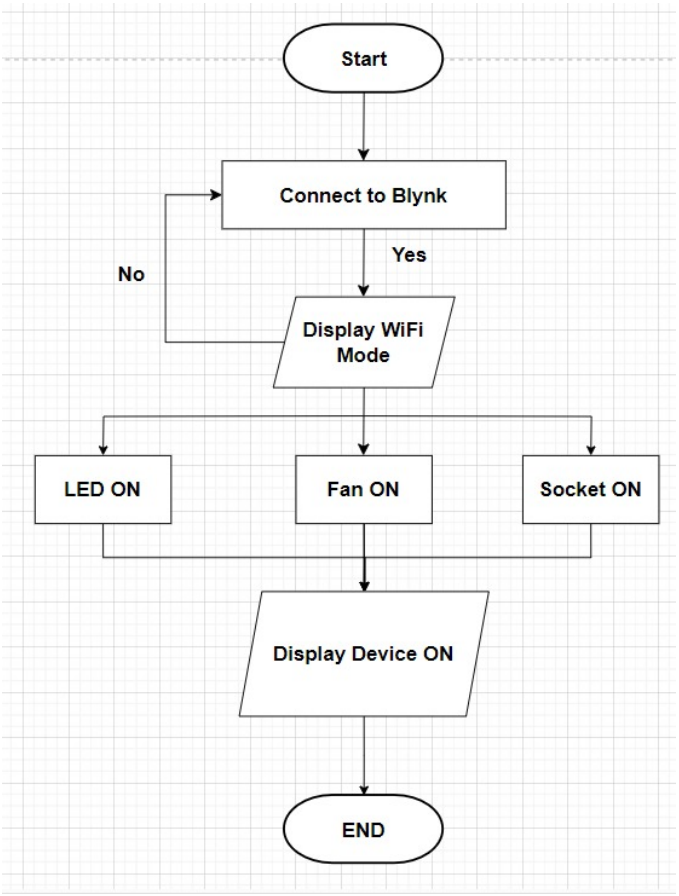
### 7.3. Circuit-Diagram




### 7.4. Flow-Chart 1 (For Hardware)




### 7.5. Flow-Chart 2 (For Software)




## 8. Result and Discussion

The circuit diagram created the experimental model, and the anticipated outcomes were obtained. It was possible to remotely control the home appliances using a Wi-Fi network. The control approaches for voice mode and switch mode were both effectively implemented. The Blynk application was successful in showing each application's status.

Our findings show that the Internet of Things-based smart home automation system functioned wonderfully in real-world scenarios regarding task automation and user-friendliness. The system greatly enhanced the users' everyday routines and was straightforward to set up and operate. Still, a few important facts were apparent:

1. Latency and Responsiveness: Although the system usually reacted quickly to user commands, occasionally long delays were seen, particularly during periods of high usage. This emphasizes the importance of decreasing latency by improving the network and cloud architecture.

2. Interoperability: The system successfully integrated a range of IoT devices from various manufacturers. However, several compatibility problems were found, underscoring the IoT ecosystem's continued need for standardized communication protocols and interoperability standards.

3. User Input: Insights from user input were extremely helpful in improving the user experience. Several users expressed a need for quick technical help and more customization choices, including the capacity to design unique automation rules. These suggestions should guide future system improvements.

### 8.1. Using Mobile App:

Using our developed app, we can control our total system and all loads using buttons specifically assigned to loads. We have designed a button widget to operate a fan via the Blynk app. Pressing the button initiates a signal to the microcontroller, turning the fan on or off. We've included a button widget to turn lights on and off similarly for lighting control. All these loads may be controlled from anywhere in the world using the Blynk App.

## 9. Future Scope

### 9.1. Automated Light Intensity Control:

Automation of light intensity in homes is positioned to become increasingly important as we move closer to a future with greater connectivity and intelligence. Traditional lighting systems are being replaced with smart lighting solutions that dynamically alter intensity based on ambient circumstances, user preferences, and time of day. To deliver a smooth and energy-efficient lighting experience, we will also look at integrating sensors, artificial i ntelligence, a nd m achine learning algorithms.

### 9.2. Advanced Security Features:

Security is still a top priority in home automation. We will look into using biometric authentication methods such as fingerprint a nd f ace r ecognition t o strengthen access control and secure personal spaces. These new security features are expected to replace or supplement traditional methods of house entrance, providing a more secure and convenient means of entry.

### 9.3. Integration of Gadgets:

Numerous smart gadgets have become vital in our daily lives. Home automation systems will easily incorporate smart thermostats, doorbell cameras, and voice-activated assistants. This integration strives to establish a cohesive, interconnected environment in which various devices communicat to improve overall efficiency and user experience.

## 10. Conclusion

This project's work clarifies low-cost, locally sourced individual control home automation systems may be built reasonably and utilized to operate various household equipment, such as air conditioner, door security and the lighting system for the entire house. After testing, the home automation system was allowed to control various domestic appliances, including air conditioning, home theatre and lighting. This setup is, therefore, flexible and expandable.

Our results demonstrate how important IoT technology will be in shaping the future of automation for smart homes. We can confidently traverse the constantly changing IoT ecosystem and smoothly incorporate it into our daily lives by taking care of performance concerns, guaranteeing security, improving scalability, and prioritising the user experience. By enabling previously unheard of levels of ease and efficiency in our homes, the practical use of IoT-based smart home automation systems can completely transform how we manage and interact with our living environments. The options are unlimited since the route towards smarter homes is constantly being planned.

## References

[1] Waqar Ali, Ghulam Dustgeer, Muhammad Awais, and Munam Ali Shah. Iot based smart home: Security challenges, security requirements and solutions. In *2017 23rd International Conference on Automation and Computing (ICAC)*, pages 1–6. IEEE, 2017.

[2] Priyang Bhatt, Bhasker Thaker, and Neel Shah. A survey on developing secure iot products. *International Journal of Scientific Research in Computer Science and Engineering*, 6(5):41–44, 2018.

[3] H ElKamchouchi and Ahmed ElShafee. Design and prototype implementation of sms based home automation system. In *2012 IEEE International Conference on Electronics Design, Systems and Applications (ICEDSA)*, pages 162–167. IEEE, 2012.

[4] Ahmed ElShafee and Karim Alaa Hamed. Design and implementation of a wifi based home automation system. *International Journal of Computer and Information Engineering*, 6(8):1074–1080, 2012.

[5] Punit Gupta and Jasmeet Chhabra. Iot based smart home design using power and security management. In *2016 International Conference on Innovation and Challenges in Cyber Security (ICICCS-INBUSH)*, pages 6–10. IEEE, 2016.

[6] Perumal Iyappan, Jayakumar Loganathan, Manoj Kumar Verma, Ankur Dumka, Rajesh Singh, Anita Gehlot, Shaik Vaseem Akram, Sukhdeep Kaur, and Kapil Joshi. A generic and smart automation system for home using

internet of things. *Bulletin of Electrical Engineering and Informatics*, 11(5):2727–2736, 2022.

[7] Shiu Kumar. Ubiquitous smart home system using android application. *arXiv preprint arXiv:1402.2114*, 2014.

[8] Md Sadad Mahamud, Md Saniat Rahman Zishan, Syed Ishmam Ahmad, Ahmed Rezaur Rahman, Mehedi Hasan, and Md Lutfur Rahman. Domicile-an iot based smart home automation system. In *2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)*, pages 493–497. IEEE, 2019.

[9] Mehul Manhas, Divij Sanduja, Nikhil Aggarwal, and Rashmi Vashisth. Design and implementation of artificial intelligence (ai) based home automation. In *2021 6th International Conference on Signal Processing, Computing and Control (ISPCC)*, pages 122–126. IEEE, 2021.

[10] Ms Preeti U Melikatti and Mr Vinayak V Palmur. Application of home automation system using google assistant. *Open Access Repository*, 9(5):31–37, 2022.

[11] Vamsikrishna Patchava, Hari Babu Kandala, and P Ravi Babu. A smart home automation technique with raspberry pi using iot. In *2015 International conference on smart sensors and systems (IC-SSS)*, pages 1–4. IEEE, 2015.

[12] Rajeev Piyare and Seong Ro Lee. Smart home-control and monitoring system using smart phone. *ICCA, ASTL*, 24:83–86, 2013.

[13] Rajeev Piyare and M Tazil. Bluetooth based home automation system using cell phone. In *2011 IEEE 15th International Symposium on Consumer Electronics (ISCE)*, pages 192–195. IEEE, 2011.

[14] KASV Rathnayake, SIAP Diddeniya, WKI L Wanniarachchi, WHKP Nanayakkara, and HN Gunasinghe. Voice operated home automation system based on kinect sensor. In *2016 IEEE International Conference on Information and Automation for Sustainability (ICIAfS)*, pages 1–5. IEEE, 2016.

[15] Uzair Saeed, Sana Syed, Sheryar Zahoor Qazi, Nida Khan, Aneeba Khan, and Muhammad Babar. Multi-advantage and security based home automation system. In *2010 Fourth UKSim European Symposium on Computer Modeling and Simulation*, pages 7–11. IEEE, 2010.

[16] A Sebastian and S Sivagurunathan. A survey on load balancing schemes in rpl based internet of things. *International Journal of Scientific Research in Network Security and Communication*, 6(3):43–49, 2018.

[17] Shradha Somani, Parikshit Solunke, Shaunak Oke, Parth Medhi, and PP Laturkar. Iot based smart security and home automation. In *2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA)*, pages 1–4. IEEE, 2018.

[18] Young-Sung Son, Topi Pulkkinen, Kyeong-Deok Moon, and Chaekyu Kim. Home energy management system based on power line communication. *IEEE Transactions on Consumer Electronics*, 56(3):1380–1386, 2010.