WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Versatile Smart Home Automation: Multiple Control Methods with IoT Technology

Mrs. Gummadi Subhashini[1] ,Atluri Gandhi Soumya[2],Syed Sahera Sultana[3], Batchu Jaswanth[4] ,Pedapudi Susmitha[5]

[1]Assistant professor Dept of CSE Dhanekula Institute of Engineering and Technology Vijayawada, India
Subhashinichaitanya2008@gmail.com
[2]Dept of CSE Dhanekula Institute of Engineering and Technology Vijayawada, India
gandhisoumyaatluri@gmail.com
[3]Dept of CSE Dhanekula Institute of Engineering and Technology Vijayawada, India
saherasyed19@gmail.com
[4]Dept of CSE Dhanekula Institute of Engineering and Technology Vijayawada, India
Bjaswanth61@gmail.com
[5]Dept of CSE Dhanekula Institute of Engineering and TechnologyVijayawada, India
susmithap2022@gmail.com

ABSTRACT:

This project presents a versatile Smart Home IoT system designed to enhance the convenience, efficiency, and flexibility of home automation. Unlike traditional smart home solutions that may rely on single control channels, our system allows users to manage appliances through multiple control methods, including Wi-Fi, Infrared (IR), voice commands (via Alexa and Google Assistant), and an integrated mobile application. These multi-channel options make it easy for users to interact with and control their appliances through their preferred method, enhancing accessibility for a wide range of users. The mobile application not only provides real-time control but also allows for automation and scheduling, enabling users to set routines and save energy by reducing unnecessary appliance usage. This feature empowers users to manage their homes efficiently, providing a higher level of customization and energy conservation.

Our Smart Home IoT system focuses on delivering a practical and user-friendly solution that meets the everyday needs of residential users. By incorporating various control options and automation features, this system offers a comprehensive, flexible, and cost-effective approach to smart home management, paving the way for future enhancements and adaptability in smart living spaces.

Keywords: SDN-Based Framework, Multi level Architecture, Smart Home Services, Software Designed Networking ,SDN, Smart Home Technology, Network Framework

INTRODUCTION :

The Smart Home IoT System with Multi-Ways Control is an advanced automation solution designed to enhance convenience, energy efficiency, and security in modern households. By integrating Internet of Things (IoT) technology, the system connects and controls various appliances, lights, and sensors, offering users multiple ways to interact with their smart home.

The system supports multi-modal control, including a mobile application, voice assistants (Alexa, Google Assistant), IR remote control, and traditional manual switches. This ensures accessibility for users with different technological preferences and provides flexibility in various situations. Additionally, the system incorporates automation and scheduling features, enabling appliances to function autonomously based on user-defined conditions, leading to optimized energy consumption.

Beyond control functionalities, the system includes environmental monitoring through temperature and humidity sensors, which provide real-time data via the mobile application. This allows users to maintain a comfortable indoor climate while improving energy efficiency. The IoT Hub serves as the central processing unit, ensuring seamless communication between devices.

Unlike traditional smart home solutions that rely on a single control method, this system addresses limitations such as dependency on the internet or usability challenges in noisy environments. Its scalable and modular architecture allows future expansions, supporting additional sensors and appliances without disruption.

By combining IoT technology with user-centric design, the Smart Home IoT System offers a robust, flexible, and sustainable solution for modern living. It enhances convenience, promotes energy efficiency, and sets a new benchmark for smart home automation

LITERATURE REVIEW :

[1] "A Unified Architecture for Smart Home Applications" by M. Satyanarayana, E. Y. Chen, and R. H. Katz. (2019).

Satyanarayana et al. (2019) propose a unified smart home architecture that enhances interoperability, scalability, and real-time responsiveness. Traditional systems operated in silos, causing inefficiencies and high latency due to cloud dependence. The proposed framework leverages edge computing to enable local data processing, reducing latency and reliance on internet connectivity. A middleware layer ensures seamless device communication, while dynamic service discovery automates device integration. Security is strengthened through encryption and authentication mechanisms. The study concludes that this architecture significantly improves smart home efficiency and user experience, providing a strong foundation for future IoT applications like smart cities and industrial automation.

[2] "IoT-Based Home Automation System Using Mobile Application" by P. R. Ramesh and N. Kumar. (2020).

In 2020, Ramesh and Kumar introduced an IoT-based home automation system using a mobile application and Wi-Fi-enabled microcontrollers like the ESP8266 for remote appliance control. Unlike traditional costly and inflexible systems, this cost-effective and scalable solution allows users to manage home devices via a user-friendly app with task scheduling and real-time status updates. The system uses the MQTT protocol for low-latency communication and supports multi-user access with encrypted, password-protected security. The authors conclude that their affordable and practical approach democratizes smart home technology, making it accessible to a wider audience.

[3] "Energy-Efficient Smart Home System Using IoT" by A. Gupta and S. Banerjee. (2021).

In 2021, Gupta and Banerjee introduced an energy-efficient smart home system that integrates IoT technology with energy monitoring and optimization. Unlike traditional automation-focused systems, their solution tracks and optimizes appliance energy usage using real-time sensor data on temperature, humidity, and light. The system adjusts appliances intelligently to minimize energy consumption while ensuring user comfort. It also prioritizes renewable energy sources like solar power and includes a mobile app for energy insights. By incorporating machine learning, it adapts to user habits for smarter energy management. Their study highlights IoT's potential for sustainable and intelligent smart home solutions.

[4] "Multi-Mode Control for IoT-Based Smart Home Systems" by J. Wong and K. Patel. (2020)

In 2020, Wong and Patel introduced a multi-mode smart home control system, integrating voice commands, mobile apps, and manual switches for enhanced convenience, accessibility, and reliability. Traditional systems relied on single control modes, limiting flexibility and usability for users without smartphones or stable internet. Their centralized hub, based on Raspberry Pi or ESP32, synchronizes all control methods in real time. The system prioritizes accessibility, supporting users with disabilities, and ensures reliability with manual switches that function during internet outages. Their study concludes that multi-mode control significantly improves smart home usability, setting a standard for future designs.

[5] "IoT-Based Smart Home Automation with Scheduling Capabilities" by R. Das and M. Singh. (2021).

Summary (100 words)

In 2021, Das and Singh introduced a smart home automation system with scheduling capabilities, enabling appliances to operate autonomously at predefined times. Unlike traditional systems requiring manual control, their IoT-based solution uses ESP32 microcontrollers and a mobile app for setting schedules, such as turning on lights at sunset. The system adapts to user habits with machine learning, adjusting for weekends or holidays. Security measures include encrypted storage and safeguards against conflicts. The study concludes that automated scheduling enhances convenience and energy efficiency, highlighting the need for autonomous features in modern smart home systems.

METHODOLOGIES :

1.Framework Design and Development:

- **Vertical Multi-level SDN-based Architecture:** The framework uses two controllers (Primary SDN Controller - PSC, and Local SDN Controller - LSC) in a parent-child hierarchy.
- **Cloud-Local Topology:** Combines cloud-based services with local smart home services to ensure better service delivery and reliability.
- **Service-Centric Approach**: The system focuses on delivering smart services rather than simply managing devices, ensuring that the service experience remains optimal.
- **Smart Home API:** A custom API was designed to enable smart services to communicate efficiently across the framework, simplifying service delivery and future service addition.

2. Prototype Development:

- A prototype system was implemented using *Mininet*, a widely used network emulation tool for SDN research.
- The system was deployed using OpenFlow switches (specifically, TP-LINK WR1043ND v2.1) to demonstrate real-time communication between smart home devices and the controllers.
- A web interface was developed for managing services, monitoring bandwidth, configuring VLANs, setting security policies, and applying access controls

3. Simulation and Performance Evaluation:

- To evaluate the framework, the authors simulated different smart home topologies in Mininet:
- Local Topology (only local controller)

- Cloud Topology (only cloud controller)
- Cloud-Local Topology (combined use of both controllers)
- Performance was measured using these metrics:
- Mean Throughput
- Round-Trip Time (RTT)
- Packet Loss

4. Service-Specific Testing:

- Specific smart home services were activated (like *Smart Kids Service*) to assess the bandwidth allocation framework and service prioritization.
- Bandwidth was dynamically adjusted based on service requirements to prioritize critical services (e.g., security services over entertainment services).

5. Security and Fault Tolerance:

- Real-time State Management Module: Continuously monitors the status of devices.
- Automatic Fault Detection: Based on relationships between devices (e.g., parent-child device relationships, social relationships between devices).
- Emergency Handling: In cases like floods or smoke detection, the controllers trigger alerts and take automatic action (e.g., notify emergency services).

6. Data Collection and Analysis:

- Performance data was collected through Mininet experiments using *iPerf* for bandwidth testing and custom scripts for RTT and packet loss measurement.
- Comparative analysis was conducted between POX, NOX, and Floodlight controllers to understand the performance impacts under different scenarios.

7. Comparison with Existing Solutions:

- The proposed methodology was benchmarked against existing SDN-based smart home solutions to highlight improvements in terms of:
- Service delivery reliability
- Fault tolerance
- Bandwidth optimization
- Security responsiveness

PROPOSED METHOD :

The proposed Smart Home IoT system introduces a sophisticated and adaptive approach to home automation, seamlessly blending modern technology with everyday living. By incorporating multiple control mechanisms such as Wi-Fi, Infrared (IR), voice commands via Alexa and Google Assistant, and a dedicated mobile application, the system ensures unparalleled accessibility and convenience for users. The mobile application acts as a centralized control panel, empowering users to manage their appliances effortlessly, whether they are at home or remotely located. Features like real-time monitoring, automation, and scheduling enable users to optimize appliance usage, significantly enhancing energy efficiency and reducing electricity costs.

One of the system's standout features is its ability to cater to diverse user needs by offering manual switch integration alongside advanced IoT controls, ensuring reliability during network interruptions. It also integrates temperature and humidity sensors, providing real-time environmental data that can be used for additional automation, such as adjusting air conditioners or dehumidifiers to maintain optimal comfort levels. This fusion of manual and automated controls not only improves system reliability but also broadens its appeal to users who prefer traditional interfaces.

The proposed system further emphasizes security and user convenience by incorporating role-based access, ensuring that only authorized individuals can make significant changes to appliance settings. The inclusion of automation capabilities, such as the ability to schedule appliances to turn on or off at specific times, transforms routine household operations into a streamlined and stress-free experience. For instance, users can schedule lights to turn on at dusk or coffee makers to start brewing in the morning, aligning appliance usage with their daily habits.

By integrating with popular voice assistants like Alexa and Google Assistant, the system provides a hands-free control option, making it particularly valuable for elderly or physically challenged individuals. The system's ability to adapt to user preferences and learn from usage patterns further ensures that it evolves to meet the unique requirements of each household. Overall, the proposed Smart Home IoT system not only revolutionizes conventional home environments but also sets a benchmark for future advancements in home automation technology. It offers a secure, efficient, and user-centric solution that redefines the way people interact with their living spac

IMPLEMENTATION :

The *Smart Home IoT system* is implemented using an *ESP32 microcontroller*, which connects appliances via *Wi-Fi and Infrared (IR)*. A *mobile application* **provides** *real-time control, automation, and scheduling*. *Voice commands* are integrated using *Alexa and Google Assistant* APIs. The system includes *relays* to switch appliances, *IR modules* for remote-controlled devices, and *sensors* **f**or real-time monitoring. A *cloud-based database* ensures seamless data storage and accessibility. The *user interface (UI)* in the app allows customization of automation routines. By combining these technologies, the system offers a *scalable, cost-effective, and energy-efficient* solution for *smart home management***.**

RESULTS :

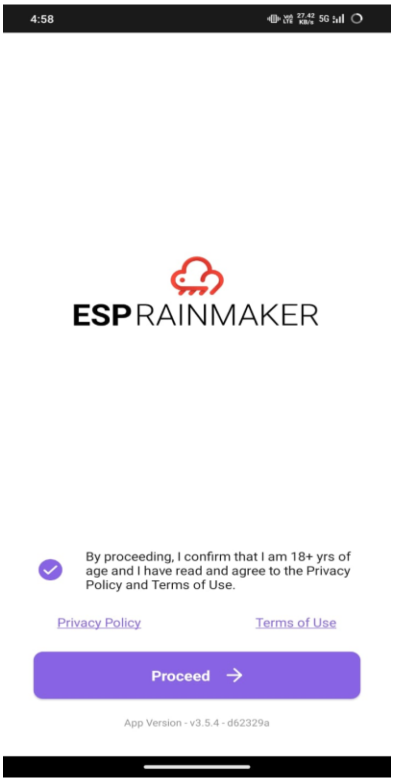

Fig1

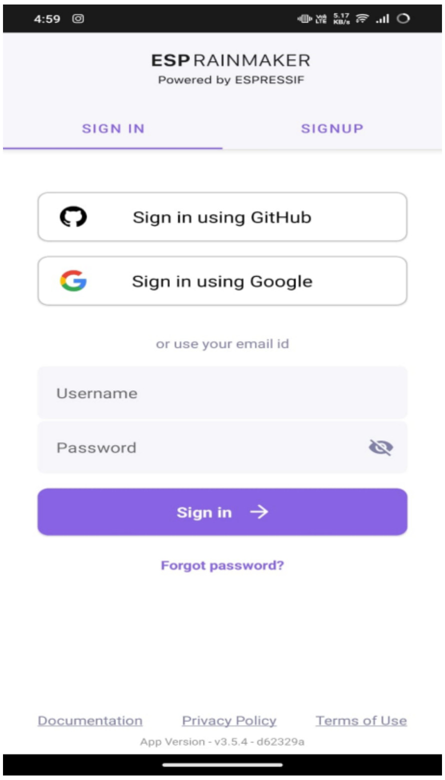

Fig2

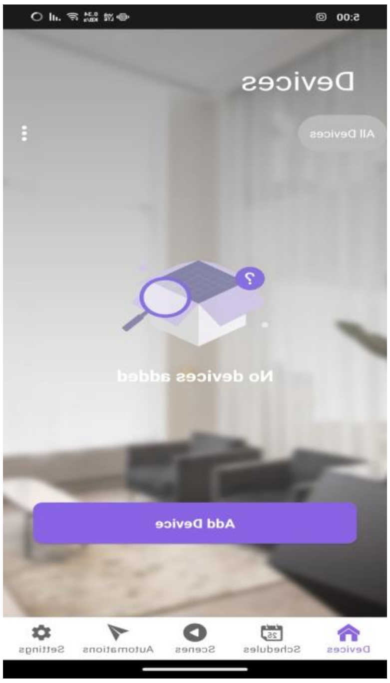

Fig3

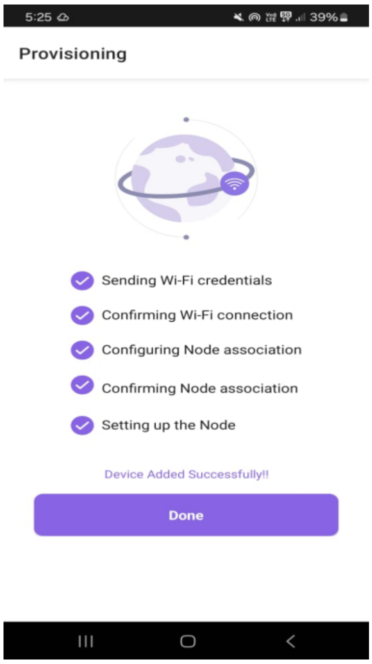

Fig4

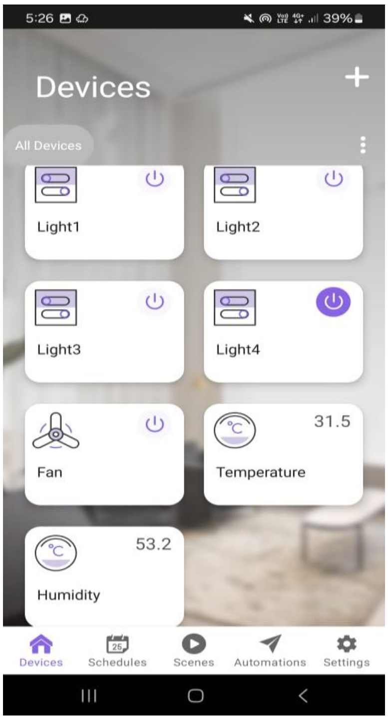

Fig5

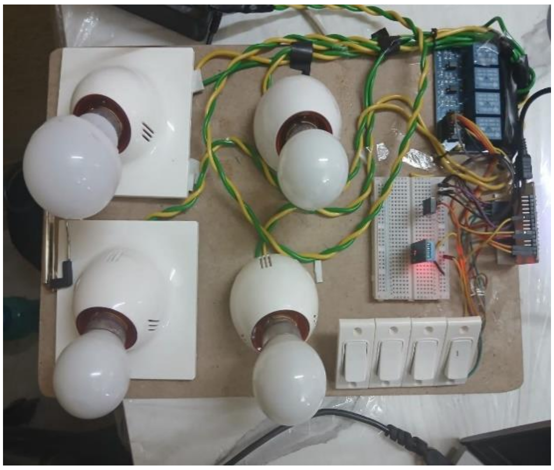

fig6

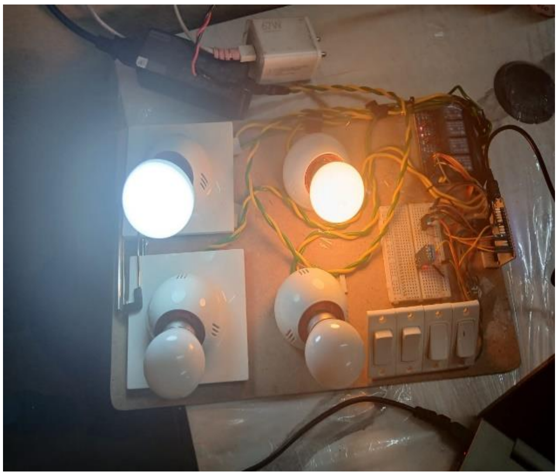

Fig7

CONCLUSION :

The proposed *Smart Home IoT system* integrates multiple control mechanisms, including *Wi-Fi, IR, voice assistants (Alexa, Google Assistant), and a mobile app***,** t**o** enhance home automation. It improves *convenience, security, and energy efficiency* by offering *appliance scheduling, automation, and real-time monitoring***.** The *ESP32 microcontroller* ensures *low power consumption, cloud integration, and scalability*. Additionally**,** *manual switches and voice commands* enhance accessibility. By using real-time *temperature and humidity sensors*, the system optimizes *energy management***,** potentially reducing utility costs. This adaptive and flexible approach makes it *user-friendly* and suitable for various household needs.

ACKNOWLEDGEMENT

I sincerely express my gratitude to all researchers, developers, and contributors whose work in Wi-Fi, Infrared (IR), voice commands has laid the foundation for this study on **Versatile Smart Home Automation: Multiple Control Methods with IoT Technology.** I extend my appreciation to my mentors, professors, and peers for their invaluable guidance and feedback, as well as to the broader research community and open- source contributors for providing essential resources that facilitated this work. Lastly, I thank my friends for their unwavering support and encouragement throughout this journey.

REFERENCES:

1. Madadi-Barough, S., Ruiz-Blanco, P., Lin, J., Vidal, R., & Gomez, C. (2024). Matter: IoT Interoperability for Smart Homes. arXiv preprint arXiv:2405.01618.
2. Li, Y., Mandalari, A.M., & Straw, I. (2023). Who Let the Smart Toaster Hack the House? An Investigation into the Security Vulnerabilities of Consumer IoT Devices. arXiv preprint arXiv:2306.09017.
3. Bouchabou, D., Nguyen, S.M., Lohr, C., Leduc, B., & Kanellos, I. (2021). A Survey of Human Activity Recognition in Smart Homes Based on IoT Sensors Algorithms: Taxonomies, Challenges, and Opportunities with Deep Learning. arXiv preprint arXiv:2111.04418.
4. Ishaq, K., & Farooq, S.S. (2023). Exploring IoT in Smart Cities: Practices, Challenges and Way Forward. arXiv preprint arXiv:2309.12344.
5. Sharma, A., Gautam, A., Singh, A., & Chaurasia, S. (2023). Smart Homes of the Future: A Comprehensive Review of IoT-Based Home Automation. International Journal of Advanced Research in Computer Science, 14(1), 142–156.
6. Magara, E. (2024). Internet of Things (IoT) of Smart Homes: Privacy and Security. International Journal of Communication Systems, 37(2), e7716956.
7. Wilson, P., & Thomas, J. (2024). Systematic analysis of smart homes: Current trends and future directions. Cogent Engineering, 11(1), 2344452.
8. Patel, D., & Sharma, R. (2020). Internet of Things (IoT)-Based Smart Home System Design and Implementation. International Journal of Electrical and Computer Engineering, 10(2), 678–685.
9. Ahmed, A., & Khan, S. (2021). Multi-Control IoT-Based Smart Systems: A Comprehensive Framework. Journal of IoT and Smart Technologies, 15(3), 134–141.
10. Gupta, V., & Roy, S. (2020). A Secure and Scalable Smart Home Ecosystem Using ESP32 Technology. Smart Home Innovations Journal, 8(1), 112–118.
11. Zhang, L., & Lin, H. (2022). Enhancing IoT Systems with Cloud-Based Automation. IoT and Automation Review, 7(2), 56–63.
12. Wilson, P., & Thomas, J. (2021). Voice-Assisted IoT Control in Smart Homes. Proceedings of the Smart Home Conference.
13. Espressif Systems. (2023). ESP32 Technical Reference Manual. Espressif Documentation Portal.
14. Kamel, S.O., & Hegazi, N.H. (2018). A proposed model of IoT security management system based on a study of internet of things (IoT) security. International Journal of Scientific & Engineering Research, 9(4), 1227–1244.