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A Comprehensive Review of IoT-Based Smart Switch Boards for Home Automation Systems

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Abstract: *The fast pace of the Internet of Things (IoT) technology has converted the traditional electrical systems into smart and automated control systems. Among them, the smart switchboard system has emerged as an indispensable part of home and industrial automation systems. This paper reviews the smart switchboard system implemented using the Internet of Things (IoT) technology. In this regard, the article introduces the basic concepts of various intelligent switchboard systems implemented using microcontrollers such as ESP32, Arduino, and Raspberry Pi, as well as wireless communication technologies including Wi-Fi, Bluetooth, and Zigbee. In addition, the article includes a review of recent research contributions to understand the trends and limitations of the existing system. In this regard, the advantages of energy efficiency, user-friendliness, automation, and scalability are discussed; however, the disadvantages related to security risks, network requirements, and reliability are discussed more critically. Moreover, comparisons and discussions of the various approaches have been included to evaluate their suitability for real-world use. In addition, recent developments in technologies such as artificial intelligence-based automation, voice-based management systems, and edge computing have been incorporated to improve the smart switchboard system. The results would be more relevant to researchers and developers aiming to develop a secure, efficient smart switching system for the next-generation smart environment..*

Keywords: Smart Switch Board, IoT, Home Automation, ESP32, Wireless Control, Energy Efficiency, Smart Home

I. INTRODUCTION

This is attributed to the rapid evolution of digital technologies, especially the Internet of Things (IoT), which has revolutionized traditional electrical and electronic systems, making them intelligent, interconnected, and automated. One of the most significant applications of this technological evolution is the development of smart switchboards, which replace traditional manual switchboards with automated, remotely controllable, and energy-efficient alternatives. This is an essential component of modern smart homes, buildings, and even industrial automation systems, which enable users to monitor and control their electrical appliances remotely from anywhere and anytime using their smartphones and web applications [1-3].

This is because digital technologies, particularly the Internet of Things (IoT), have advanced rapidly and profoundly transformed traditional electrical and electronic systems, making them smart, connected, and automated. The most impressive examples of this technological advancement include the creation of smart switchboards, which are intended to replace traditional manual switchboards with computerized, remote-controlled, and energy-efficient ones. This is one of the most important aspects of modern smart homes, smart buildings, and industrial automation systems, enabling users to remotely monitor and control electrical appliances from anywhere, at any time, using smartphones, web tools, and voice assistants [1-3].

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In the past, electrical switchboards were operated manually, which meant that you had to be physically present to switch the devices either on or off. It is an easy and inexpensive solution, though not efficient, nor smart, nor flexible. With urbanization and population growth, as people seek convenience and safety, the traditional solution is no longer sufficient. This has seen the emergence of a new generation of smart switchboards based on IoT, embedded systems, and wireless technologies. These systems not only provide remote access but also allow devices to be automated according to a pre-defined schedule [4].

A common smart switch board is a microcontroller or microprocessor chip, like an ESP32, an Arduino, or a Raspberry Pi, which is the control unit of the board. Relay modules are related to these units and may physically manipulate the devices. Moreover, the system may also be linked to the sensors, which may perceive the surroundings, such as temperature, humidity, movement, or the brightness of light, and be employed in a context-dependent control. The wireless protocols that can be used to establish communication between the user and the system include Wi-Fi, Bluetooth, Zigbee, or GSM. The most popular of these is the Wi-Fi-based ESP32 system, as it is cost-effective, offers high processing power, and includes built-in network operational capabilities [5].

The smart switchboard features are also improved by incorporating cloud computing, which enables real-time storage, processing, and data accessibility. Cloud computing platforms such as Blynk, ThingSpeak, and Firebase allow users to interact with them using user-friendly interfaces. The use of cloud computing platforms has enabled users to monitor appliance status and send notifications and alerts. The use of mobile applications also improves the usability of smart switchboards, making it easier to interact with them or with an office/home [6].

Voice assistants like Alexa and Google Assistant are another major innovation in the field of smart switchboards. This further adds the extra benefit and accessibility of smart switchboards, especially for the aged and the physically challenged. Moreover, the integration of artificial intelligence (AI) and machine learning (ML) technologies is helping predict and automate the use of smart switchboards. This means that the smart switchboard can be set to automatically switch off appliances that are not in use to conserve energy, e.g., [7]. One of the major factors affecting the use of smart switchboards is their energy efficiency. The world's energy requirements are growing rapidly. As a result, the need to maximize energy use and prevent energy waste has emerged. This is done through smart switchboards, which allow users to monitor the use of electrical devices and employ various methods to minimize energy usage. This not only saves money but also promotes environmental sustainability.

However, the advantages of smart switchboards should not be overlooked, and some problems need to be addressed to increase their popularity. One such problem is security, as IoT devices are likely to be targeted by cybercriminals, hackers, and information thieves. The first condition for the popularity of smart switchboards is secure data transmission, which should be achieved through encryption, authentication, and cloud security. Secondly, smart switchboards may also face network dependence, latency, and reliability issues, as internet popularity is not uniform everywhere.

Interoperability with devices from other manufacturers is also a challenge. This is because communication protocols and system architectures are not standardized, which can create compatibility problems and make it harder to integrate various devices into a single system. This has led to the creation of standardized frameworks and protocols that enable communication and interoperability between devices. Also, the costs might pose a constraint, but this is mitigated by technology, which simplifies implementation.

Regarding research, the smart switchboard has received much interest because it can be used to transform the management process and control of electrical systems. Several studies have been conducted to develop effective, cost-effective solutions across diverse hardware and software architectures. Different communication protocols, optimization techniques, and security control systems have been explored to enhance the system's efficiency and reliability. The trend in research is shifting toward the development of smart systems that can act without a large number of human participants.

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Besides using it at home, smart switchboards are also becoming a popular trend in businesses and industry. Smart switchboards installed in offices are used in commercial settings and help improve office operations and reduce electricity costs. Automation is very important in industrial sectors using smart switchboards.

Another solution being developed in the current COVID-19 situation is smart technologies, including smart switchboards, as more individuals seek solutions that do not require contact with their environment. This pandemic, in turn, has demonstrated the importance of automation in the framework of remote control, which has prompted a greater interest in solutions based on IoT, thus becoming one of the catalysts in the market of smart home and automation solutions in the years to come.

The primary goal of the paper review is to present the big picture of the smart switchboard systems through an analysis of current studies. This paper discusses the methodologies, components, communication protocols, and software used in the development of smart switchboards. In addition, an extensive literature review is incorporated to identify trends, issues, and research gaps in smart switchboard systems. Additionally, a comparative study of different methodologies is provided to evaluate their effectiveness in implementing smart switchboard systems.

The primary aim of this review paper is to (i) learn the prevailing situation of smart switch board systems, (ii) learn the assorted methodologies that have been adopted in developing smart switch board systems and their effectiveness, (iii) learn the problem involved in developing smart switch board systems, and (iv) learn the future perspectives of developing more efficient smart switch board systems.

To sum up, smart switchboards are the next step in the evolution of electrical system design, which has better functionality, efficiency, and convenience. IoT, cloud computing, and algorithms used on switchboards have transformed them into intelligent systems capable of meeting the demands of contemporary life. Nevertheless, security, reliability, and compatibility issues should also be mentioned to use smart switchboards more effectively. More research and development regarding the same is expected to yield better, more efficient, and smarter switchboards, which will allow more advanced smart systems.

II. LITERATURE SURVEY

A smart switch-based IoT home automation system with Blynk mobile application integration for remote control and monitoring of appliances in a home environment was proposed by Nilanjan Dutta et al. [8]. In this methodology, IoT-based smart switches are used, which are connected to a centralized gateway for control and monitoring of appliances in a home environment. The proposed system can be controlled and monitored using a smartphone, which enhances the usability of the system. Moreover, the system can be used for scheduling, monitoring, and controlling appliances, which represents a significant improvement over existing home automation system. In this system, the devices are connected to the internet, which enables communication between the devices and the smartphone, thereby improving the usability of the system. However, the security of the proposed system is not well addressed, as encryption and other security protocols are not considered in the proposed methodology, which makes the system vulnerable to cyber-attacks. Moreover, the proposed system does not consider scalability across other smart home environments, which creates a research gap in the development of a smart switch-based IoT home automation system.

Rahul Kasbe et al. [9] proposed a smart system for a touch switch board for home automation using Bluetooth communication. In this system, the methodology primarily focuses on using an Arduino Uno microcontroller with a Bluetooth device and a mobile application created with MIT App Inventor. The outcomes of the proposed system demonstrate its cost-effectiveness and user-friendliness for automating homes by reducing energy consumption through scheduled tasks. However, the proposed system has the disadvantage of limited Bluetooth connectivity and does not offer internet connectivity for remote access. In addition, the proposed system does not offer the security and scalability benefits of a smart environment. This shows the need for an IoT-based system for enhancing the proposed system.

Prabakaran S et al. [10] proposed an IoT-based smart home automation and security system, which includes automation and security features. The methodology for the proposed system includes using Arduino Uno and Node MCU microcontrollers, along with gas, temperature, and ultrasonic sensors, as well as a camera module. The proposed system

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enhances safety, automation, and real-time capabilities for the smart home. The proposed system includes multiple sensors, which ensure comprehensive monitoring of the environment. However, the proposed system also increases the complexity and cost of the hardware components, as multiple components are used. Moreover, the paper does not discuss the privacy, security, and optimization of the proposed system, which are important for the practical implementation of a smart home automation system.

The article by Basudeb Dey et al. [11] on a smart home automation system based on the Internet of Things and the Raspberry Pi as the controller device is reviewed. The server-based approach is adopted in this methodology, with a web server running on the Raspberry Pi to manage multiple devices via a user interface. The system will support multiple communication protocols, including Bluetooth and Ethernet. The system will enhance device availability and user control. The historical events and the development of automation systems are also discussed in the review. Nevertheless, the review does not include experimental validation or performance evaluation of the suggested system. In addition, no discussion is provided on security issues, delays, or system reliability; as a result, the research gaps remain unaddressed.

R. K. Ragavapriya et al. [12] have proposed an IoT-based smart power supply switch system that uses an MSP430 controller and a Wi-Fi communication module. This system is founded on the approach of a web interface, which allows the user to remotely manage the tools through an internet connection via a server. The system switches via a relay, and the devices can use Zigbee, GSM, or Wi-Fi. The benefit of this type of system is that it remains useful even when the internet is not connected. Nevertheless, this system is not that advanced in terms of automated features, including AI-based decision-making. Moreover, the study failed to account for cybersecurity, which is highly important for IoT systems.

In a paper titled "Smart Switchboard System for Home Appliances Control Using IoT and Voice Recognition Technology," M. Hariharan et al. proposed a smart switchboard system that uses IoT and voice recognition to control home appliances. In this paper, the methodology of the proposed system will be presented, consisting of Arduino control, Android applications, and wireless sensor networks to monitor appliance status in real time. The suggested system will also have remote control and manual control, which is more convenient for people with physical difficulties. Additionally, voice recognition technology increases the system's automation efficiency. The suggested system is more efficient to automate due to its convenient, flexible, and speedy control. The suggested system incorporates several communication interfaces, such as cloud control, and is therefore efficient for automation. Nevertheless, the proposed system has not assessed the correctness of its voice recognition or the latency, which makes it less efficient in the automation process. Also, the given system lacks interoperability, security, and compatibility with other smart home architectures, so it is less efficient for automation.

Vaishnavi S. Gunge et al. [14] have conducted an extensive literature review of smart home automation systems across different communication technologies. This research will be carried out by analyzing various automation schemes of Bluetooth, ZigBee, GSM, Wi-Fi, and cloud-based automation systems. The results demonstrate the advantages of wireless automation systems, including reduced installation costs, increased flexibility, and greater accessibility at greater distances. Nevertheless, other issues related to wireless automation systems, including high costs, lack of standardization, and the complexity of the user interface, are also listed in the research paper. However, the research paper does not experimentally test the suggested system. It does not address in detail the potential of new technologies, including the implementation of AI and cybercrime structures.

Jayesh Sonar et al. proposed an electromechanical smart switch system based on IoT for enhanced control and security purposes in [15]. The methodology is based on electrical switching mechanisms, Arduino, and IoT to enhance control and security. The proposed system is designed for safety and efficiency across different applications, including electric vehicles. The results show that the proposed system is highly efficient for different applications, including enhanced control, security, and reliable performance. The proposed system is based on the combination of mechanical and electrical systems, which is highly efficient for different applications. However, the proposed methodology is specific

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to a particular application rather than home automation systems. Furthermore, scalability, user interface, and cloud computing are not discussed in this paper, which are very important for a home automation system.

Sakshi Mirikar et al. [16] surveyed smart switches used in home automation systems, with an emphasis on smart city IoT-based applications. This paper examines the different types of sensors, actuators, and communication systems used in smart switch systems. The article compares the costs, performance, and functionality of several smart home automation systems. The paper highlights the significance of IoT in delivering digital lifestyles, energy savings, and user experiences. The paper also discusses issues in implementing smart home automation systems, such as cost and performance challenges. Nonetheless, the article does not provide experimental confirmation or a technical examination of the smart home automation systems. Further, these aspects, such as security, interoperability, and real-time performance, are not discussed in the paper.

Prathibha K N et al. [17] suggested a smart switchboard which has automated the scheduling, gas leakage, and the automation of the windows. The smart home uses microcontrollers, sensors, Bluetooth, and cloud-based control as part of the methodology. Its system proves effective in scheduling, safety, and convenience, as reflected in the results. Its functionality and flexibility are improved by the fact that the system combines various automation capabilities. The system, however, relies on Bluetooth, which restricts access to it. Besides that, security, scalability, and compatibility with other IoT devices were not discussed in the research and should be enhanced.

In a paper by Cristina Stolojescu-Crisan et al., a smart home automation system named qToggle was proposed, leveraging IoT to connect sensors, actuators, and other devices via a shared API. This technology uses an ESP8266 and a Raspberry Pi as a controller to communicate smoothly over the internet via Wi-Fi and cloud-based interfaces. The system architecture is scalable for device integration and includes a mobile application and a web interface for control. Various applications of this system can be carried out, such as lighting, energy management, and security. The findings demonstrate the system's high flexibility and scalability for integration with a large number of IoT devices. Nonetheless, the paper also highlights the system's shortcomings and limitations, including network limitations, power consumption of Wi-Fi-based systems, security/privacy concerns, interoperability among devices, and the complexity of the system when used at scale.

Jayesh Sonar et al. [19] proposed an electromechanical smart switch system using IoT for intelligent control and safety. The methodology for this system uses an Arduino UNO board, sensors, relay switches, and an ESP8266 Wi-Fi module. The system uses mechanical switches for more efficient, secure switching. The system is based on circuit design, IoT, and real-time testing. The system is more applicable to systems that require both manual and automatic control. However, the research is more focused on vehicle-based systems rather than home automation. The scalability, cloud, and UI are also not discussed. Security is also not discussed, which is another area for improvement in IoT-based smart switch systems.

R. Krishnakumar et al. proposed a smart multifunction switch box using IoT technology that combines traditional and modern appliances in a unified automation platform. The methodology involves using an ESP32 microcontroller, relay modules, energy sensors, and environmental sensors such as the DHT11 module. The proposed system provides various control options for the appliances, including Wi-Fi, Bluetooth, remote access, and voice control via Alexa and the Google Assistant. The proposed system also provides a fault-protection mechanism to prevent overload and short-circuit conditions. The proposed methodology provides improved energy efficiency, real-time monitoring, enhanced safety, and control options for appliances. The proposed system is also flexible for future IoT technology upgrades. However, the complexity of the proposed system arises from the various components it uses. Moreover, the proposed system's latency and reliability have not been deeply discussed in the proposed methodology. In addition, security aspects such as encryption and authentication have not been deeply discussed in the proposed methodology.

Yinyan Chen et al. [21] discussed the design and implementation of an IoT-based smart home system, which utilizes an ATMEGA2560 microcontroller with advanced technologies such as voice recognition, GPS positioning, and security monitoring. The methodology for this paper is based on the use of multiple sensors, such as temperature, gas, motion, and fire. Also, it uses communication modules to transmit data in real time via the MQTT protocol. As shown in the

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system diagram on page 2, the overall system design uses control, sensor, and IoT modules to achieve full automation. The overall system has shown increased reliability, reduced complexity, and increased security. However, the overall system has increased hardware complexity and costs. Furthermore, privacy, cybersecurity, and user adaptability, particularly for seniors, are also research gaps that need to be addressed.

III. SUMMARY OF LITERATURE SURVEY

The literature review on smart switchboards and IoT-based home automation systems reveals that the development of intelligent electrical control systems has made significant advances in design and implementation. Various authors analyzed various solutions using microcontrollers, which are Arduino, ESP32, Raspberry Pi, and ATmega2560, and the communication technologies, which include Wi-Fi, Bluetooth, Zigbee, and MQTT protocols. The papers under analysis suggest that simplified switching systems have been replaced by fully automated, remotely accessible, sensor-based smart settings. The aspects identified as most significant in the literature are remote control of appliances, energy management, scheduling, safety (gas and fire sensors), and voice control. In addition, others are user-friendly, low-cost, and easily scalable through mobility and cloud technology. Nevertheless, despite these advancements, critical challenges remain in cybersecurity, interoperability, system complexity, and dependency. The survey offers an extensive overview of the methodologies used so far, highlights current trends, and, most importantly, lays the foundation for safer, more efficient, and smarter switchboard mechanisms. The summary of the literature survey is presented in Table I.

TABLE I. SUMMARY OF LITERATURE SURVEY

Ref	Author & Year	Technology Used	Controller	Communication	Key Features	Results	Limitations
[1]	Dutta et al., 2023	IoT + Blynk	ESP8266	Wi-Fi	Remote control, scheduling, and monitoring	Improved energy efficiency	No security & scalability
[2]	Kasbe et al., 2023	Bluetooth Automation	Arduino UNO	Bluetooth	Touch switch, mobile control	Low cost, easy use	Limited range, no remote access
[3]	Prabakaran et al., 2023	IoT + Security System	Arduino + NodeMCU	Wi-Fi	Sensors, camera, alerts	High safety & automation	Complex hardware, cost
[4]	Dey et al., 2025	IoT Review	Raspberry Pi	Wi-Fi/Bluetooth	Web-based control	Flexible & scalable	No experimental validation
[5]	Ragavapriya et al., 2023	IoT Smart Switch	MSP430	Wi-Fi/Zigbee	Web control, relay system	Reliable & flexible	No AI & security features
[6]	Hariharan et al., 2023	IoT + Voice Control	Arduino	Wi-Fi	Voice automation, remote access	Improved usability	No latency/security analysis
[7]	Gunge et al., 2016	IoT Survey	Arduino/RPi	Multi-protocol	Comparative study	Identified trends	No practical validation

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[8]	Sonar et al., 2023	Electro-mechanical IoT	Arduino UNO	Wi-Fi	Smart switching, safety	Reliable performance	Not focused on home use
[9]	Mirikar et al., 2023	IoT Survey	Various	Wi-Fi/Zigbee	Smart switches analysis	Cost & efficiency insights	No deep comparison
[10]	Prathibha et al., 2024	IoT Smart Switchboard	Microcontroller	Bluetooth	Scheduling, gas detection	Improved safety	Limited remote access
[11]	Stolojescu et al., 2021	IoT qToggle System	ESP8266/RPi	Wi-Fi	API-based control, automation	Scalable system	Security & network issues
[12]	Sonar et al., 2023	IoT Smart Switch	Arduino	Wi-Fi	Electro-mechanical switching	Safe & efficient	Limited scalability
[13]	Krishnakumar et al., 2024	IoT Multifunction Switch	ESP32	Wi-Fi/Bluetooth	Energy monitoring, voice control	High efficiency & safety	Complex design, no security
[14]	Chen et al., 2024	IoT Smart Home	ATmega2560	MQTT/Wi-Fi	Voice, GPS, sensors	Advanced automation	High cost & complexity

The comparative study presented in Table III clearly illustrates the evolution of a smart switchboard system from a primitive wireless control system to a highly developed, sophisticated IoT-based automation system. The latest research suggests incorporating Wi-Fi-based communication and microcontrollers such as the ESP32 and Arduino, as they are highly flexible and cost-effective. The incorporation of remote access and scheduling, energy consumption monitoring, and safety features is seen as a highly developed and sophisticated area of switchboard system design. However, the table also shows that most existing systems suffer from shortcomings, including inadequate security, limited scalability, and the need to maintain a stable network environment. Additionally, little research has been conducted on incorporating new features, such as AI-based automation and heterogeneous device compatibility. This clearly illustrates that, while much has been done, much remains to be done to develop a highly secure, highly scalable, and highly intelligent switchboard system.

IV. DISCUSSION

The trend toward developing smart switchboard systems is part of a broader effort to build home automation systems using IoT, in which a smart system replaces a simple electric control system. The systems were wired, and wireless technologies such as Bluetooth were also used for short-range connectivity. The systems were intended for operation, for instance, for turning ON/OFF, but lacked scalability, remote connectivity, and intelligence. The Arduino microcontrollers were also widely used for their simplicity and cost-effectiveness, but they are not suitable for long-range connectivity since they are not internet-enabled.

On the other hand, recent trends have shown significant changes in the use of Wi-Fi, cloud computing, and mobile applications in IoT-enabled smart switchboards. Recent systems have been using high-performance microcontrollers such as the ESP32 and Raspberry Pi for development, which can track things in real time, control remotely, and connect to the cloud. It is now standard practice to include energy monitoring, a schedule, voice control with Alexa and Google Assistant, and sensor-based decision-making in smart switchboards developed with recent systems. Another

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illustration of the increasing complexity of modern solutions is the introduction of multifunctional systems, such as safety systems (e.g., gas-leakage sensors), fault protection systems, and environmental control systems.

Despite these developments, several disadvantages remain. Various issues are urgent, and one of them is cybersecurity because most of the systems do not have proper encryption, authentication, and communication protocols, which exposes them to unauthorized access and cyberattacks. Another notable limitation is network dependency, as the system's performance is highly reliant on a strong network connection. Besides, there is the issue of scalability and interoperability, since the communication frameworks are not standardized and thus cannot communicate with devices from other manufacturing organizations. A major challenge is also the system's complexity, the cost of hardware (especially in Wi-Fi-based systems), and power consumption. In addition, latency and real-time responsiveness are seldom adequately incorporated into existing implementations.

As per the literature, there are some gaps in the research that can be outlined. No thorough research exists on a secure IoT architecture specifically designed for use in smart switchboards. The majority of the research fails to leverage advanced AI and machine learning to predict automation and make intelligent decisions. Additionally, little has been done in edge computing to minimize latency and enhance system efficiency. The integration of heterogeneous devices into a single ecosystem remains a challenge, and user-oriented design factors, especially for older people and people with disabilities, are not given much attention. Also, it lacks a target to streamline energy use at the device and system levels.

In the future, the trend toward smart switchboard systems will drive the creation of smarter, more secure, and more scalable systems. Artificial intelligence and machine learning can be integrated to form predictive and self-learning systems, which will adjust to user behavior and optimize the consumption of energy. The implementation of edge and fog computing will improve real-time computing and decrease the reliance on cloud computing. It can also be assumed that blockchain-based security frameworks will be implemented in future systems to secure communication and maintain data integrity. The uniformity of protocols will be instrumental in achieving smooth interoperability between devices. Also, the development of low-power communication technologies and energy-saving hardware will help make systems more sustainable. Lastly, the creation of convenient interfaces and accommodating designs will lead to broader adoption by different user groups, making smart switchboards part of next-generation smart homes and smart cities.

V. CONCLUSION AND FUTURE DIRECTIONS

This review paper presents a detailed discussion of smart switchboard systems in the context of home automation and IoT technologies. Some of the studies reviewed in the paper considered system architecture, hardware systems, communication protocols, and implementation plans. Smart switchboards have come a long way from simple manual and short-range wireless systems to high-tech systems driven by the IoT that can monitor remotely, offer powerful controls, and process real-time information. Other technologies, such as ESP32, Arduino, and Raspberry Pi, and communication protocols, such as Wi-Fi, Bluetooth, Zigbee, and MQTT, have also played a significant role in making it easy to build an efficient and scalable automation system. These features have been a combination of energy monitoring, scheduling, safety, and voice control, which has enhanced the convenience of the user and saved energy, as well as the functionality of the system. Nevertheless, even with these improvements, several issues remain, including security vulnerabilities, network dependency, interoperability, and system complexity. Most available systems lack well-developed cybersecurity and cannot enable the smooth integration of heterogeneous devices. Besides, automation systems are not fully utilized due to low adoption of smart decision-making methods.

Future research on the topic should aim to make smart switchboard systems more secure, scalable, and intelligent. Predictive automation and adaptive control based on user behavior can be enabled by integrating artificial intelligence and machine learning techniques. In addition, edge and fog computing can improve real-time performance and reduce system latency. Moreover, interoperability can be enhanced by using standard communication protocols and blockchain-based security mechanisms to strengthen system security. Sustainability should also be promoted through research on energy-efficient designs and power-saving communication technologies. In conclusion, the smart

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switchboards will be a key constituent of the future smart homes and smart cities, which will be secure, efficient, and user-friendly.

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