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Original Research Article

AN OVERVIEW OF THE INTERNET OF THINGS (IOT) IN BUILDING SMART HOMES

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This study was a collaborative effort among all authors. Each author reviewed and approved the final version of the manuscript for publication.

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ABSTRACT
The Internet of Things (IoT) has revolutionised the concept of smart homes by enabling interconnected devices to communicate and collaborate, thereby enhancing convenience, efficiency, and security for residents. In a smart home environment, IoT facilitates the seamless integration of various household appliances and systems, such as lighting, heating, air conditioning, security, and entertainment, allowing for centralized and remote control. This interconnectedness not only automates routine tasks but also optimises energy consumption, leading to potential cost savings. For instance, smart thermostats can learn user preferences and adjust heating or cooling accordingly, while smart lighting systems can reduce energy usage by turning off lights in unoccupied rooms. Moreover, IoT-enabled security systems provide real-time monitoring and alerts, enhancing the safety of the household. Advanced security systems offer real-time monitoring, facial recognition, and activity tracking, allowing homeowners to manage access and receive alerts about unusual activities remotely. Despite these advancements, challenges persist, particularly concerning interoperability among diverse devices and ensuring robust security and privacy measures. Ongoing developments, such as the Matter protocol, aim to address these issues by establishing universal standards for device communication, thereby fostering a more cohesive and secure smart home ecosystem.

Keywords: Internet of Things (IOT), Smart Homes, Sensor, Actuator, artificial intelligence

INTRODUCTION

The Internet of Things (IoT) has significantly transformed modern living by introducing smart home technologies that enhance convenience, efficiency, and security. A smart home is a residence equipped with internet-connected devices that enable remote monitoring and management of systems such as lighting, heating, and security (Magara, 2024). In this interconnected ecosystem, devices communicate and collaborate to automate routine tasks and respond to user preferences. For instance, smart thermostats can learn household patterns to optimize heating and cooling schedules, thereby reducing energy consumption. Similarly, smart lighting systems can adjust brightness based on natural light availability or occupancy, contributing to energy efficiency. Security is another critical aspect of IoT-enabled smart homes. Advanced security systems offer real-time monitoring, facial recognition, and activity tracking, allowing homeowners to manage access and receive alerts about unusual activities remotely (Ahmed and Akhtar, 2021). The integration of artificial intelligence (AI) with IoT devices further enhances the smart home experience. AI enables devices to learn from user behaviours, anticipate needs, and make informed decisions. For example, AI-powered ovens can detect the type of food being prepared and adjust cooking settings accordingly, while smart washing machines can recommend optimal cycles based on usage patterns. Despite these

advancements, challenges persist, particularly regarding interoperability among diverse devices and ensuring robust security and privacy measures. Efforts are underway to establish universal standards and protocols to address these issues, aiming to create a more cohesive and secure smart home ecosystem (Madadi-Barough *et al,.* 2024). Before the advent of the Internet of Things (IoT) in home automation, traditional systems faced several significant challenges:
INFLEXIBILITY: Many systems lacked the adaptability to integrate with new technologies or devices, limiting their functionality and longevity.

POOR MANAGEABILITY: Complex setups and interfaces made it challenging for users to manage and control their home automation systems effectively.

SECURITY CONCERNS: Ensuring the security of home automation systems was difficult, leading to potential vulnerabilities and unauthorised access. Interoperability of various devices and home appliances (Ghayvat *et al*., 2019)

These challenges underscore the need for more advanced, flexible, and user-friendly solutions, paving the way for the development and adoption of IoT technologies in smart homes. The integration of the Internet of Things (IoT) into smart homes has revolutionized residential living, offering enhanced convenience, energy efficiency, and security. By enabling devices to communicate and operate autonomously, IoT has transformed traditional homes into interconnected, intelligent environments. (Ahmed and Akhtar, 2021).

LITERATURE REVIEW

The Internet of Things (IoT) has emerged as a transformative force in modern living, particularly through the development of smart home technologies. These innovations aim to enhance convenience, efficiency, and security within residential environments. This literature review examines the current state of IoT applications in smart homes, focusing on their benefits, challenges, and future directions.

INTRODUCTION TO INTERNET OF THINGS (IOT) IN SMART HOMES

Smart homes are residences equipped with internet-connected devices that enable remote monitoring and management of household systems such as lighting, heating, and security. The integration of IoT in these settings allows for seamless communication between devices, facilitating automation and improved user experiences. This interconnected ecosystem not only enhances daily living but also contributes to energy efficiency and personalized services (Alam and Shakil, 2021).

APPLICATIONS AND BENEFITS

- Energy Efficiency: IoT-enabled devices, such as smart thermostats and lighting systems, adapt to user behaviors and environmental conditions to optimize energy consumption. For instance, smart thermostats can learn household patterns to adjust heating and cooling schedules, thereby reducing energy usage (Bouchabou *et al*., 2021).
- Elderly Care: Smart home technologies offer significant support for elderly individuals by providing monitoring systems that detect falls, track health metrics, and facilitate communication with caregivers. These systems enhance the autonomy and safety of older adults living independently (Alam and Shakil, 2021)
- Security Enhancements: Advanced security systems in smart homes utilise IoT devices for real-time monitoring, facial recognition, and activity tracking. These features allow homeowners to manage access and receive alerts about unusual activities remotely, thereby enhancing the overall security of the residence (Demiris and Hensel, 2008).

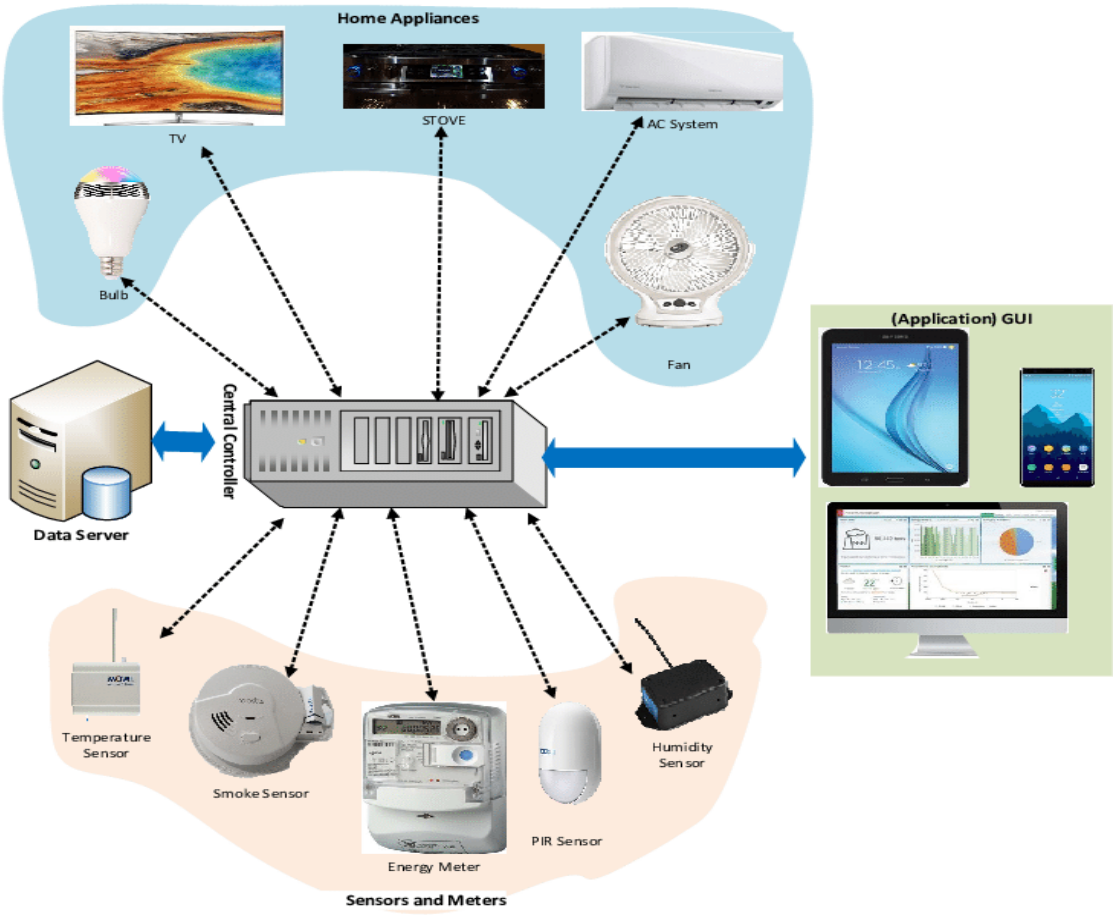
FUTURE DIRECTIONS

The integration of artificial intelligence (AI) with IoT devices is poised to further enhance smart home experiences. AI enables devices to learn from user behaviours, anticipate needs, and make informed decisions, leading to more personalized and efficient home automation systems (Bouchabou *et al*., 2021).
Designing an Internet of Things (IoT) model for smart homes involves integrating various devices and systems to enhance automation, security, and energy efficiency. A typical IoT-based smart home architecture comprises multiple layers, each serving distinct functions:

PERCEPTION LAYER: This foundational layer includes sensors and actuators that monitor environmental parameters and control devices. Examples encompass temperature sensors, motion detectors, smart thermostats, and lighting controls.
Network Layer**:** Responsible for transmitting data between devices, this layer utilizes communication protocols such as Wi-Fi, Zigbee, Bluetooth, and Z-Wave to facilitate connectivity within the home network.

PROCESSING LAYER: Also known as the middleware layer, it processes data collected from the perception layer. This involves data storage, analysis, and decision-making processes, often employing cloud computing resources to manage and analyze large datasets.

APPLICATION LAYER: The topmost layer provides user-oriented services, enabling homeowners to interact with and control smart home devices through applications on smartphones, tablets, or computers. (Zhou and Yang, 2021).
The following diagram further illustrates the interaction between these layers and demonstrates how IOT works in building smart homes.



Architecture of a Smart Home (Al-Mutawa, *et al*. 2020)

In this model, various IoT devices within the home collect data and communicate through the network layer. The processing layer analyzes this data to make informed decisions, such as adjusting heating systems or activating security protocols. Users can monitor and control these processes via applications in the application layer, ensuring a seamless and efficient smart home experience. This layered architecture ensures modularity, scalability, and efficient management of smart home systems, allowing for the integration of new devices and technologies as they emerge.

CONCLUSIONS

The integration of the Internet of Things (IoT) into smart homes has revolutionized residential living, offering enhanced convenience, energy efficiency, and security. By enabling devices to communicate and operate autonomously, IoT will transform traditional homes into interconnected, intelligent environments. Key Benefits of IoT in Smart Homes:

i) Enhanced Convenience: IoT devices automate routine tasks, such as adjusting lighting and temperature, and can be controlled remotely via Smart phones or voice commands, providing homeowners with greater ease and flexibility.
ii) Energy Efficiency: Smart thermostats and lighting systems optimize energy consumption by learning user preferences and adjusting settings accordingly, leading to reduced utility costs and a smaller carbon footprint.

iii) Improved Security: IoT-enabled security systems offer real-time monitoring, facial recognition, and activity tracking, allowing homeowners to manage access and receive alerts about unusual activities remotely.
iv) Personalization: IoT devices can learn from user behaviors, anticipate needs, and make informed decisions, enhancing the overall living experience.

RECOMMENDATIONS

Integrating Internet of Things (IoT) technologies into smart homes offers enhanced convenience, efficiency, and security. To maximize these benefits, consider the following recommendations:

i) **Prioritize Interoperability:** Select devices that adhere to common communication protocols, ensuring seamless interaction among various smart home components.
ii) Enhance Security Measures: Isolate IoT devices on a separate Wi-Fi network to protect sensitive data on personal devices.
iii) **Invest in Energy Management Systems:** Utilize IoT-enabled solutions to monitor and optimize energy consumption, contributing to sustainability and cost savings.
iv) **Implement Regular Software Updates:** Keep all devices updated to safeguard against vulnerabilities and ensure optimal performance.
v) **Educate Users on Device Management:** Provide guidance on configuring and maintaining devices to promote a secure and efficient smart home environment.

By implementing and integrating these recommendations, homeowners can create a cohesive, secure, and efficient IoT-enabled smart home ecosystem.

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