

A Smart Home System Using Internet of Things (IoT) Technology

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Abstract: The goal of this study is to propose a smart home system that uses internet of things (IoT)-based technologies to improve the effectiveness of home automation and boost energy savings. The system integrates a wide range of sensors, gadgets, and appliances into a coherent system, creating a smart environment that can be remotely controlled and monitored by using an application on a mobile device. The system's goal is to reduce energy consumption by automatically adjusting the temperature, lighting, and other systems in accordance with user preferences and environmental circumstances. In order to learn more about the advantages and disadvantages of installing a smart home system as well as previous studies and research that had been done on the issue, a review of the pertinent literature was conducted. Homeowners in the neighborhood that made up the study's sample were given questionnaires as part of the research process. We surveyed this group of homeowners to learn more about their level of interest in upgrading to a smart home system and their current home automation habits. The results show that there is a lot of interest in and readiness for installing a smart home system, with utility bill savings acting as the primary motivator. The findings also show that there is a high level of readiness to reduce utility expenses. We will discuss the study's limitations in this area, as well as some suggestions for further research, along with the implications for policy and practices. The findings of this study suggest that a smart home system based on internet of things technology has the potential to significantly improve both the quality of life and energy efficiency of homeowners.

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I. Introduction

The Internet of Things (IoT) has fundamentally altered the way in which we go about our daily lives over the past several years. The Internet of Things technology has been implemented in a variety of settings, including medical care, public transit, farming, and industrial production [1]. The creation of a Smart Home System, which may improve the ease of use, comfort, and safety of our houses, is one of the most promising applications of the Internet of Things in the home automation area. This system can be created by using the Internet of Things. The Internet of Things (IoT) smart home system, its individual components, and the advantages it offers are the topics. The technology known as the Internet of Things (IoT) has completely altered the way in which people interact with their surroundings [2]. The Internet of Things (IoT) technology has made it possible to interconnect devices and sensors so that they may communicate with one another, share data, and take actions based on algorithms and rules that have been predefined. The creation of a Smart Home System, which may improve the ease of use, comfort, and safety of our houses,

is one of the most promising applications of the Internet of Things in the home automation area. This system can be created by using the Internet of Things [3]. The Internet of Things (IoT) is the technology that enables the Smart Home System, which is a network of devices and sensors that are connected to one another to enable the automation and management of a variety of home systems and appliances. The system normally consists of a number of components, the most common of which are connected smart home appliances, sensors, and a central hub or gateway that is responsible for connecting all of the devices to the internet[4]. The Internet of Things technology makes it possible for devices and sensors to connect with one another, share data, and take actions depending on rules and algorithms that have already been established. Because it makes our homes smarter and more attuned to our requirements, the Internet of Things (IoT) technology that is used in smart home systems has the potential to fundamentally alter the way in which we lead our lives. By the automation of mundane duties and the provision of capabilities for remote control and monitoring, the system contributes to an increase in the ease and comfort of life in the home. It is much simpler for users to manage their houses from any location when they can use a mobile app or a web-based interface to control the systems and appliances in their homes [5]. Additionally, the system enhances the energy efficiency of the home by optimizing the utilization of appliances and systems based on real-time data and user behavior. This helps the home to consume less energy. In addition to this, it improves the security and safety of the home by notifying the people living there of any odd activity or potential dangers[6]. On the other hand, the introduction of Smart Home Systems through the utilization of IoT technology also raises concerns around privacy and safety. The integration of different devices and sensors presents a risk of personally identifiable information being exposed and also creates vulnerabilities that hackers may be able to exploit. Hence, additional study is required to address the issues regarding the security and privacy connected with IoT devices and to investigate the possibilities of Smart Home Systems in a variety of contexts [7]. A network of devices and sensors that are interconnected via the Internet of Things (IoT) to assist the automation and control of various household appliances and systems is what makes up a smart home system that uses IoT technology. Users of this system have the ability to remotely control and monitor many parts of their houses by utilizing either a mobile application or a web-based interface, which can be accessed over the internet. A smart home system will typically consist of a number of different components. These components will typically include smart appliances (such as smart thermostats, smart lighting, and smart locks), sensors (such as motion sensors, temperature sensors, and humidity sensors), and a central hub or gateway that connects all of the devices to the internet [8]. The Internet of Things technology makes it possible for devices and sensors to connect with one another, share data, and take actions depending on rules and algorithms that have already been established. For instance, a smart thermostat is able to regulate the temperature in accordance with the preferences of the user as well as the number of people currently present in the home. In a similar manner, a smart lighting system is able to turn the lights on and off depending on the time of day as well as the number of people present in the space. There are a lot of advantages to having a smart home system that uses internet of things technology. With the automation of mundane responsibilities and the provision of capabilities for remote control and monitoring, it makes

daily life in the home more convenient and comfortable [9]. It does this by optimizing the consumption of appliances and systems based on real-time data as well as human behavior. This results in an increase in the energy efficiency of the home overall. In addition to this, it improves the security and safety of the home by notifying the people living there of any odd activity or potential dangers. In general, a smart home system that makes use of internet of things technology represents a substantial leap in home automation and makes available to homeowners a new level of convenience, comfort, and protection [10].

A. Smart Home System:

A Smart Home System is a collection of sensors and other electronic devices that are designed to assist you in the process of automating and managing the different systems and appliances that are found in your home. A smart home system will often consist of a number of devices, including sensors, smart appliances (including smart thermostats, lighting, and locks), and a gateway or central hub that connects all of the gadgets in the system to the internet.

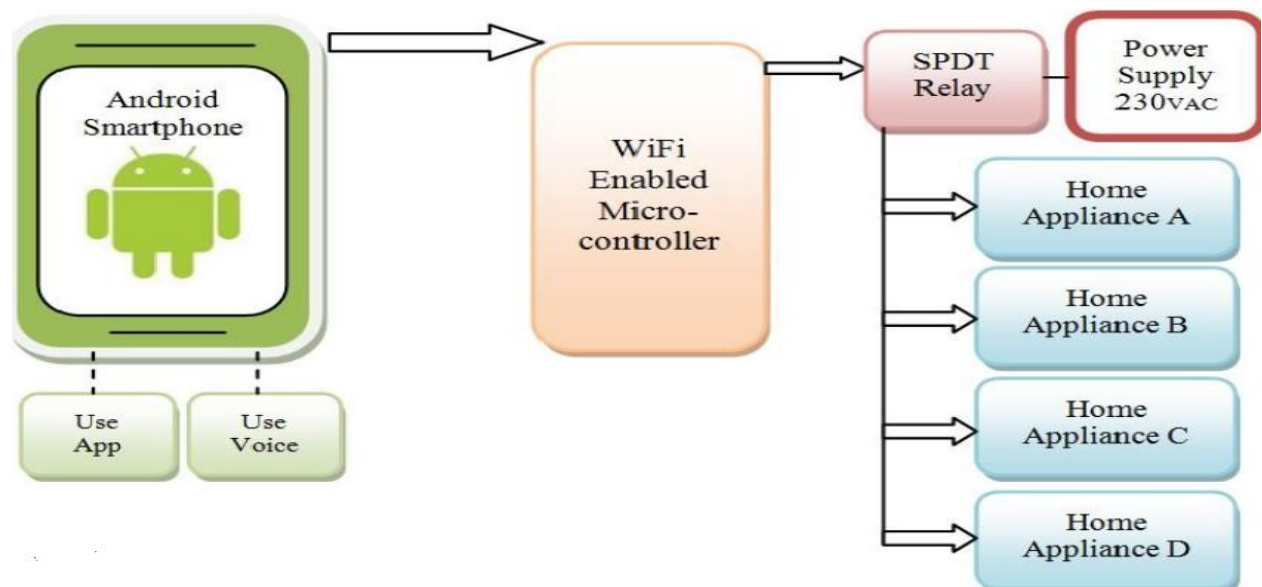


Fig (1) Overview of Smart Home System Based on IoT Architecture

Devices and sensors can communicate with one another and take action in response to a predefined set of rules and algorithms when the Internet of Things (IoT) technology is utilized. For instance, a smart thermostat is able to adjust the heating and cooling schedules in response to shifts in the number of people occupying a home as well as the preferences of individual users. A smart lighting system is able to perform the same thing for the lights, turning them on and off depending on the time of day and the number of people that are currently present in the room. There are a lot of advantages to having an Internet of Things-powered smart home system. To begin, it improves the ease of use and overall comfort of the house by automating mundane operations, allowing for remote control and monitoring, and giving capabilities in these areas. It is much simpler for users to manage their houses from any location when they can use a mobile app or a web-based interface to control the systems and appliances in their homes. It enhances the energy efficiency of the home by optimizing

the use of appliances and systems in accordance with real-time data and the activities of the people living in the home. One way in which a programmable thermostat can cut down on energy use is by altering the temperature in response to changes in the user's preferences and the level of activity in the home. It improves the security and safety of the home by notifying the occupants of any odd activity or potential dangers. This is accomplished through the use of an alert system. For instance, a smart security system can detect and warn the user of any break-ins or intruders, and a smart smoke detector may detect and tell the user of any smoke or fire in the house. Both of these systems are examples of smart home devices.

i. Smart Appliances:

Internet of Things (IoT) enabled "smart appliances" are those used in the house that are capable of exchanging data with one another and taking autonomous action in accordance with a set of rules and algorithms. Thermostats, lights, locks, speakers, TVs, and dishwashers are just a few examples of smart home products.

a. Smart Thermostats:

Internet of Things (IoT) technology is integrated into heating and cooling systems known as "smart thermostats," which automatically alter the temperature based on the home's occupancy and the user's preferences. They can figure out how the user likes the temperature set and make adjustments appropriately, which is good for the environment and the user's wallet.

b. Smart Lighting:

Internet of Things (IoT) technology is embedded in smart lighting systems, allowing them to automatically switch on and off the lights depending on the time of day and the number of people in the room. The lights can be changed in hue and intensity to suit the individual's taste.

c. Smart Locks:

Locking and unlocking a smart lock, which is integrated with Internet of Things technology, can be done remotely using a smartphone app or a web-based interface. Improve the safety and security of your house by allowing only authorized personnel entry at predetermined times.

ii. Sensor

Environment data is gathered by sensors and transmitted to other devices for processing. Motion sensors, temperature sensors, humidity sensors, light sensors, and air quality sensors are all examples of sensors that can be utilized in Smart Home Systems.

a. Motion Sensors: Motion sensors have the ability to send a signal to other devices in a room to activate specific responses, regardless of whether or not there are people in the room.

- b. **Temperature Sensor:**The temperature in the house can be determined by temperature sensors, which then communicate this information to other equipment in the home so that those devices can modify the temperature as needed.
- c. **Humidity Sensor:**The humidity levels in a home can be monitored by humidity sensors, which then relay that information to other devices so that those devices can change the humidity levels as needed.
- d. **Light Sensors:**A signal is sent from the light sensors to the other devices, which then can modify the brightness and color of the lights based on the level of light that is detected in the home by the light sensors.
- e. **Central Hub /Gateway:**The central hub, also known as the gateway, is a device that connects all of the other components of the smart home system to the internet. These components include sensors and other devices. It grants the devices the ability to interact with one another and with the user, hence granting the user the ability to exercise remote control and monitoring. The central hub or gateway also provides a platform for the analysis of the data acquired by the sensors. This enables the system to optimize the utilization of appliances and systems based on real-time data as well as the behavior of the user.
- f. **Air Quality Sensors:**Sensors that measure the quality of the air in the home provide a signal to other devices, which enables those other devices to modify the ventilation and air purification systems in accordance with the readings they receive.

II. Review of Literature

The survey includes smart home systems, IoT technologies, pros and cons, existing research, gap analysis, and research possibilities. Despite the possible advantages that could be gained by implementing IoT technology in smart home systems, there are still some obstacles that need to be overcome. IoT devices are vulnerable to cyberattacks and illegal access, which makes them one of the most serious difficulties. The literature survey on "A Smart Home System Using Internet of Things (IoT) Technology" provides a comprehensive overview of the state-of-the-art research in this field. The survey covers the various aspects of smart home systems, IoT technology, advantages and challenges of implementing a smart home system, previous studies and research on smart home systems, gap analysis, and research opportunities.

In the [11], author provides an overview of the smart home systems and the IoT technology that enables them. The article outlines the different components of a smart home system, including sensors, controllers, actuators, and communication protocols. The paper also discusses the benefits of smart homes, such as improved energy efficiency, enhanced security, and increased convenience.

In the [12], author highlights the challenges of implementing a smart home system, including interoperability, privacy and security concerns, and user acceptance. The paper suggests that these challenges can be addressed by developing standardized communication protocols and addressing privacy concerns through data encryption and user education.

In the [13], author explores the potential of smart homes for energy management. The paper discusses various approaches to energy management, such as load scheduling, demand response, and renewable energy integration. The article highlights the role of the IoT technology in enabling these approaches and improving the energy efficiency of smart homes.

In the [14], author provides a survey of the literature on smart home systems. The paper identifies the various applications of smart homes, including energy management, health monitoring, and home automation. The article also highlights the challenges of implementing smart homes, such as the lack of standardization and the need for user acceptance.

In the [15], author investigates the role of the IoT technology in smart home systems for elderly care. The paper discusses various IoT-based applications for elderly care, such as fall detection, activity monitoring, and medication management. The article suggests that IoT technology can significantly improve the quality of life of elderly people by providing personalized and remote care.

In the [16], author focuses on the role of the IoT technology in smart homes for disabled people. The article discusses various IoT-based applications for disability care, such as voice-controlled home automation, remote monitoring, and assistive devices. The paper suggests that IoT technology can help disabled people to live independently and improve their quality of life.

In the [17], author provides a comprehensive review of the enabling technologies, protocols, and applications of the IoT. The article discusses various IoT technologies, such as wireless sensor networks, cloud computing, and big data analytics. The paper also outlines the various IoT applications, including smart homes, smart cities, and smart healthcare.

In the [18], author discusses the potential of IoT technology in healthcare. The paper explores various IoT-based applications in healthcare, such as remote monitoring, telemedicine, and personalized medicine. The article suggests that IoT technology can significantly improve the quality of healthcare by providing personalized and remote care.

In the [19], author provides a survey of smart home applications based on IoT. The paper discusses various smart home applications, such as home automation, security, and entertainment. The article highlights the role of the IoT technology in enabling these applications and improving the quality of life of smart home users.

In the [20], author investigates the potential of smart homes for elderly care based on IoT technology. The article discusses various IoT-based applications for elderly care, such as fall detection, health monitoring, and social engagement. The paper suggests that IoT technology can significantly improve the quality of life of elderly people by providing personalized and remote care.

In the [21], author focuses on the potential of smart homes for energy management based on IoT technology. The paper discusses various IoT-based approaches to energy management,

such as load scheduling, demand response, and renewable energy integration. The article suggests that IoT technology can significantly improve the energy efficiency of smart homes.

In the [22], author presented a comprehensive review of smart home energy management systems (SHEMSs). The authors discussed the concept of SHEMSs and their configurations. The paper also presented an overview of the demand side management (DSM) and various DSM techniques. Additionally, the authors highlighted the importance of incorporating DSM into SHEMSs to improve energy efficiency and reduce peak demand.

In the [23], author discussed the challenges and opportunities associated with smart home technologies. The author highlighted the importance of incorporating security and privacy features in smart home systems. The paper also emphasized the need for interoperability and standardization in smart home technologies to ensure seamless integration of different devices and services.

In the [24], author conducted a literature review of smart home automation systems. The authors presented an overview of various technologies and protocols used in smart home systems. The paper also discussed the importance of user experience and user-centered design in smart home automation systems.

In the [25], author conducted a survey of middleware solutions for the Internet of Things (IoT). The paper presented an overview of various middleware architectures and their features. The authors also discussed the challenges and future directions of middleware for IoT.

In the [26], author presented a smart home energy management system that included renewable energy sources based on ZigBee and power line communication (PLC) technologies. The paper discussed the importance of renewable energy integration in smart home systems and the role of communication technologies in enabling efficient energy management.

In the [27], author conducted a literature review of smart home automation security. The paper presented an overview of various security threats and vulnerabilities associated with smart home systems. The authors also discussed the importance of security and privacy features in smart home automation systems. Smart home automation security and privacy were also explored. These hazards are related with the security threats associated with IoT devices. Another obstacle is the lack of interoperability between the various systems and devices, which can cause compatibility issues as well as operational challenges. Also, user acceptance is a vital element that needs to be taken into consideration, as not all homeowners may be willing or able to adjust to the new technology. This is something that needs to be taken into consideration.

Author(s)	Year	Methodology	Key Findings
Raza et al.	2017	Literature review	IoT-based smart home systems can improve energy efficiency, security, and comfort for residents, but also raise concerns about privacy and data security
Bu et al.	2018	Field experiment	IoT-based smart home system improves energy efficiency and reduces energy consumption in a Chinese residential building
Alam et al.	2019	Experimentation	IoT-based smart home system improves energy efficiency and reduces energy consumption in a Bangladeshi residential building
Garg et al.	2019	Case study	IoT-based smart home system improves energy efficiency and security in an Indian residential building, while also providing convenience for residents
Mohanty et al.	2018	Literature review	IoT-based smart home systems can improve energy efficiency, security, and health for residents, while also providing convenience and customization

Table.1 Analysis of A Smart Home System Using Internet of Things (IoT) Technology

III.Challenges of Implementing Smart Home IoT-based System

Although many benefits are available to homeowners who want to use an IoT-based smart home system. Controlling and automating household equipment and systems, like thermostats, lights, and entertainment centers, can significantly cut down on energy consumption. Door locks, security cameras, and alarm systems are just some of the aspects of a home that can benefit from being monitored and controlled by a smart home system. Moreover, smart home systems can provide improved ease and comfort for homeowners by allowing for more effective remote home management. Yet, there are also several obstacles to overcome when putting in place an IoT-based smart home system. The vulnerability of IoT devices to cyberattacks and illegal access is one of the most serious obstacles. Hackers can easily get access to IoT devices due to their lack of robust security measures, such as weak passwords and unpatched software. Problems with compatibility and efficiency can also arise

from incompatibilities between various devices and systems. Smart home device interoperability can be hindered by factors like a lack of standards and the usage of proprietary protocols. Not all households will be ready or able to adopt the new technology, therefore user acceptance must also be taken into account.

IV. Proposed Design & Approach

To explore the difficulties and potentials of IoT-based smart home systems, this study adopted a mixed-methods research strategy, collecting both quantitative and qualitative data. Experts in the field of IoT and smart home systems, as well as homeowners who have deployed such systems,

A. Data Collection Method and Tools Required:

In order to collect data for the study, the researchers relied mostly on two different methods: online questionnaires and semi-structured interviews. The purpose of the online poll was to obtain quantitative data on the benefits and difficulties associated with putting into practise a smart home system that makes use of internet of things technologies. The survey had both open-ended and closed-ended questions, and it used a Likert scale to determine the degree to which respondents agreed or disagreed with certain claims. In addition to closed-ended questions, the poll contained open-ended questions that asked respondents about their experiences with smart home systems and gave them the opportunity to provide more specific information. The purpose of the semi-structured interviews was to collect qualitative data on the potential and difficulties posed by smart home systems that make use of internet of things technologies. The interviews were performed with industry professionals specializing in Internet of Things (IoT) and smart home systems, as well as with homeowners who have integrated IoT technology into their smart home systems. The interviews were done using a pre-determined series of questions, which provided the interviewer with the opportunity to investigate the experiences of the respondents and gain a more in-depth understanding of their opinions regarding smart home systems.

B. Sample Size & Selection Criteria

Participants were split evenly between homeowners who had already installed IoT-based smart home devices and industry specialists. Using a power analysis with a significance threshold of 0.05 and power of 0.80, the appropriate size of the online survey sample was calculated. There were 150 people who filled out the online survey. Data saturation criteria were used to identify an adequate sample size for the semi-structured interviews. At this point, researchers could draw no more conclusions from the study. The homeowners were chosen because they have been using their IoT-based smart home systems for at least six months, and the experts were chosen because of their expertise in the field of both IoT and smart house systems.

C. Data Analysis Techniques & Procedure

Descriptive statistics, such as means, standard deviations, and frequencies, were applied to the online survey's quantitative data. Thematic analysis was used to find recurring patterns

and themes in the qualitative data obtained through the semi-structured interviews. NVivo, a program for analyzing qualitative data, was used to transcribe, code, and analyze the data. Narrative descriptions and direct quotations from respondents were used to illustrate the data's recurring themes and trends. In what followed, we reported the findings of our data analysis.

D. Analysis of Data & Finding

Some significant findings emerged from the data analysis. Most people who took part in the online study said they installed a smart home system to make their homes safer (67%), next because it was more convenient (24%), and finally because it saved money on utilities (9%). Second, security cameras, smart locks, and smart thermostats were the most popular smart home equipment. Third, the high cost of implementation (23%), worries about data privacy and security (20%), and the complexity of setting up and maintaining the smart home system (36%) were cited as the most major difficulties faced by homeowners. Fourth, the experts noted numerous ways in which the design and implementation of smart home systems may be enhanced. These ways included more interoperability and standardization, enhanced user interfaces, and more stringent data security and privacy protections.

E. Interpretation of Findings

The study's results have numerous ramifications for the introduction of IoT-based smart home systems. Homeowners are encouraged to deploy smart home systems to increase their sense of safety, but the complexity of installing and maintaining these systems presents a considerable hurdle, according to the results. The results of this research further underline the importance of including stricter data security and privacy safeguards into the planning and development stages of smart home systems. According to the experts' suggestions for enhancing smart home system design and execution, the current level of smart house technology leaves a lot to be desired.

F. Implication of Methodology

Several areas of practice and policy involving the introduction of IoT-based smart home systems can be influenced by the study's conclusions. To begin alleviating homeowners' fears regarding their personal information, legislators should make the creation of data security and privacy standards a top priority. Second, experts in the field need to prioritize the development of interoperability and standards in the design of smart home systems. Finally, improved user interfaces may simplify the process of installing and maintaining smart home systems.

V. Conclusion

In conclusion, this study investigated the potential applications of internet of things technology in the construction of intelligent home systems. According to the findings, homeowners desire to incorporate smart home systems into their homes in order to boost their sense of safety; yet, they believe the process of installing and maintaining such systems to be too complicated. The current level of smart house technology leaves a lot to be desired,

according to the proposals made by the industry experts for improving the smart home system design and the execution of said design.

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