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Review on the Implementation and Working of Smart Homes using Internet of Things and its Impact on Modern World

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ABSTRACT

With the evolution of Internet, Internet-of-Things (IoT) has been a standard example which undergoes various changes in our ways of living resulting towards a hi-tech lifestyle. Looking forward towards the present world, IoT is expected to invade in almost all facets of day-to-day being. Through this paper, we present a smart home automation system which is powered by sensors and things and managed by the Blynk application. This system is implemented on Internet of Things technology. It provides users with remote control of their home appliances and alerts them to any changes in their environment through notifications on their mobile devices. The proposed system offers an efficient and convenient solution for smart home automation that enhances home security, energy efficiency, and user experience. The project implementation, including hardware design, software development, and testing, is presented in detail in this paper. The results of the system's performance evaluation demonstrate its reliability and effectiveness in fulfilling its intended functions.

Keywords: Internet of Things (IoT), home automation, microcontroller, architecture, application, future technologies, sensor, Blynk.

1. Introduction

The name "Internet of Things" (IoT) refers to the interconnection of physical objects, such as machinery, automobiles, buildings, and many more items, which are equipped with sensors, software, and network connections. Automation, remote control, and the capacity to acquire and analyse significant volumes of data are all made possible by the IoT, which enables the smooth interchange of data between devices and systems. As a result, a variety of sectors and applications may now benefit from increased efficiency, cost savings, and new prospects for innovation [1].

2. Overview of the Project

Our home automation system project intends to give consumers access to a web application that enables them to remotely operate their home's equipment on an autonomous basis. The project is planned and implemented in C++ language using the Arduino IDE. You can access and manage the appliances in your house using a mobile device. Homes where practically all of the electrical outlets, lights, and appliances are linked to a remotely programmable network are better described as having "home automation." Automatic doors, gas detection systems, fire alarms, and a lot more sensors are included in this from the perspective of home security.

In this specific project, the ESP8266 microcontroller serves as the central hub or controller. It is a cost-effective, low-power microcontroller with built-in Wi-Fi capabilities. It can be programmed to communicate with various sensors and devices in the home, such as infrared sensor, gas sensor, and appliances. The relay module is used to control the power to the home appliances. It is an electronic switch that can be controlled by the microcontroller. RFID sensor is used to prevent unauthorized access to the premises. Only person who carries the RFID key can have access to the home [2].

3. Technical Details

The microcontroller is frequently used in our system to analyze data and manage devices. Actuators like relays, motors are used to operate equipment and appliances, whereas sensors are used to collect data and initiate actions. Users of mobile applications may remotely manage and keep an eye on their devices. In designing the system, it's crucial to take the power supply in mind as well. Microcontroller programming and mobile application development are all included in software development [3].

3.1 Description of the components used

We used the following components in our project:

i. *Microcontroller:* The ESP8266 microcontroller is a popular choice for home automation systems and is responsible for processing data, controlling devices, and communicating with gadgets.

ii. *Relay Module:* It is an electrical switch mainly operated by an electromagnet. It is used to control AC devices like fan, lights etc. and are directly connected to AC power supply.

iii. *Infrared Sensor:* A radiation-sensitive optoelectronic component having a spectral sensitivity in the infrared wavelength which is used for object detection in our project.

iv. *Gas Sensor:* Conversion of the components and concentrations of various gases into standard electrical signals by using specific physical and chemical effects, which is widely used in the detection of noxious and harmful gases and natural gas leakage.

v. *Flame Sensor:* Referred to as a short, thin metallic rod creating a small current of electricity to test the presence of a flame burning within the furnace.

vi. *RFID Sensor:* The Radio Frequency Identification sensor is a form of wireless communication that uniquely identifies an object, animal or person. It uses radio frequency to automatically detect and track tags attached to the objects [2].

vii. *Servo Motor:* Servo motors are the devices that can turn to a specified position. Usually, they have a servo arm that can turn 180 degrees.

viii. *5V DC Motor & Motor Driver:* The rotary electrical machines used for the conversion of electrical energy into mechanical energy. Motor drivers acts as an interface between the motors and the control circuits.

ix. *LED:* It stands for Light-Emitting Diode which is a semiconductor device, emitting light when current flows through it. Electrons inside the semiconductor recombines with electron holes, releasing energy in the form of photons.

x. *Buzzer:* The buzzer or beeper is an audio signalling tool, which may be mechanical, electromechanical, or piezoelectric.

xi. *Breadboard:* A breadboard, solderless breadboard, or protoboard is a construction base used to build semi-permanent prototypes of electronic circuits.

xii. *Jumper Wires:* An electrical wire connecting remote electric circuits used for printed circuit boards.

3.2 Explanation of how the system works

The system works by connecting various devices and appliances in a home through a network of sensors, actuators, and a microcontroller. It can be controlled and monitored remotely through a mobile application or a web interface.

Here is a general explanation of how the system works:

i. *Sensors:* Flame, infrared, gas and RFID sensors are placed throughout the home to gather data and send it to the microcontroller. These sensing devices can be used to detect the changes in gas level or the presence of person and flame in the home.

ii. *Microcontroller:* The microcontroller receives the data from the sensors and processes it to determine the appropriate actions to take. The microcontroller can also be used to send data to the cloud-based services and receive commands from the mobile application.

iii. *Actuators:* Actuators such as relays and motors are connected to the microcontroller and used to control devices and appliances in the home. For example, a relay can be used to turn on and off a light, or a motor can be used to open and close a window.

iv. *Mobile application:* A mobile application is provided to the user, allowing them to control and monitor the system remotely and receive notifications on any activity. In this project, we used Blynk application through which we control the devices and monitor every change in the sensors [3].

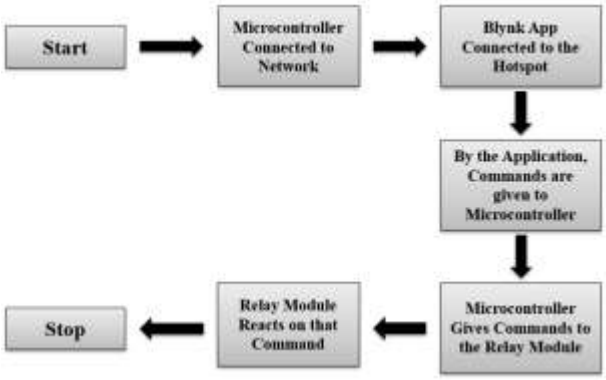

Fig. 1. Flowchart of the complete process

3.3 Discussion on the programming language

The microcontroller is programmed using the Arduino-based C++ programming language. Arduino is an open-source electronics platform allowing developers in writing and uploading code to the microcontroller. It provides a user-friendly development environment and a large community of developers who share code and libraries [4].

4. System Design and Implementation

The designing and implementations of the system includes following steps:

i. *Requirements Analysis:* The first step is gathering all the requirements of the system, which includes identifying some specific tasks that the system should be able to perform, such as controlling the lighting, temperature, and appliances in the home.

ii. *Hardware selection:* In the next step, we selected the hardware(s) that will be used in the system. This includes the microcontroller, sensors, actuators, and other components.

iii. *Circuit design:* The next step is to design the circuit that connects all the components together. This includes connecting the sensors, actuators, and microcontroller and any other components to the power supply.

iv. *Microcontroller programming:* We programmed the microcontroller using Arduino IDE. This step also includes setting up the configurations and interfacing the mobile application.

v. *Testing and debugging:* Once the hardware and software are developed, we tested the system and debugged any issues that were found.

vi. *Deployment:* After testing and debugging, the system is ready to be deployed in the home environment.

vii. *Maintenance:* The system needs to be maintained and updated regularly to ensure that it is functioning properly and is secure [5].

5. Connection and Communication

In our system, the devices communicate with each other over the internet using a protocol called MQTT (Message Queuing Telemetry Transport) which is a lightweight message protocol that allows devices to publish messages to a broker, which then distributes the messages to other devices that have subscribed to the same topic. In our system, the microcontroller acts as a client that connects to the MQTT broker. All the sensors are connected to the ESP8266 and send data to the broker when triggered. The LEDs, relay module, servo motor, and piezo buzzer are also connected to it and receive commands from the broker to turn on/off, move, or sound an alarm [6].

6. Circuit Diagram

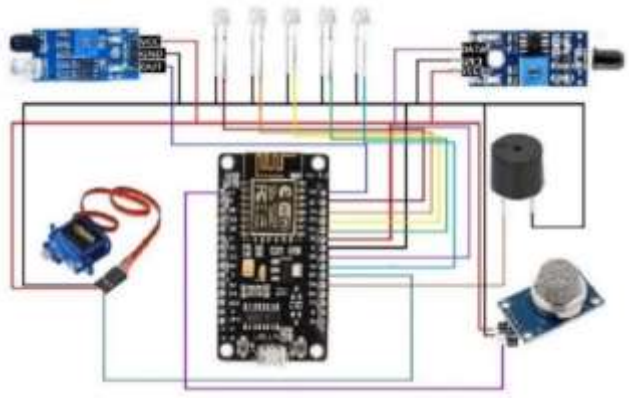

Fig. 2. Connection between microcontroller, sensors, motor and piezo buzzer

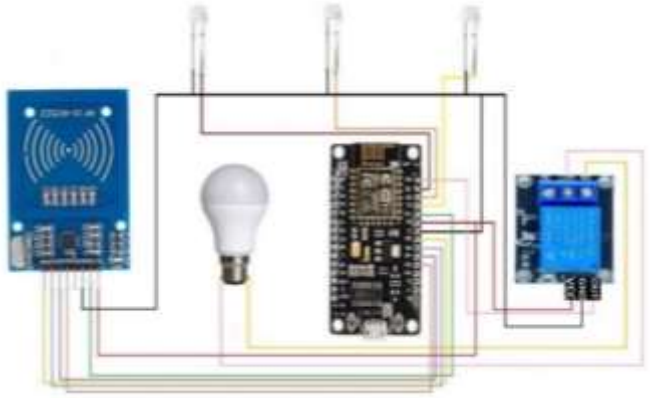

Fig. 3. Microcontroller connected to the relay module, LEDs and RFID sensor

7. Result and Evaluation

After demonstrating several times, we were able to communicate with all the devices. We tested the entire model many times and got everything worked. Below are some images which show the testing of the devices:

Fig. 4. Switching the LEDs using Blynk (Status: OFF)

Fig. 5. Switching the LEDs using Blynk (Status: ON)

Fig. 6. Firing the flame sensor

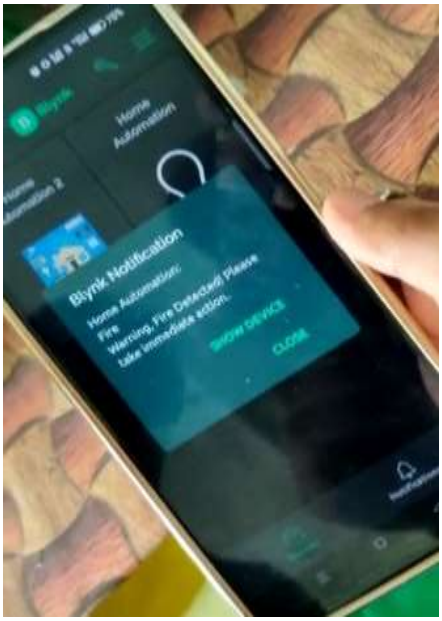

Fig. 7. Receiving fire notification

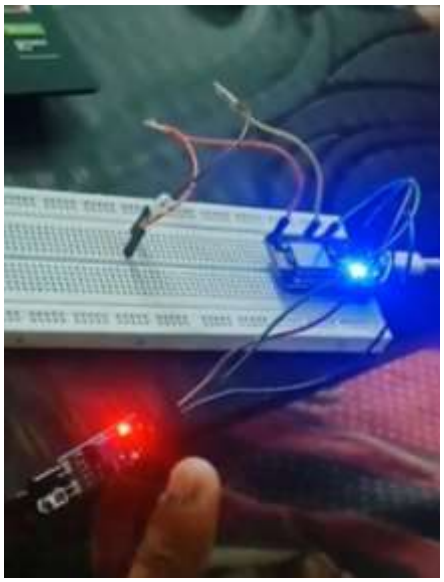

Fig. 8. Demonstrating infrared sensor

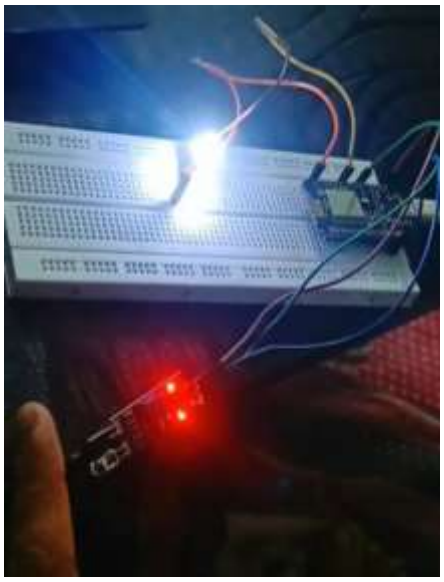

Fig. 9. Detection of object

7.1 Discussion on the benefits achieved by the system

Our automation system offers several benefits, such as:

i. Energy savings: The system can be utilized in monitoring and controlling energy usage of homing appliances and devices, leading to a reduction in energy consumption and cost savings.

ii. Improved safety: The system can be used to detect and alert the user of potential security and safety hazards, such as gas leaks or fires.

iii. Increased convenience: The system can be controlled remotely through a mobile application, allowing users to operate the devices and appliances in the home from anywhere.

iv. Remote monitoring: The system can be used to monitor the status of the home and its appliances remotely which can be very useful for people [7].

7.2 Analysis of any security concern:

IoT devices were not built with security in mind. So, it results in myriad IoT security challenges that can lead to disastrous situations. Among many security issues, some are the following:

i. Lack of Visibility: Users frequently deploy IoT devices without sufficient security understanding, making it challenging to maintain an accurate inventory of what needs to be protected.

ii. Bounded security integration: Integrating IoT devices into security systems is difficult to impossible due to their variety and scale.

iii. Open-source code vulnerabilities: IoT device firmware frequently includes open-source software, which is prone to faults and vulnerabilities.

iv. Blockchain and IoT: IoT lacks security measures which can be improved by adapting blockchain technology because of its inbuilt security and transparency. The combination of Blockchain and IoT frames a new concept of Blockchain-of-Things (BC-o-T) where blockchain provide a new strength to IoT with more secured layers [8].

7.3 Points for the resolution of security concerns:

It's important to address these security concerns by implementing appropriate security measures such as:

- Using strong and unique passwords for all devices and the system.
- Encrypting the communication between devices and the system.
- Regularly updating the firmware of all devices.
- Using firewalls and intrusion detection systems.
- Monitoring the system for unusual activity.

- Conducting regular security audits.
- Prioritize Wi-Fi and private network.
- Integrating Blockchain technology with Internet of Things [9].

8. Applications of IoT

The applications of IoT, the Internet-of-Things is quite diversified as it is penetrating in virtually every strands of daily-life aspects whether it is an individual, institution or society. It covers broader areas of interests which includes the industrial and manufacturing sectors, healthcare fields, agriculture, smart cities and many more [10]. Some of these are discussed below-

8.1 IoT in Smart Cities

IoT improves the smartness of the city. In building smart city, some IoT application includes – transportation, smart buildings, lighting, parking, etc. These IoT-based applications includes various functions such as keeping track of the parking areas in the cities, monitoring vehicles etc. and many more. IoT embedded in Artificial Intelligence (AI) can be employed in monitoring, controlling and reducing traffic jams in Smart cities [11].

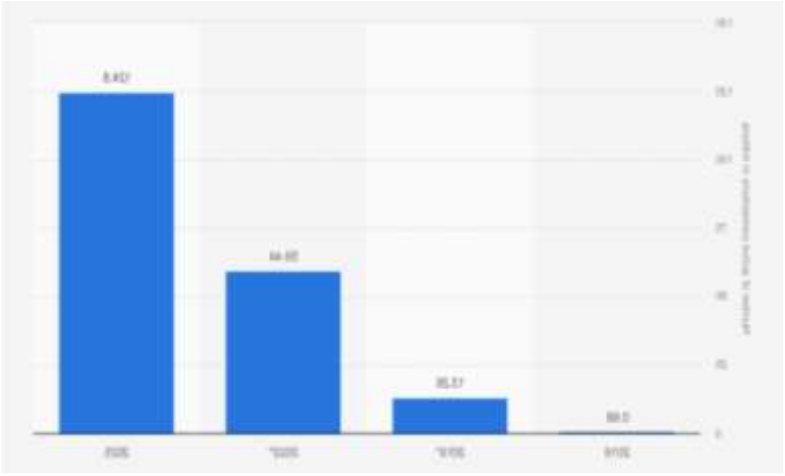

Fig. 10: Number of IoT active connections in EU statistics [12]

8.2 IoT in Healthcare sector

In India, there are many patients lying on the floor in the hospitals due to lack of beds and money. In many countries around the world, there are most healthcare organizations which is unskilled, slow and unavoidably subjected to errors. Also, this is not constant which means it can be changed easily as the healthcare areas depends on innumerable activities and countless devices which are automated and upgraded via technologies and communication. If we talk about the adaptability of the IoT devices in the healthcare sector then, we will see that there are many researches and various engineers involved in improving the technology and developing more efficient IoT based devices for monitoring different health problems faced by the people such as diabetes, cancer etc. [13, 14].

8.3 Smart Agriculture

If we talk about the world's growing population then we find that it estimates to reaches approximates to 10 billion by 2050. Since the population is becoming more and more large in the coming years so we need to progress in the current approaches towards agriculture to feed a bulky population. Thus, to figure this out, there is a need to link technology with agriculture for an efficient production of raw materials and crops. One of the approaches to this context is the Greenhouse technology as it provides a technique for managing the environment's criterion aiming to improve the productions. With the evolution of IoT technology, IoT embedded devices and sensors have made it simpler for the people to manage the climate inside the hall, also observe the processes which resulted in energy conservation and also upgraded productions [13, 15].

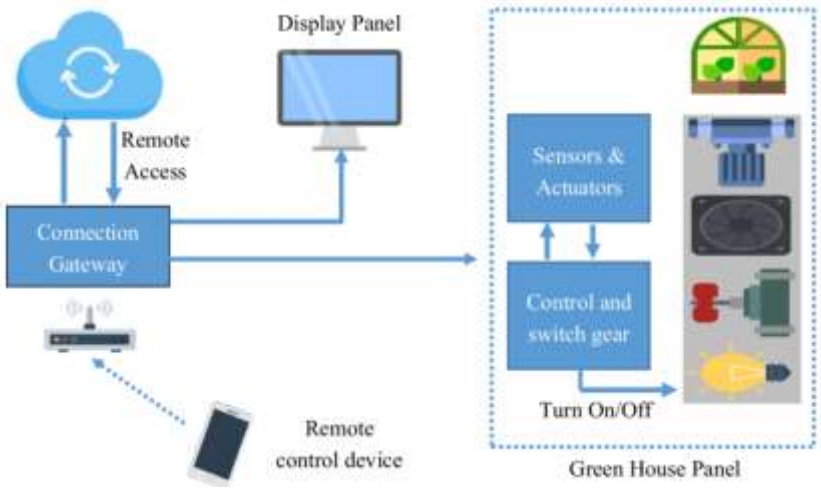

Fig. 11: A working structure of IoT system in agriculture production [16]

8.4 Management of Water

In the water management field, the function of Internet of Things (IoT) involves the study of water suitability in rivers and seas which is used for both purpose that is for drinking and agricultural use. Also, it is used for determining pressured variation in pipes and presence of liquids outside the tanks as well as observing water levels in rivers, dams and reservoirs [13, 17].

9. Impact on Modern World

The Internet of Things (IoT) and smart home technology have had a significant impact on the modern world. Here is a detailed explanation of the impact of the Internet of Things (IoT) and smart homes on the modern world:

i. *Convenience and Efficiency:*

IoT and smart home devices have made our lives more convenient and efficient. According to a report by the International Energy Agency, smart home technologies could potentially reduce global energy consumption by up to 10% by 2040.

ii. *Improved Health and Safety:*

IoT devices have also had a positive impact on health and safety. It can monitor air quality, detect gas leaks, and alert homeowners to potential security threats. They also enable remote monitoring of elderly or disabled individuals, allowing them to live more independently.

iii. *Environmental Sustainability:*

Internet of Things have the potential to help mitigate climate change by reducing energy consumption. According to a report by the American Council for an Energy-Efficient Economy, the smart home market could reduce greenhouse gas emissions by up to 1.3 gigatons of carbon dioxide equivalent by 2030.

iv. *Economic Impact:*

Lighting to a report by McKinsey & Company, the IoTs market could have a total economic impact of $3.9 trillion to $11.1 trillion per year by 2025. Smart home technologies are also expected to drive growth in the home automation market, which is projected to reach $121.73 billion by 2026.

v. *Energy Efficiency:*

Smart home devices like thermostats, lighting systems, and appliances can help reduce energy consumption and promote sustainability. Studies have shown that smart homes can reduce energy use by up to 30%.

vi. *Increased Productivity:*

Smart homes can automate many tasks such as turning on lights, adjusting temperature, etc. This automation can free up time for more productive tasks, leading to increased productivity [17, 18].

Fig. 12. Impact of IoT on different industries [18]

10. Scope for Future Research

The scope for future research on IoT-based home automation systems can include the following:

i. Improved security: Developing new and more secure methods to protect the system from unauthorized access and data breaches.

ii. Energy management: Investigating and developing new techniques to optimize energy consumption in the home.

iii. Human-computer interaction*:* Investigating ways to improve the user experience, such as developing more intuitive interfaces or natural language processing capabilities.

iv. Smart grid integration: Integrating the system with smart grid technology to allow for real-times monitor and control of energy usage.

v. Machine learning and artificial intelligence: Incorporating machine learning and AI algorithms to improve the system's performance, such as optimizing energy usage or detecting potential security threats.

vi. Voice control: Investigating the use of voice control to interact with the system, which can improve the user experience and accessibility [20, 21].

11. Conclusion

An automation system is a technology that allow the user to control and monitor home appliances and devices remotely through a mobile application or web interface. This system can provide many benefits such as energy savings, improved safety, increased comfort, and increased convenience. The results of the system are analysed against the goals and objectives set for the system. This analysis is used to identify areas for improvement and optimization.

In conclusion, an IoT-based home automation system can provide many benefits, but also poses some security concerns. By implementing appropriate security measures and regularly monitoring the system, these concerns can be mitigated to provide a secure and efficient home automation system.

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