An Energy Efficient IoT Based Smart Home Automation and Automated Water Pump Control System

Rajib Mondal[1], Md Lutfur Rahman[2], Md Hasan Bepari[3], Umme Hani Riya[3], Md Abu Hena Shatil[4], Rapsan Amin Anonto[5]

[1]Assistant Professor, Department of Electrical and Electronic Engineering, RPSU, Bangladesh

[2]Lecturer, Department of Electrical and Electronic Engineering, RPSU, Bangladesh

[3]Research Assistant, Department of Electrical and Electronic Engineering, RPSU, Bangladesh

[4]Associate Professor, Department of Electrical and Electronic Engineering, AIUB, Bangladesh

[5]Ph.D Researcher, Department of Electrical and Computer Engineering, Morgan State University, USA

Corresponding Author: Md Lutfur Rahman, lutfur_eee@rpsu.edu.bd

ARTICLE INFO

Keywords: Arduino UNO, IoT, Ultrasonic Sensor, Relay Module, Telegram Application, ESP8266 Wi-Fi module

RECEIVED
22 March 2025

ACCEPTED
09 August 2025

PUBLISHED
31 August 2025

DOI
https://doi.org/10.5281/zenodo.17243400

ABSTRACT

The Internet of Things (IoT), which allows for communication between humans and machines, has a significant impact on daily lives. This research article will invent technology and ideas that allow humans to communicate with machines more effectively and efficiently. In this paper, we basically presented an energy-efficient IoT-based smart home automation system. This system is based on the Telegram application, which is controlled by an ESP8266 Wi-Fi module. The most popular feature of Telegram is that it can handle commands from users and provide appropriate command functionality. Additionally, in this research, an automated pump system is used, which automatically fills the water tank when the water level goes down and turns off the pump when the tank is full.

1. Introduction

We are shifting toward the internet era, where every accessible item will be managed and connected to the internet. According to a study, there will be 75.44 billion Internet of Things (IoT) connected devices installed globally within 2025 (M. S. Mahamud, M. S. R. Zishan, S. I. Ahmad, A. R. Rahman, M. Hasan, and M. L. Rahman, 2019). The main purpose of home automation is to make life as easy as possible through the utilization of an IoT system. For instance, this is achieved by enabling lights to be turned on or off remotely (T. R. Beegum, 2017). This paper's focus is to devise a method for effective and economical conversion of an existing house into a smart home. In this study, we have suggested an energy-efficient Internet of Things (IoT)-based smart home automation system. A user can operate their home appliances with this technology at any time and from any location. Here, the Telegram messaging app is used, which provides better advantages with an IoT framework and with the most notable flexibility in network arrangement. Both the control device and the IoT device can be situated anywhere, as long as internet service is accessible (Soni, Gaurav, et al., 2021). In order to enable the control of home devices through Telegram, an ESP8266 Wi-Fi module development board is used. This Arduino-compatible gadget may be used to interact directly or through a relay with the automation target. IoT devices could be controlled with simple instructions via the Telegram app when the required setup is finished. Additionally, by evaluating the data obtained from the ultrasonic sensor, Arduino in this study regulates the water pump's activation and deactivation. (Dhillon, Javed, et al. 2021).

2. Literature Review

In recent years, IoT technology has gained prominence for its incorporation into daily life. IoT's capacity to provide seamless communication between humans and machines has opened up many prospects for innovation and efficiency improvement. This section reviews literature on IoT, Telegram, and automated systems in complaint management and water supply control. (Adinegoro, Prasetyo, et al. 2020). The literature has extensively examined IoT-driven smart homes. Security, energy management, and resource allocation could be monitored and controlled by IoT devices and sensors. These apps can improve life and ease educational processes. (Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M., 2015).

Telegram, an emerging instant messaging service, has grown rapidly thanks to its strong feature set and developer-friendly environment. Previous studies have integrated Telegram with customer service and IoT device control, proving its

versatility and efficacy. (Baumgartner, Antonioli, D., & Zingirian, N., 2019). Efficient complaint management is essential for student and staff satisfaction in educational institutions. The use of IoT technologies has improved complaint processing. IoT sensors could identify temperature changes, equipment failures, and security breaches and send notifications, as well as reduce response times and improve user satisfaction. (Gupta, P., & Kumar, N., 2020).

Technology in communities and home appliances has made water pumps important to daily life, especially for household users (S. J. Sukoco, A. Setiawan, M. I. Suhermin, S and Rahim 2017, D. Cooper R. A. Pasquina, P. F. and Fici-Pasquina L 2011, Nam T and Pardo T. A. 2011, Cook D J and Das S. K. 2005, Napitupulu D, 2018). Research has also focused on water supply automation. Automated pump systems monitor storage tank levels and manage pumps to maintain water delivery. These efficient technologies conserve water by preventing waste. (Han, D., Lian, J., Liu, L., & Fan, W., 2019). Telegram interaction with IoT systems is new. Researchers have investigated using Telegram for IoT device and communication. Telegram can take user commands and offer real-time updates, making it perfect for remote IoT management and monitoring (Muslih, Muhamad, et al. 2018). While the integration of IoT with Telegram for complaint management and automation offers numerous benefits, it also presents challenges. These include security concerns, data privacy issues, and the need for robust authentication mechanisms to prevent unauthorized access to sensitive systems.

3. Objectives

- To design an efficient smart home system that minimizes time, effort, cost, and human error.
- To leverage IoT technology for seamless remote control and automation of household devices via the internet.
- To promote energy efficiency and water conservation through the integration of smart technologies.

4. System Description

4.1. Arduino UNO

An open-source platform for basic electronics prototyping is the Arduino Uno board. Since it features an Atmel ATmega328P microprocessor, it is ideal for introducing microcontrollers and embedded programming. (Sadikin, Nanang, Marliana Sari, and Busye Sanjaya. 2019). It's 32KB flash memory includes 2KB of SRAM and 0.5KB utilized by the bootloader. It also includes a 16MHz clock speed and a 1KB EEPROM. The server, loads, and all of the sensors are connected through Arduino.

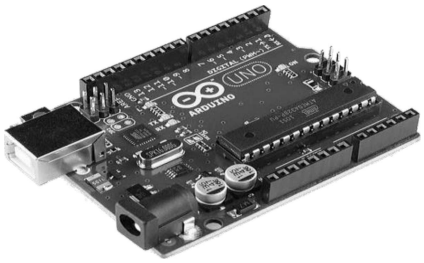

Fig.01. Arduino UNO Board

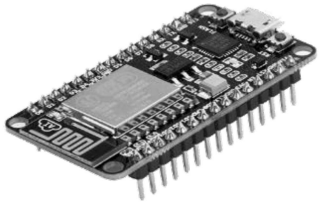

Fig.02. ESP 8266 Wi-Fi Module

4.2. NodeMCU ESP 8266 Wi-Fi Module

The Node MCU is an open-source software and hardware development environment based on an affordable architecture on a chip known as the ESP8266. The ESP8266, invented and manufactured by Espressif Systems, has the essential components of a computer: CPU, RAM, networking (WiFi), and even an updated operating system. This makes it an excellent choice for IoT-based research. (Parihar, Yogendra Singh. 2019).

4.3. Ultrasonic Sensor

Ultrasonic sensor's echo pin is connected with Arduino's pin No.7, trig pin is connected with Arduino's pin No. 8, Vcc pin with Arduino's 5V, and GND pin with Arduino's GND pin. Arduino's 10th no. The pin is connected to the relay module, and there is also a buzzer which is connected to Arduino's 9th no. pin (Carullo, Alessio, and Marco Parvis,2001).

4.4. Relay Module

Relay is an electromechanical device that can be used to make or break an electrical connection. A relay is essentially a mechanical switch that may be turned on or off by an electrical signal rather than by hand. It is made up of a flexible movable mechanical component that can be controlled electronically by an electromagnet. Moreover, this relay's operation is limited to electromechanical relays. (Vogel, Burkhard, and Burkhard Vogel. 2011).

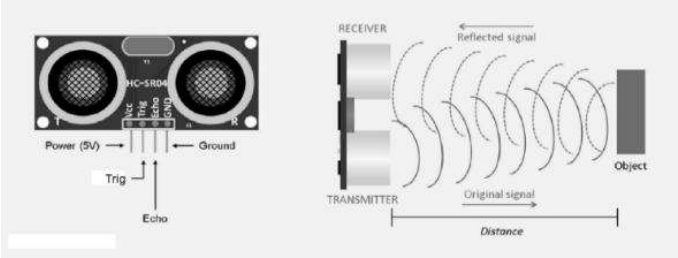

Fig.03. Ultrasonic Sensor

Fig.04. Relay Module

5. Architecture Model with Flow Chart and Simulation

5.1. Architecture Model of Proposed System

Fig. 05 shows the block diagram of the proposed system. A user sends commands via the Telegram app on their smartphone through the internet. The ESP-8266 receives these commands and controls multiple devices via a relay module. The Telegram application was used to control the whole system. Fig. 6 shows the block diagram of the water pump control system. The ultrasonic sensor detects the distance of an object and sends data to the Arduino Uno. Based on the sensor input, the Arduino controls the relay module. The relay module then switches the motor on or off using power from the power supply.

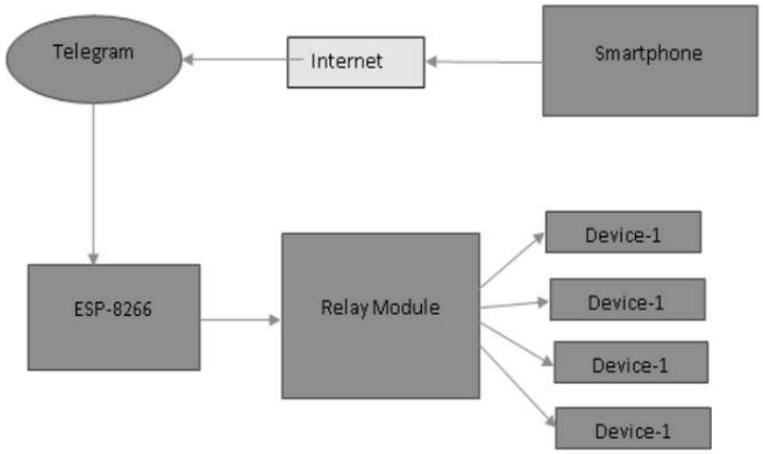

Fig.05. Architecture Model of the proposed Control System

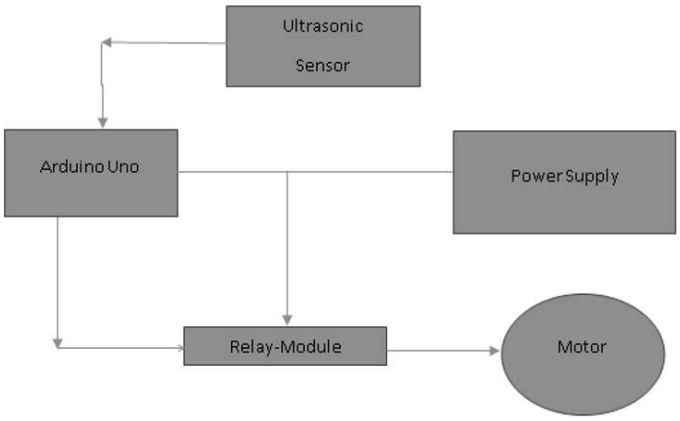

Fig.06. Architecture Model of the Automated Water Pump Control System

5.2. Flow Chart

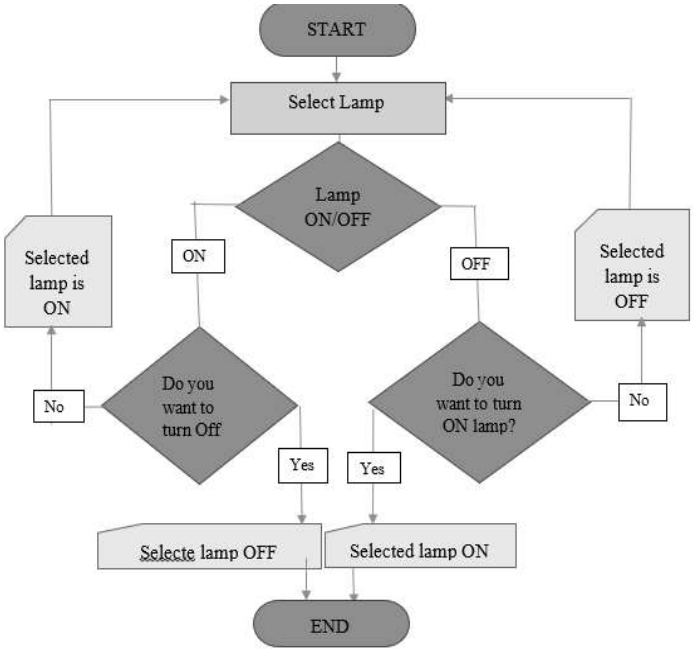

Fig. 07. An IoT Based Smart Home Automation Lamp Control System.

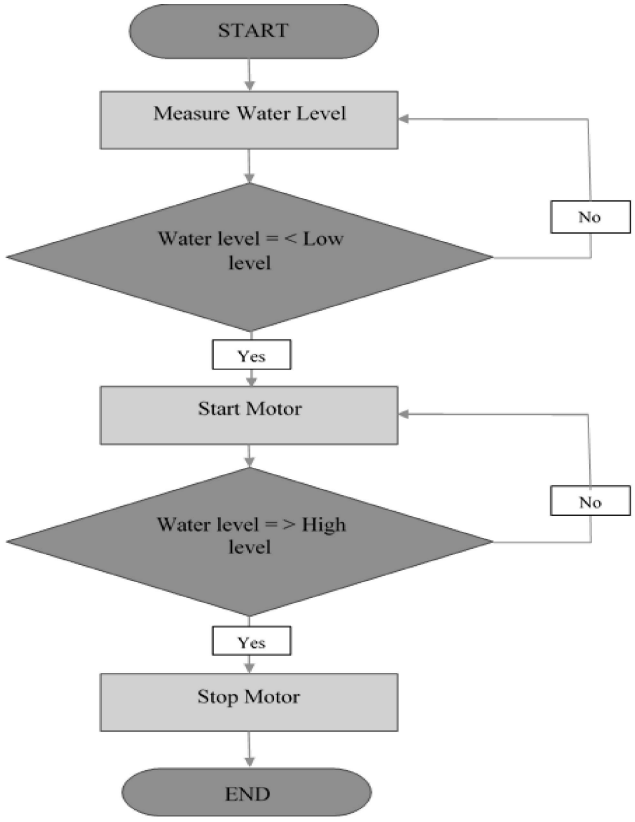

Fig. 08. Automated Water Pump Control System

Fig. 07 shows the flow chart of an IoT-based smart home automation lamp control system. This flowchart describes the process of selecting and controlling a lamp. After selecting a lamp, the system checks if it is ON or OFF. If ON, it asks if you want to turn it OFF; if OFF, it asks if you want to turn it ON. Based on user input, the lamp is either switched ON or OFF, and the process ends. and Fig. 08, and an automated water pump control system. This flowchart automates motor control based on water level. It starts by measuring the water level and checking if it is below the low threshold. If yes, the motor starts and keeps running until the water reaches the high level. Once the high level is detected, the motor stops and the process ends.

5.3. Simulation

This system consists of electrical and electronic components. Fig.09. shows the representation of the main circuit diagram of the design and construction of the home device control system, and Fig. 10 shows the circuit diagram of the water pump control system.

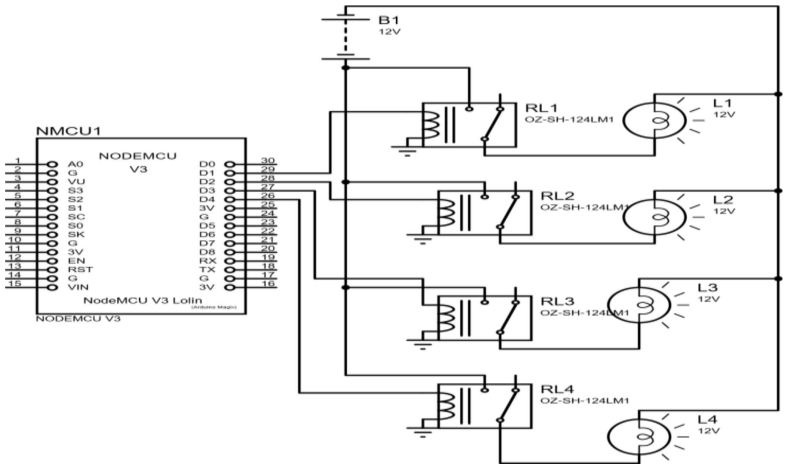

Fig. 09. Simulation of Design and Construction of Smart Home Automation

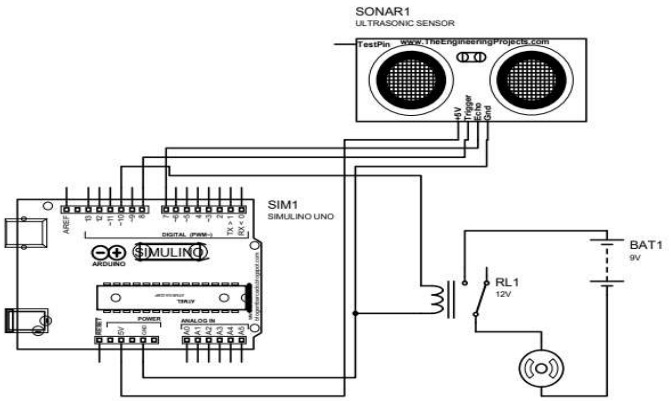

Fig. 10. Simulation of the Water Pump Control System

6. Architecture Model

The whole process of hardware implementation has been described in the segment. Fig. 11 shows the hardware implementation of the whole system.

Fig. 11. Hardware Model of the Proposed System

7. Results and Cost Analysis

Table 01. The total number of connecting power of customers.

Appliances	Power (W)	Quantity	Total Watt
Light	18 20	10 10	380
Fan	65	5	325
Ac	1000	2	2000
Washing machine	500	1	500
Blender	500	1	500
Egg bitter	260	1	260
Rice cooker	700	1	700

Oven	1000	1	1000
Refrigerator	500	2	1000
Water heater	1000	1	1000
Electronic Iron	800	1	800
TV	100	1	100

Table 02. Power saving analysis of the customer.

Bill Month	Consumption	Monthly Bill	Saved Power	Saved Money
March 2024	364	2231	69.16	423
April 2024	562	4161	106.78	790
May 2024	397	2450	75.43	452
June 2024	428	2763	81.32	570
July 2024	332	2018	63.08	378
August 2024	582	4370	110.58	830
September 2024	406	2533	77.14	470
October 2024	314	1898	59.66	357
November 2024	801	3138	152.19	1140
December 2024	520	3724	98.8	691
January 2025	428	2612	81.32	530
February 2025	520	3724	98.8	632

Here, table 01. and table 02. respectively shows the total number of connecting power and power saving analysis of customers.

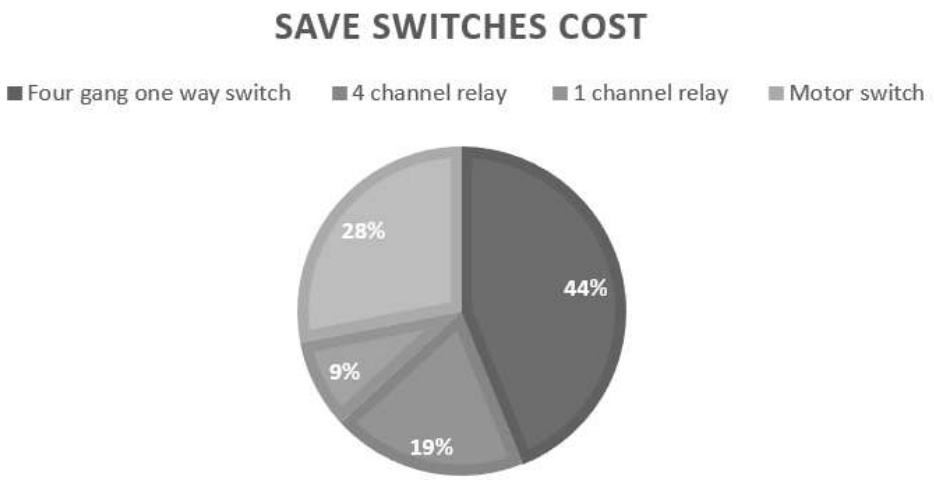

Fig. 12. Switch Costs Analysis

A smart home has few switching costs. Only the relay module switch can operate the whole system. In this system, there is no need for a manual switch. The cost analysis of the smart house is displayed in Fig. 12.

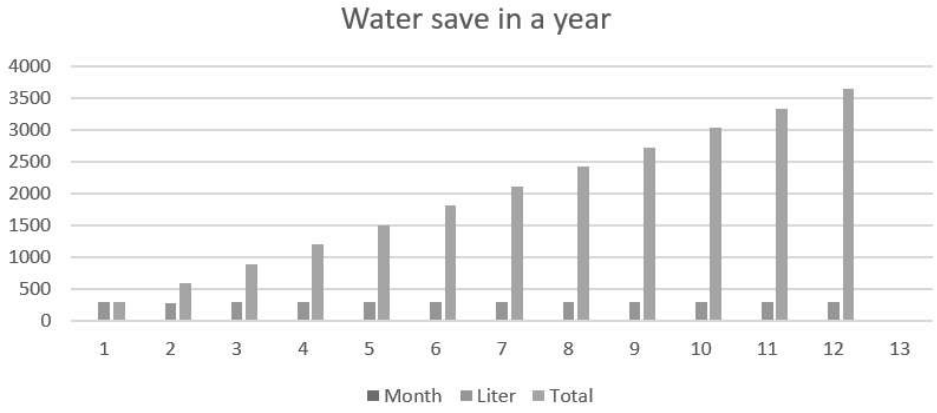

Fig. 13. Water Save Analysis

Smart homes reduced 44% the switching cost. Fig. 13, Fig. 14, and Fig. 15, respectively, show water saving analysis, power consumption analysis, and power and money saving analysis.

The automation pump utilized in projects for smart homes also conserves a significant amount of water. Nearly 36,500 liters of water can be saved annually, as shown in Fig.13. The automated water pump system contributes to the conservation of both water and electricity. It eliminates the need for manual operation, ensuring efficient usage.

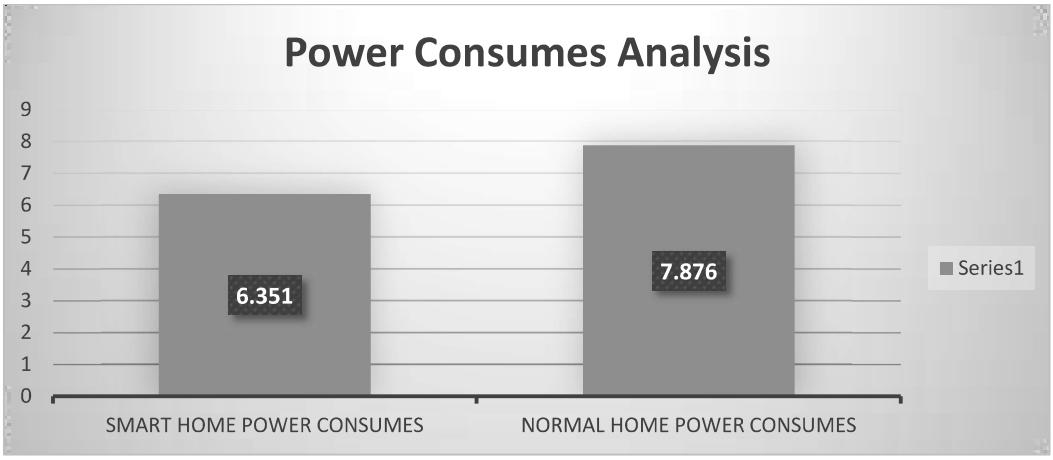

Fig. 14. Power Consumption

The power loss of smart homes is low. Neither a system error nor a power outage has occurred. Fig.14. shows the power consumption analysis. This figure addresses the topic of savings analysis. It delves into discussions concerning power consumption, monthly expenses, conserved energy, and the financial savings achieved.

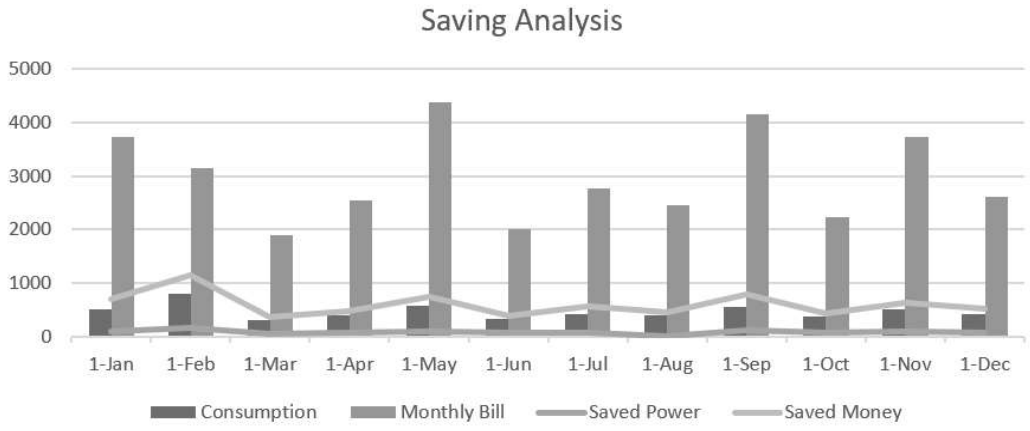

Fig. 15. Power and Money Save Analysis

The Fig.15. provides a comprehensive overview of the analysis for each month of the year. This research demonstrates the implementation of an IoT system to control home appliances and the management of a water tank using an Arduino Uno and an ultrasonic sensor.

8. Advantages and Applications

Advantages:

Remote Monitoring – This system can be controlled from anywhere in the world.

Cost and Energy Savings – With comprehensive information on the work and energy consumption of each smart device, this model merely optimizes the use of each smart device and modifies the smart home settings in a more economical manner.

Environmental Impact – Energy savings contribute to lessening the harm done to the environment and ensure the living of a greener life in addition to lowering expenses.

Comfort – People have always desired to have everything in a more pleasant and convenient way, and smart homes are perhaps the greatest achievement in this direction.

Automatic Water Pump Control – It keeps the water level in the tank constant and automatically turns on and off the water pump, allowing us to save water and minimize our electricity bill.

Applications:

• This system could be used in our home appliances.
• Control industrial equipment because this can save electricity, time, and effort.
• This system could be used in an office, College, University, etc.
• This smart home system is very suitable for people who travel often. They can control the home appliance from anywhere in the world, and they can be aware of the fact that which of home appliances are ON and which are OFF.

9. Conclusion

The main goal of this system is to use IoT to make human life more affordable and comfortable. People are seeking a more flexible lifestyle these days since they are so occupied with their professional obligations. IoT has a significant role in the present situation. Certainly, the most significant uses of the Internet of Things are in home automation. People can live more easily and comfortably by utilizing it. In this system, a method to develop a smart home automation system based on Internet of

Things software has been implemented and tested with the built prototype. Using most of the newest technology available, it focuses on the safety and security aspects of home automation. The Node MCU ESP-8266 and Arduino Uno were the technologies employed in this research. The Arduino Uno served as the system's main control unit, to which other sensors and devices were linked, and the system was controlled by the Telegram application. Compared to other IoT-based home automation systems, this one is easier to operate. We feel that humans are able to distinguish between smart lives and ordinary lives by using the Internet of Things.

References

M. S. Mahamud, M. S. R. Zishan, S. I. Ahmad, A. R. Rahman, M. Hasan and M. L. Rahman, (2019)"Domicile - An IoT Based Smart Home Automation System," International Conference on Robotics,Electrical and Signal Processing Techniques (ICREST), Dhaka, Bangladesh, pp. 493-497.

T. R. Beegum, (2017) "Energy aware virtual backbone construction using cluster heads in Wireless Sensor Network," 2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), Chennai, India.

Soni, Gaurav, et al. (2021) "Design and implementation of object motion detection using telegram." 2021 International Conference on Technological Advancements and Innovations (ICTAI). IEEE.

Dhillon, Javed, et al. (2021) "IoT based water level monitoring and motor control system." 2021 4th International Conference on Recent Developments in Control, Automation & Power Engineering (RDCAPE). IEEE, 2021.

Adinegoro, Prasetyo, et al. (2020) "The design of a telegram IoT-based chicken coop monitoring and controlling system." JPSE (Journal of Physical Science and Engineering) pp: 56-65.

Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A survey on enabling technologies, protocols, and applications. IEEE Communications Surveys & Tutorials, 17(4), 2347-2376.

Baumgartner, Antonioli, D., &Zingirian, N. (2019). Design and implementation of a Telegram bot for a sensor monitoring system. In 2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 6175-6181).

Gupta, P., & Kumar, N. (2020). Internet of Things (IoT) for Smart ampuses: A Comprehensive Review and Future Directions. IEEE Access, 8, 193459-193477.

Suyono J Sukoco A Setiawan M I Suhermin S and Rahim R (2017) Impact of GDP Information

Technology in Developing of Regional Central Business (Case 50 Airports IT City Development in Indonesia) J. Phys. Conf. Ser. 954 1 p. 12045
Ding D Cooper R A Pasquina P F and Fici-Pasquina L (2011) Sensor technology for smart homes Maturitas 69 2 p. 131–136
Nam T and Pardo T A (2011) Conceptualizing smart city with dimensions of technology, people, and institutions in Proceedings of the 12th Annual International Digital Government Research Conference on Digital Government Innovation in Challenging Times - dg.o '11 p.282
Cook D J and Das S K (2005) Smart Environments: Technology, Protocols and Applications
Napitupulu D (2018) Analysis of Student Satisfaction Toward Quality of Service Facility J. Phys. Conf. Ser. 954 1 p. 12019
Han, D., Lian, J., Liu, L., & Fan, W. (2019). Design and implementation of a real-time monitoring system for smart water supply in agriculture based on the Internet of Things. Sensors, 19(4), 792.
Muslih, Muhamad, et al. (2018) "Developing smart workspace based IOT with artificial intelligence using telegram chatbot." 2018 International Conference on Computing, Engineering, and Design (ICCED). IEEE.
Sadikin, Nanang, Marliana Sari, and Busye Sanjaya. (2019) "Smarthome using android smartphone, arduino uno microcontroller and relay module." Journal of Physics: Conference Series. Vol. 1361. No. 1. IOP Publishing.
Parihar, Yogendra Singh. (2019) "Internet of things and nodemcu." journal of emerging technologies and innovative research pp: 1085.
Carullo, Alessio, and Marco Parvis. (2001) "An ultrasonic sensor for distance measurement in automotive applications." IEEE Sensors journal.
Vogel, Burkhard, and Burkhard Vogel. (2011) "Modules 1–4." The Sound of Silence: Lowest-Noise RIAA Phono-Amps: Designer's Guide pp: 679-691.