IOT BASED WATER HEATER-PROJECT

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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ABSTRACT

This project aims to create a project based on The Internet of Things (IoT) which is used by humans to interact with everyday appliances, which offers enhanced control and efficiency. We propose an IoT-based smart water heater control system for optimizing energy usage and to help the user in their convenience.The system consists of a microcontroller, sensors, actuators, and a user interface accessed by mobile application or website. Temperature and humidity sensors used to monitor environmental conditions and changes are made according to them. These data are transmitted to the microcontroller which is a mini computer,used to integrate the embedded systems and optimize water heating schedules accordingly.Through the mobile application or web portal, users can control the water heater without manual mode, and by adjusting the temperature, scheduling the heating cycles, and can receive real-time status updates. Machine learning algorithms may be used inorder to learn more about user preferences over time and further optimization of energy usage.The benefits of this project includes energy conservation, cost savings, and improving the user experience. By using various IoT technologies, this project demonstrates the capability of controlling the systems to enhance the efficiency and provide the user with better usability of household appliances like water heaters.

ACKNOWLEDGMENT

First, we thank the almighty god for the successful completion of the project. Our sincere thanks to our chairman **Mr. S. Meganathan B.E., F.I.E.,** for his sincere endeavor in educating us in his premier institution. We would like to express our deep gratitude to our beloved Chairperson **Dr. Thangam Meganathan Ph.D.,** for her enthusiastic motivation which inspired us a lot in completing this project and Vice Chairman **Mr. Abhay Shankar Meganathan B.E., M.S.,** for providing us with the requisite infrastructure.

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CHAPTER 1

INTRODUCTION

In this modern era we have various technologies to make our day easier, one such thing is integrating, internet of things in our daily activity for ensuring efficient delivery and accessibility. With the advancement of technology, the Internet of Things (IoT) is emerging as a platform which makes human work easier,by revolutionizing various aspects of our daily lives. One area which made IoT a great success is home automation, where smart devices can enhance convenience, efficiency, and control. Here, in our project we focus on developing an IoT-based control system for water heaters, aimed at optimizing energy consumption and improving user experience. Traditional water heaters operate on fixed schedules or require manual controls, often resulting in energy wastage and inconvenience for users. However, by integrating IoT with water heater systems, by introducing these intelligent features we can adapt to user preferences and environmental conditions.

Oue core idea of this project is to use IoT technologies to create a smart water heater which offers remote access, automated scheduling, and energy-efficient operation. By connecting the sensors, actuators, and connectivity features,we can monitor our system and adjust water heating processes in real-time, based on the factors such as ambient temperature, and user preferences. We can also access the mobile applications or web portals which are user-friendly, users can remotely monitor and control their water heaters. They can set desired temperature levels, schedule heating cycles according to their daily routines, and we receive notifications about system status by which we can modify the system and energy consumption.

The main benefits of our IoT-based water heater control system have different parts,forms and features. Firstly, it provides many benefits to the users to optimize energy usage, thereby reducing utility bills and environmental impact. Secondly, it provides convenience by allowing remote control and monitoring, enabling users to have hot water according to their needs. Lastly, by incorporating data analytics and machine learning algorithms, the system can learn continuously and adapt to user behavior, further improving the efficiency and providing user satisfaction over time. In summary, our project aims to showcase the idea which provides an automated environment of IoT technology in the realm of household appliances, specifically water heaters. By creating a smart, connected system, we create a future where energy-efficient and user-friendly solutions become the norm, ultimately contributing to sustainability and enhanced quality of life.

1.1 PROBLEM STATEMENT

The traditional water heating systems lack efficiency and control, and also need man power to make it work, often resulting in unnecessary energy consumption and inconvenience for users. Inefficient usage of water heaters resulting in increased energy bills and also contributes to environmental degradation and nowadays most of the people are using Electric Normal Water Heater. On some occasions a few people lost their life because of touching the water when the power supply is on. To solve these issues, there is a need for an IoT-based solution which makes the operation of water heaters easier,and by providing users with enhanced control, energy efficiency, and convenience.

1.2 SCOPE OF THE WORK

Initially, through research and requirements we will conduct experiments to understand existing systems and gather stakeholder needs. This will give us details more about the design phase, where the system architecture, hardware components, and software modules will be specified. Following this, hardware development will involve selecting, as well as integrating safety features. Simultaneously, software development will focus on the basement for microcontrollers, control algorithms, and user interface which is used for designing of mobile and web applications. Integration and testing of the project will then bring the hardware and software components for comprehensive validation, ensuring reliability, scalability, and compatibility. Documentation and training materials will be prepared to support installation, operation, and maintenance.

1.4 AIM AND OBJECTIVES OF THE PROJECT

The primary objective is to enhance energy efficiency, user convenience, and safety in water heating operations. By using IoT sensors, actuators, and connectivity, the system aims to optimize energy consumption through intelligent control algorithms, allowing users to remotely monitor and adjust settings based on their requirements. Additionally, the project aims to improve safety by integrating features such as leak detection and overheating prevention mechanisms.

The primary focus is on optimizing energy usage by enabling users to adjust settings remotely based on their preferences and schedules. Additionally, the system aims to improve safety through the integration of features such as leak detection and overheating prevention mechanisms, thereby mitigating potential risks associated with water heaters. Furthermore, the project seeks to provide a user-friendly interface for seamless interaction and control, ensuring ease of use and accessibility for all users. Overall, the objective is to deliver a cost-effective and sustainable solution that not only reduces energy consumption and operational costs but also enhances user comfort and contributes to environmental conservation efforts.

RESOURCES

This project has been developed by verifying various research papers in terms of accredited manuscripts, standard papers, business journals, white papers, analysts' information, and conference reviews. Since we need significant resources to achieve an effective completion of this project.

The following prospectus details a list of resources that will play a primary role in the successful execution of our project:

- A properly functioning workstation (PC, laptop, net-books etc.) to carry out desired research and collect relevant content.
- Unlimited internet access.
- Unrestricted access to the university lab in order to gather a variety of literature including academic resources (for e.g. Prolog tutorials, online programming examples, bulletins, publications, e-books, journals etc.), technical manuscripts, etc. Prolog development kit in order to program the desired system and other related software that will be required to perform our research.

1.5 MOTIVATION

The primary motivation for the IoT-based water heater project stems from the pressing need to revolutionize conventional water heating systems to meet modern energy efficiency and user convenience standards. Traditional water heaters often operate inefficiently, leading to unnecessary energy consumption and high utility bills for users. By integrating IoT technology into water heating systems, the project aims to address these challenges comprehensively. The prospect of optimizing energy usage through remote adjustment of settings based on user preferences and schedules serves as a compelling motivation. Additionally,we are enhancing the safety features by integrating leak detection and overheating prevention mechanisms to mitigate potential risks associated with water heaters, ensuring user safety. Furthermore, the promise of providing a user-friendly interface for interaction and control enhances accessibility for users of all technical proficiencies, driving adoption.

CHAPTER 2
LITERATURE SURVEY

(Chandrasekaran, Gokul, et al) This project proposes a smart solar water heater system that uses Internet of Things (IoT) technology to monitor and control water temperature, tank levels, and water quality. By adding sensors and internet connectivity to the water heater, users can adjust settings remotely via their smartphones or computers. The system aims to reduce wastage of cold water by reusing it and purifying water based on its cleanliness. This smart system not only enhances efficiency but also offers convenience for users, making it suitable for both smart homes and industrial applications.

(Chandla ellis, et.al., 2022)This research mainly discusses how solar water heating systems in homes have become more energy efficient with the help of Internet of Things (IoT) technology. IoT devices are used to collect various data about the system, which is then used to identify ways to improve different parts of the system. Control techniques are also developed to ensure that the entire system operates efficiently. The performance of the solar water heater is monitored using different sensors like those for measuring Total Dissolved Solids (TDS), liquid levels, temperature, and turbidity. By constantly monitoring the system, issues can be detected early on, reducing energy losses and improving overall efficiency. Additionally, the use of IoT allows for accessing the data from the solar water heater remotely, from anywhere.

(Cardona, et.al., 2019)This project mainly addresses the need for an electronic tool to monitor water temperature over time, as solar water heaters become more popular in households. The proposed solution is a wireless temperature monitoring system for domestic water heater tanks, designed to be user-friendly and cost-effective for widespread adoption. Utilizing IoT technology, the device provides real-time temperature readings and includes machine learning algorithms to customize settings and trigger intelligent alarms for issues like water leaks, temperature deviations, and efficiency loss. Data is transmitted through local Wi-Fi to users or other devices for further automation. The scalable IoT architecture allows for additional measurements of factors affecting heater performance, such as water flow, sunlight exposure, and outdoor humidity, facilitating integration into more complex systems for commercial or industrial use.

(Khairunnas, Muhammad Dio, et.al., 2018)This system introduces an automatic faucet designed to simplify the process of filling a bathtub with hot water. Traditional water heaters can be slow to reach the desired temperature and fill the tub, so this system aims to speed up the process. It achieves this by using temperature sensors,water pumps to detect when the water in the main tub reaches the desired temperature and automatically activate the faucet. These sensors communicate using MQTT protocols through an Arduino Mega2560-based Android microcontroller. Test results demonstrate a high level of accuracy in temperature control, with the water reaching 97.60% of the desired temperature. On average, it takes 18 minutes and 30 seconds to fill the tub to the desired level, which holds approximately 12.320 cm3 of water, with about 9.240 cm3 being hot water. Various factors, such as the type of pump, power usage by the water heater, and the size of the main tub container, can influence the time it takes to reach the desired temperature.

(Susanti, Hera, et al., 2023) This project mainly focuses on leveraging IoT technology to create a system for monitoring and controlling water heaters remotely, contributing to the development of smart homes. Utilizing Android Studio application, the system ensures water heater safety, comfort, reliability, and energy efficiency by enabling users to adjust water temperature from their smartphones. The system incorporates temperature and water flow sensors, with data processed through a NodeMCU microcontroller and transmitted to Firebase for display on the application interface. Users can set desired water quantities and temperatures, with the application managing heating before transmitting instructions to NodeMCU. The outcome is an application capable of effectively managing and monitoring water heaters.

(Yang, Yunlong, et al., 2020) This work is about solar water heating system failure and the remote control problem in university, this project is mainly based on the study of Internet related technologies, sensor measurement, wireless communication and mobile terminal applications are adopted, design based on Internet of the android platform of solar hot water control system,the roof of the remote monitoring and control. The EPS8266 wireless communication module is used for remote communication and the cross array item M3 is used for remote control. The experimental results verify the feasibility and effectiveness of the design, which can provide platform support for the solar hot water control system and meet the requirements of the design.

(Hasan, et al., 2021) To strengthen home electricity control, the existing systems have been examined over the years. However, the existing PMAS method's error ratio is higher and does not allow for a remote monitoring system. Therefore, this study proposes a smart monitoring and control system (SMACS) for household appliances. The application's significance is to monitor household appliances' electricity usage using hardware and the Internet of Things (IoT) methods. The prototype of the proposed system is designed and developed considering Arduino UNO, a liquid crystal display (LCD), an ACS712 current sensor module, relays, and AC sources. The components are selected from the software library, and the simulation results are found the same as the prototype.

(Tejero-Gómez, et al., 2021) The aim of this paper is to develop a modular and low cost Energy Management System which minimizes the electricity bill without compromising the level of comfort. An algorithm is developed that estimates the appropriate hours of operation of the Electric Water Heater that guarantees comfort based on the consumption habits, the monitorization of temperatures and dynamic electricity prices.

(Morse, Hanaa F., et al., 2021)This study aims to develop a smart heater system with high performance and low cost. The smart heater system is based on the ESP8266 nodeMCU open-source controller programmed with open-source Home Assistant software connected to DHT11 Temperature and Humidity Sensor. The Raspberry Pi has been connected to the ESP8266 nodeMCU, which acts as a cloud server that displays all smartphone application measurements.

(Shen, Gulai, et al., 2021) This work describes a EWH Smart Scheduling and Control System using data-driven disturbance forecasts in a robust Model Predictive Control (MPC) to accomplish various demand side management objectives. Tested with a real-world EWH dataset and a two-state EWH model, robust MPC simulations are conducted on a central EWH supplying DHW for a multi-unit apartment building with quantified prediction uncertainty. Results show that the proposed system is capable of anticipating DHW demand with an uncertainty interval covering up to 97% of the actual demand during the test days and reducing electricity cost up to 33.2% as well as maintaining a desired DHW temperature without affecting user comfort.

(Sripriya, T., B. Muthuraj, et al., 2022) In this paper, a smart deep learning model was proposed to improve the performance of the solar water heater. The gap between the tube lights is filled with methane gas, and the tube inside is filled with water. The water thus filled is heated by sunlight. Methane gas acts as a fast conductor of solar heat. An electronic control device is placed to determine the temperature of the hot water and to expel the hot water.

(Benghanem, M., et al., 2022) This work explores the major quantities of water available in the oceans rather than in the earth. So, only a little amount of freshwater is available in the earth as lakes, rivers and groundwater. Demand for water is increasing in the world due to the increase of population, agricultural production and the industrial sector. The impure water has extreme effects on the health of humanity. So, due to the small amount of freshwater available, it is primordial to extract fresh water from impure water to meet people's needs for freshwater. For this reason, industries focus on getting fresh water from impure water using many industrial processes.

(Kalamani, M., et al., 2022) In this research work, the IoT based automation of heat pump water heater is proposed to control its process automatically and also through mobile apps based on the user requirement. So that users can operate the smart heat pump system anywhere and it will create eco-friendly environment for commercial applications.The low-temperature refrigerant absorbs free heat from the atmospheric air in the evaporator is compressed by a highly efficient electrical compressor to a high-temperature and high-pressure vapor refrigerant. This vapor is then passed through a heat exchanger (condenser) to transfer the heat to the water available in the tank to produce hot water.

CHAPTER 3

SYSTEM DESIGN

3.1 GENERAL

In this section, we would like to show the general outline of how all the components end up working when organized and arranged together. It is further represented in the form of a flow chart below.

3.2 SYSTEM ARCHITECTURE DIAGRAM

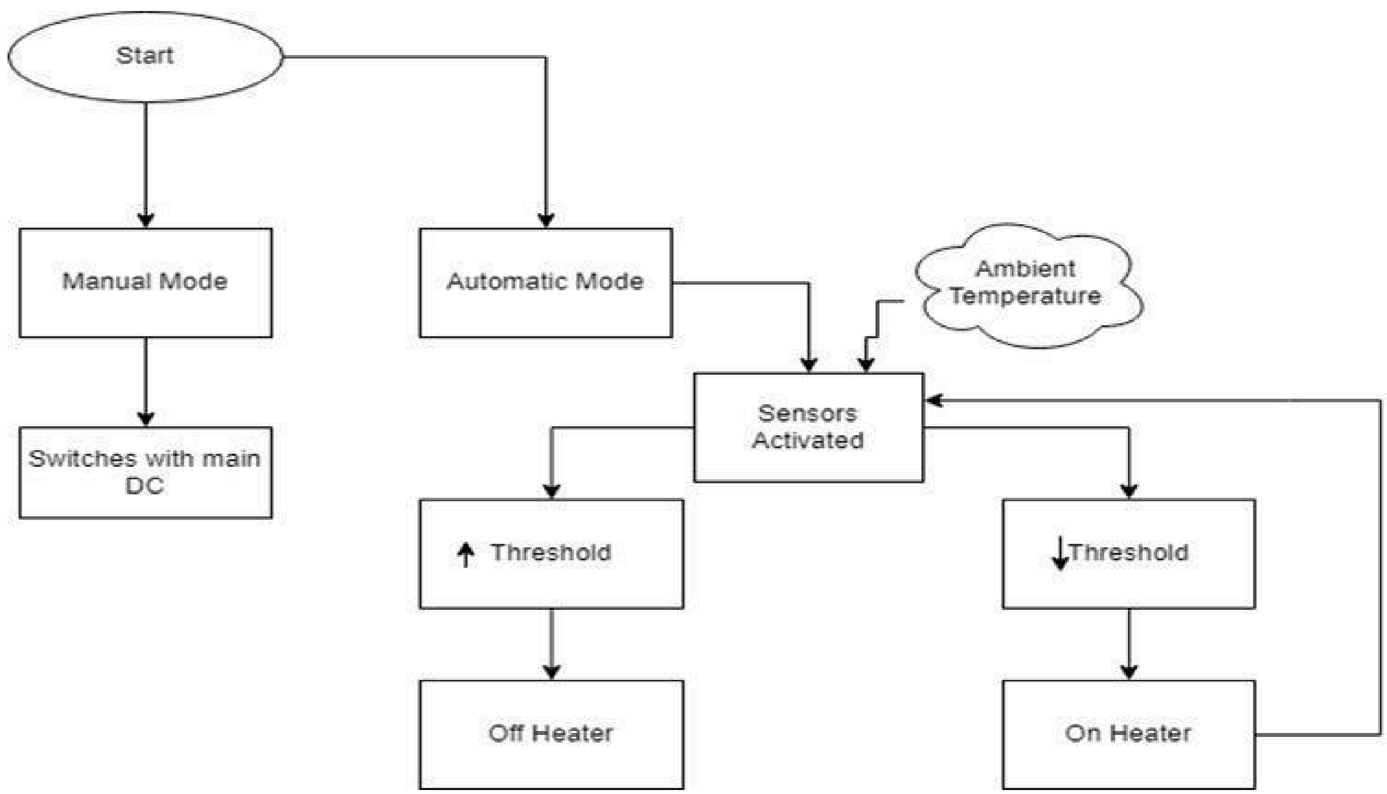


Fig 3.1: System Architecture

Architecture description

The IoT-based smart water heater is designed to provide efficient control and management of the water heater by integrating real-time temperature measurement, motion detection and remote control via the Blynk app. The heart of the system is an ESP32 microcontroller that interacts with a thermocouple (MAX6675 amplifier) to measure water temperature and a PIR sensor to detect movement near the kettle. The relay module is used to control the power supply of the water heater based on the signal received from ESP32.

After initialization, the ESP32 connects to the WiFi network and communicates with the Blynk cloud using its credentials. The thermocouple continuously sends temperature data to the ESP32, which is then sent to the Blynk cloud to be recorded and displayed on the mobile phone. If the temperature exceeds the preset value, ESP32 will alert the user via Blynk. The PIR sensor updates the ESP32's motion detection data, which is also sent to the Blynk app and an alert is triggered if detected.oneESP32 process temperature and data movement to control relays.

If the indicator is found and the temperature is lower than the threshold, the relay turns on the heater, it remains closed. Any change in the heating process will cause the ESP32 to send notifications to the Blynk app, ensuring the user is instantly aware of the heating system. The integration of these products and features creates a smart interface that increases hot water availability, safety and convenience by providing instant notification and quality control from the Blynk app. This configuration increases energy efficiency and safety not only for the heating process, but also allows users to monitor and control the system.

3.3 DEVELOPMENTAL ENVIRONMENT

3.3.1 HARDWARE REQUIREMENTS

The hardware requirements may serve as the basis for a contract for the system's implementation. It should therefore be a complete and consistent specification of the entire system. It is generally used by software engineers as the starting point for the system design.

Table 3.1 Hardware Requirements

COMPONENTS	SPECIFICATION
ESP32 DEVKITV1	WIFI Module
PIR SENSOR	HC-SR501
DS18B20 TEMPERATURE PROBE	WATER PROOF
BREADBOARD	BIG SIZE
RELAY MODULE	5V1 CHANNEL
CONNECTING CABLES	AS PER REQUIREMENT

3.3.2 SOFTWARE REQUIREMENTS

The software requirements document is the specifications of the system. It should include both a definition and a specification of requirements. It is a set of what the system should rather be doing than focus on how it should be done. The software requirements provide a basis for creating the software requirements specification. It is useful in estimating the cost, planning team activities, performing tasks, tracking the team, and tracking the team's progress throughout the development activity.

ARDUINO IDE, and **BLYNK IOT** would all be required

CHAPTER 4

PROJECT DESCRIPTION

4.1 METHODOLOGY

The methodology for the IoT-based water heater project follows a systematic approach to design, development, testing, and deployment. Initially, through thorough research and requirements, we gathered various information regarding our project to understand existing systems and stakeholder needs.The design phase includes the system architecture, hardware components, and software modules. Hardware development has all the components and integrating safety features, while software has firmware for microcontrollers, control algorithms, and user interface design. Integration and testing bring together hardware and software to validation, ensuring reliability, scalability, and compatibility. Documentation and training materials are prepared to support installation, operation, and maintenance. Compliance with regulations and standards is ensured throughout the project, and effective project management oversees milestones, timelines, and resource allocations to ensure successful project completion. This methodology ensures a structured and systematic approach to delivering an innovative IoT-based water heater system that meets user needs and industry standards.

4.2 MODULE DESCRIPTION

This project consists of various components, including sensors, actuators, microcontrollers, and communication modules. These components work together to enable remote monitoring and control of the water heater, allowing users to adjust settings based on their preferences and schedules.This project includes various modules such as sensor, iot platform, power management, security, user interface and automation and optimization modules. The sensors are responsible for monitoring parameters such as temperature, pressure, and water level, while the actuators control the heating elements and other functions of the water heater.

The microcontrollers process sensor data and execute control algorithms to optimize energy usage and ensure safety. Communication modules facilitate connectivity between the water heater and user interfaces, such as mobile and web applications. Overall, the Modulo provides energy efficiency, safety, and user convenience in a single integrated platform.

4.2.1.SENSOR MODULE

This module comprises a range of sensors strategically placed within the water heater system to gather real-time data on key variables such as temperature, pressure, water level, and flow rate. Temperature sensors monitor the temperature of the water within the heater, ensuring it remains within safe operating limits and allowing users to adjust settings for optimal comfort. Pressure sensors detect changes in pressure within the system, providing insights into potential issues such as blockages or leaks. Water level sensors track the level of water in the tank, preventing overfilling or dry heating situations. Additionally, flow rate sensors measure the rate at which water flows through the heater, aiding in efficiency optimization. The sensor module plays a crucial role in providing accurate and timely data to the control system, enabling intelligent decision-making and enhancing overall performance and safety of the water heater.

4.2.2.IOT PLATFORM MODULE

This module leverages an advanced IoT platform to facilitate seamless connectivity and integration of various components within the system. The platform collects real-time data from sensors embedded within the water heater, including temperature, pressure, water level, and flow rate, allowing for continuous monitoring and analysis of key parameters. Through cloud-based services, the platform enables remote access to the water heater system via mobile and web applications, empowering users to monitor performance, adjust settings, and receive alerts and notifications from anywhere, anytime. Moreover, the IoT platform facilitates data storage, management, and analysis, enabling insights into energy usage patterns, predictive maintenance, and optimization opportunities. By providing a robust and scalable infrastructure for communication and data processing, the IoT platform module enhances the efficiency, convenience, and safety of water heating operations, ultimately delivering a seamless and connected user experience.

4.2.3.USER INTERFACE MODULE

This module encompasses both mobile and web applications designed to offer a seamless and user-friendly experience across various devices. The UI allows users to remotely monitor the status of the water heater, adjust settings such as temperature and operating mode, and receive notifications and alerts regarding system performance or potential issues. Through a visually appealing and intuitive interface, users can easily navigate through different features and functionalities, enabling quick access to relevant information and actions. Additionally, the UI module may include features such as historical data visualization, energy usage analytics, and scheduling capabilities, empowering users to make informed decisions and optimize energy efficiency based on their preferences and usage patterns. By providing a user-centric interface that prioritizes ease of use and accessibility, the UI module enhances the overall usability and ultimately improves user experience and engagement.

4.2.4.AUTOMATION AND OPTIMIZATION MODULE

This module leverages real-time data collected from sensors and user inputs to automate various aspects of water heater operation while optimizing energy usage. Advanced control algorithms analyze the data to dynamically adjust heating settings based on factors such as user preferences, weather conditions, and energy tariffs. By continuously monitoring parameters like temperature, pressure, and water level, the system can proactively identify and address inefficiencies or potential issues, such as leaks or excessive energy consumption. Additionally, the module includes optimization features such as predictive maintenance scheduling and load balancing to ensure optimal performance and longevity of the water heater system. Through automation and optimization, the module streamlines operation, reduces energy waste, and enhances user comfort, ultimately delivering a more efficient, sustainable, and user-friendly water heating experience.

4.2.5.SECURITY MODULE

This module employs a multi-layered approach to security, incorporating various measures to protect both the hardware and software components of the water heater system. Firstly, robust authentication mechanisms are implemented to ensure that only authorized users can access and control the water heater, preventing unauthorized access and tampering. Secure communication protocols, such as SSL/TLS, are utilized to encrypt data transmitted between the water heater, IoT platform, and user interfaces, preventing interception and eavesdropping by malicious actors. Additionally, intrusion detection and prevention systems are employed to monitor network traffic and detect any suspicious activity or anomalies in real-time, allowing for timely response and mitigation. Furthermore, regular security audits and updates are conducted to identify and patch any vulnerabilities in the system, ensuring that it remains resilient against emerging threats.

4.2.6.POWER MANAGEMENT

This module focuses on managing power consumption through intelligent control strategies and scheduling algorithms. By leveraging real-time data from sensors and user inputs, the module dynamically adjusts heating settings and operating modes to minimize energy waste while maintaining user comfort. For instance, during periods of low demand or high energy prices, the module may lower the water heater's temperature setpoint or activate energy-saving modes to reduce power consumption. Additionally, the module incorporates features such as load balancing and demand response, allowing the system to adapt to fluctuations in electricity availability and grid conditions. Moreover, the Power Management module includes scheduling capabilities that enable users to preset heating schedules based on their usage patterns and preferences, further optimizing energy usage and reducing costs. By intelligently managing power consumption, the module contributes to overall energy efficiency, cost savings, and environmental sustainability of the IoT-based water heater system.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 OUTPUT

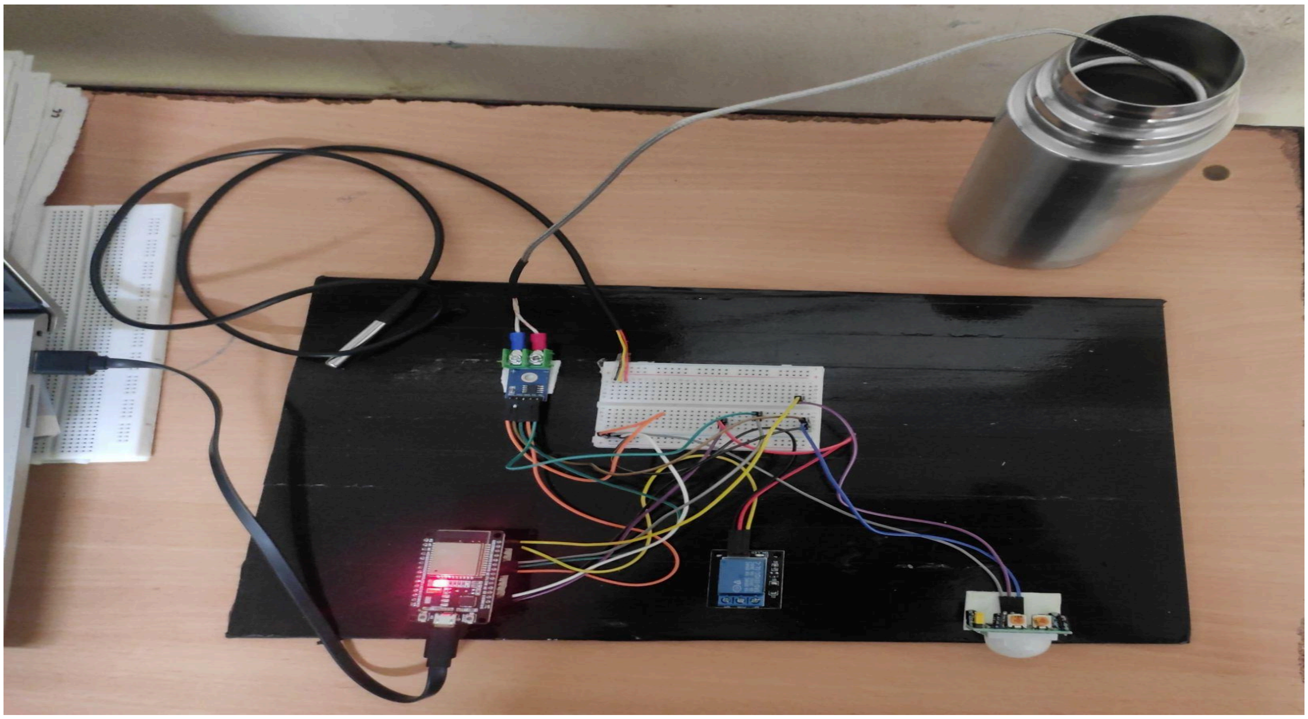


Fig 5.1:Working model

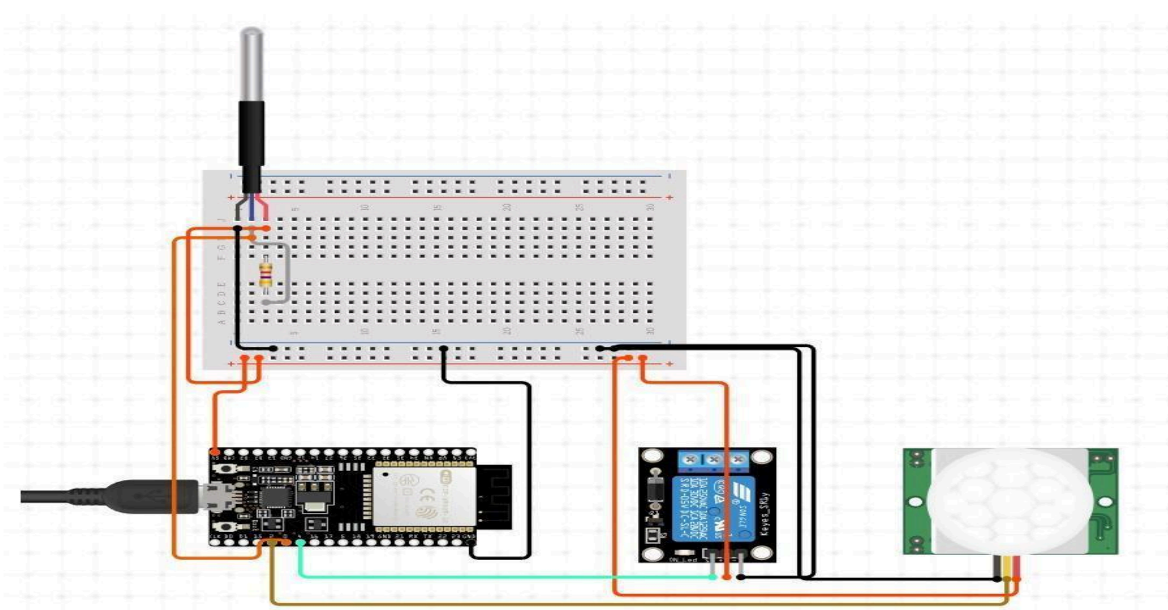


Fig 5.2:Circuit diagram

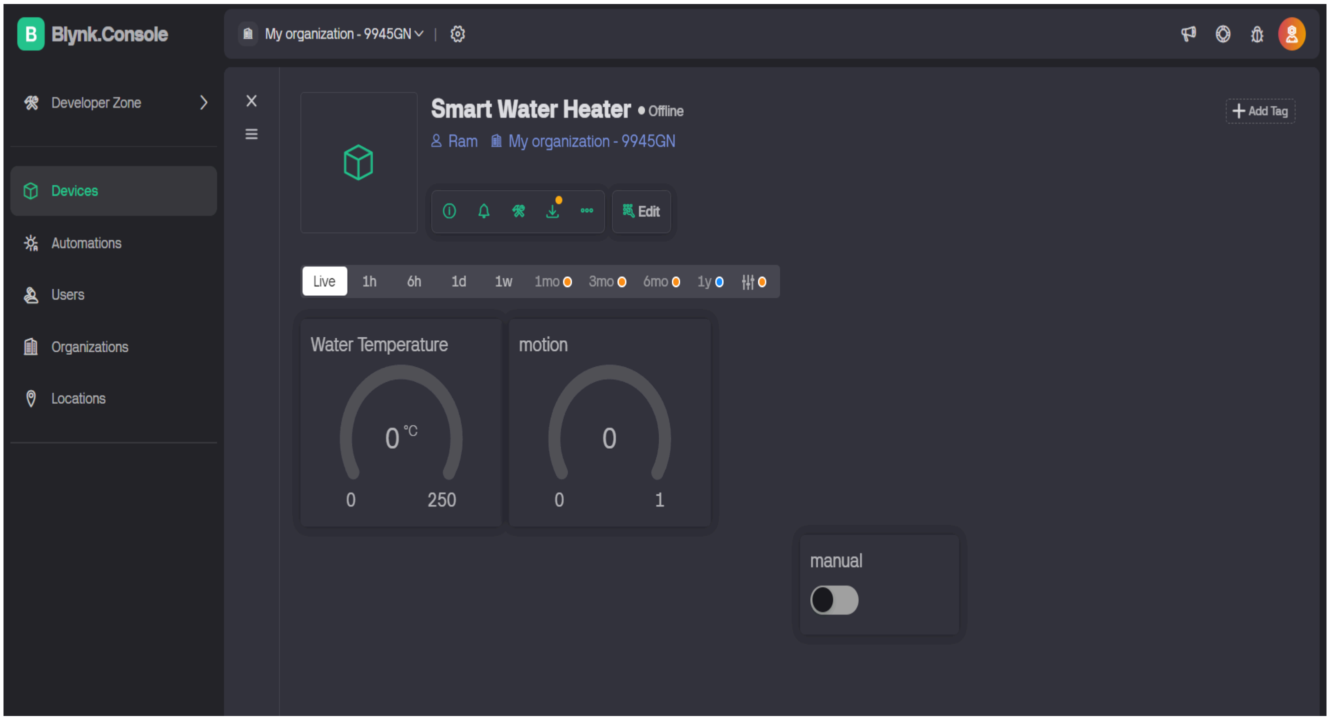
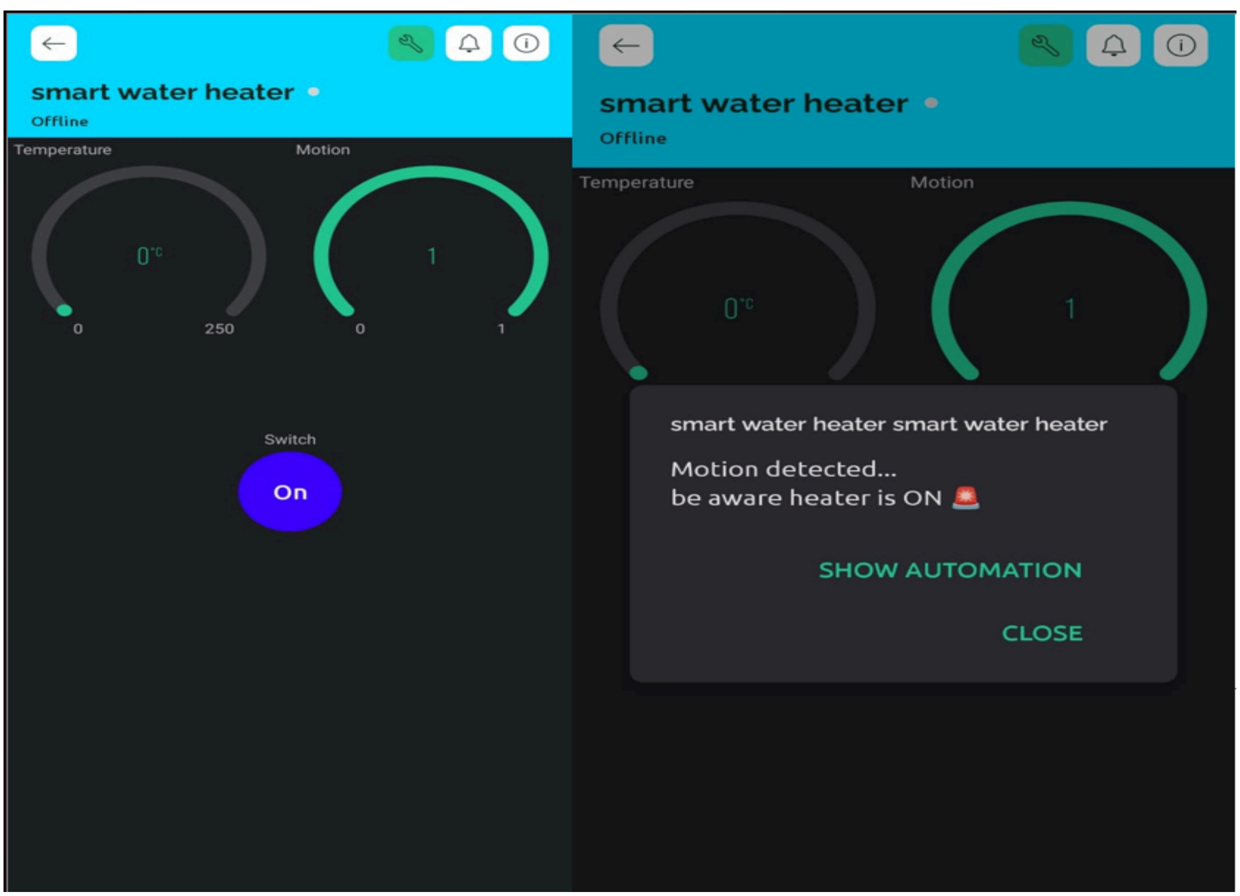


Fig 5.3:User interface



5.2 RESULT

The outcome of our IoT-based water heater project is an innovative system that significantly enhances the efficiency, convenience, and safety of water heating operations. By using the integration of advanced IoT technology, the project achieves remarkable outcomes. Firstly, users can remotely adjust the values based on their preferences and schedules,users can optimize energy usage and reduce utility bills. In the system,by integrating safety features such as leak detection and overheating prevention mechanisms we can ensure user safety and minimize potential risks associated with water heaters. Furthermore, the intuitive user interface provides seamless interaction and control, catering to users of all technical proficiencies. Overall, the project delivers a cost-effective and sustainable solution that not only reduces energy consumption and operational costs but also enhances user comfort and contributes to environmental conservation efforts. The result is a transformative advancement in water heating technology that sets new standards for efficiency, convenience, and safety in the industry.

CHAPTER 6

CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

In conclusion, in our IoT-based water heater project we represent a great idea in residential water heating technology, offering optimal levels of efficiency, convenience, and sustainability. By providing the power of internet connectivity,using advanced sensors, and applying intelligent algorithms, this innovative system allows the users to remotely monitor and provide control of their water heaters, optimize the energy used by users, and which enhances the safety through features like predictive heating control, demand response, and real-time data analysis. With a focus on customization, integration, and sustainability, our project covers not only the way we heat water but also sets a precedent for smart appliances, interconnected homes of the future, where comfort, efficiency, and environmental responsibility converge seamlessly.

FUTURE ENHANCEMENT

For future enhancements of the IoT-based water heater project, we are integrating machine learning algorithms which could further refine predictive heating control, enabling the system to adapt to users' needs which are evolving the preferences and behaviors of the users dynamically. Developed integration with resources that have renewable energy, such as solar panels or heat pumps can be used to optimize energy usage and reduce the need of users to depend on power grids, providing greater sustainability. Additionally, implementation of the blockchain technology for secure, centralized data storage and transactions could provide privacy and security while enabling one-to-one energy trading between homeowners. Moreover, we can explore the potential for advanced sensors and artificial intelligence to detect and mitigate water leaks or malfunctions in real-time would further enhance safety and minimize water wastage. Overall, these enhancements would drive the project towards greater efficiency, resilience, and user-centric innovation in the evolving landscape of smart home technology.

APPENDIX

SOURCE CODE:

```
#define BLYNK_TEMPLATE_ID "TMPL3wJgpnzjw"

#define BLYNK_TEMPLATE_NAME "smart water heater"

#define BLYNK_AUTH_TOKEN "dSVIf5Bj4DOpx4mvARmcrkd6KqZI1dGF"
// Replace with your Blynk Auth Token


#include <WiFi.h>

#include <BlynkSimpleEsp32.h>

#include <MAX6675.h>


// Blynk credentials

char auth[] = BLYNK_AUTH_TOKEN;

char ssid[] = "ESP_B94DC5";       // Replace with your WiFi SSID

char pass[] = "Password";   // Replace with your WiFi password


// Pins for MAX6675

int thermoSO = 19;

int thermoCS = 5;

int thermoSCK = 18;

MAX6675 thermocouple(thermoSCK, thermoCS, thermoSO);


// Pin for PIR Sensor
```

```
#define PIR_PIN 23

// Pin for Relay
#define RELAY_PIN 22

// Virtual Pins
#define VIRTUAL_PIN_TEMP V1
#define VIRTUAL_PIN_PIR V2

// Variables
bool pirState = false;
bool previousPirState = false;
bool heaterState = false;
bool previousHeaterState = false;
const double TEMP_THRESHOLD = 50.0; // Temperature threshold in Celsius

void setup() {
  // Initialize Serial Monitor
  Serial.begin(115200);

  // Initialize Blynk
  Blynk.begin(auth, ssid, pass);
```

```
  // Initialize GPIO
  pinMode(PIR_PIN, INPUT);
  pinMode(RELAY_PIN, OUTPUT);
  digitalWrite(RELAY_PIN, LOW); // Ensure the relay is off initially

  // Allow MAX6675 to stabilize
  delay(500);
}

void loop() {
  // Run Blynk
  Blynk.run();

  // Read Temperature
  double celsius = thermocouple.readCelsius();
  Serial.print("C = ");
  Serial.println(celsius);
  Blynk.virtualWrite(VIRTUAL_PIN_TEMP, celsius);

  // Check if temperature exceeds threshold
   if (celsius > TEMP_THRESHOLD) {
    Blynk.logEvent("temp_exceeded", String("Temperature exceeded: ") + celsius
+ "°C");
```

```
}

// Read PIR Sensor
pirState = digitalRead(PIR_PIN);
Serial.print("PIR State: ");
Serial.println(pirState);
Blynk.virtualWrite(VIRTUAL_PIN_PIR, pirState);

// Notify if motion is detected
 if (pirState && !previousPirState) {
  Blynk.logEvent("motion_detected", "Motion detected!");
}
previousPirState = pirState;

// Control Relay based on PIR and Temperature
if (pirState && celsius < TEMP_THRESHOLD) {
  digitalWrite(RELAY_PIN, HIGH); // Turn on the water heater
  heaterState = true;
} else {
  digitalWrite(RELAY_PIN, LOW); // Turn off the water heater
  heaterState = false;
}
```

```
  // Notify if the heater state changes
  if (heaterState != previousHeaterState) {
    if (heaterState) {
      Blynk.logEvent("heater_on", "Heater turned ON");
    } else {
      Blynk.logEvent("heater_off", "Heater turned OFF");
    }
    previousHeaterState = heaterState;
  }

  // Delay between readings
  delay(1000);
}
```

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