CS-335

Internet of Things

Project Report: Home Automation System

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Project Description

Introduction:

This project is a Home Automation system that integrates various sensors and devices to create a smart home environment. It uses an ESP32 microcontroller and Blynk platform for remote monitoring and control. The system includes features such as temperature and humidity monitoring, motion detection, fire detection, and control of electrical appliances. Additionally, it sends data to ThingSpeak for historical tracking and further analysis.

Objectives:

- Monitor and display real-time temperature and humidity.
- Detect motion using a Passive Infrared sensor.
- Alert the user in case of motion detection and check for potential theft.
- Detect fire using an LDR (Light Dependent Resistor) and temperature sensor.
- Control electrical appliances remotely using Blynk.
- Send sensor data to ThingSpeak for historical analysis.
- Perform Data analysis on sensor data.

Expected Outcomes:

- Real-time Monitoring: Users can monitor temperature and humidity levels in their homes in real-time through the Blynk app.
- Security Alerts: The system alerts users in case of motion detection, providing a potential security feature.
- Fire Detection: The system can detect abnormal light conditions and high temperatures, indicating a possible fire, and notify the user.
- Remote Control: Users can remotely control electrical appliances connected to relays through the Blynk app.
- Historical Analysis: Sensor data is sent to ThingSpeak for historical tracking, enabling users to analyze trends over time.

Application Requirements:

Hardware:

- ESP32 microcontroller.
- DHT22 sensor for temperature and humidity.
- PIR (Passive Infrared) sensor for motion detection.
- LDR (Light Dependant Resistor) and temperature sensor for fire detection.
- Buzzer for audible alerts.
- Relay modules for controlling electrical appliances.
- LCD for local status display.

Software:

- Blynk app for real-time monitoring and remote control.
- ThingSpeak for historical data storage and analysis.
- Google Colab for Data Analysis

3. Detail of sensors and related electronic equipment

3.1 ESP32 Microcontroller:

- The heart of the project is the ESP32, which will be used as a main microcontroller.
- It enables the Wokwi simulation to communicate with the Blynk dashboard via Wi-Fi.
- It carries out programmed logic to control attached sensors and actuators.

3.2 Push Button and Relay:

- A push button is wired directly to a relay, acting as an on/off switch for the white light bulb.
- The relay is the switch, and it lets the ESP32 turn on high-power devices like lights.

3.3 White Light Bulb:

- The white light bulb is a high-power unit governed by the relay.
- It's a light output indicator controlled by the push button or Blynk dashboard.

3.4 DHT22 Sensor:

- The DHT22 sensor measures temperature and humidity.
- The readings are shown on the LCD screen, Blynk gauges and graphs.

3.5 LCD Screen (Wokwi-LCD2004):

- On the LCD screen temperature and humidity readings are displayed locally.
- This helps with user interaction by providing current information.

3.6 Blynk Dashboard:

- This is a platform for IoT projects, its interface is user-friendly. It's called Blynk.
- It allows remote control and monitoring of the smart home project.

3.7 PIR Motion Sensor (Wokwi-PIR-Motion-Sensor):

- The PIR motion sensor detects activity in the area.
- In the theft alert system, alerts are generated and reflected in the Blynk dashboard through a red LED light.

3.8 Red Alert Light:

- Hooked up to a relay, when the red light is turned on the motion detection will be started to identify theft alert.

3.9 Photoresistor (Wokwi-Photoresistor-Sensor):

- Ambient light levels are measured by the photoresistor.Which is used in conjunction with the temperature sensor for fire alert detection.

3.10 Buzzer (Wokwi-Buzzer):

- In case of fire, the buzzer provides an audible alarm. It alerts the people at home that a fire has occurred.

4. Detail description of power consumption of every sensor should be included and the approach that can be used for the optimal consumption of power should be described.

Sensor	Power Consumption	Reference
1. pir motion sensor	40µA	PIR sensor source
2. LDR sensor	100mA	LDR sensor source
3. DHT22 sensor	0.3mA	DHT22 sensor

5. Details of communication technology and protocols used at physical, internet and application

layers. Please also discuss possible network topologies if the system needs to be scaled up.

Communication technologies and protocols:

Physical layer:

In the project, the physical layer is represented by the WiFi connection between the ESP32 (Wokwi) and the Blynk server. This includes the use of IEEE 802.11 standards for wireless communication.

Internet layer:

The Internet layer is managed by the TCP/IP protocol suite, specifically the Internet Protocol (IP). This allows the devices in the system to communicate over the Internet.

ESP32 communicates over the internet using the Internet Protocol (IP). For communication with platforms like Blynk and ThingSpeak, HTTP and HTTPS protocols are employed, especially for sending and receiving data.

Application layer:

In the application layer - Blynk, ThingSpeak and Wokwi have been used for communication and control.

- Blynk: Blynk uses its own protocol over a secure SSL/TLS connection to communicate between the ESP32 and the Blynk server.
- ThingSpeak: ThingSpeak relies on the HTTP protocol to send data to the ThingSpeak cloud server.
- Google Colab: Google Colab uses standard Internet protocols such as HTTPS to retrieve and analyze data.
- Wokwi: Wokwi, as a simulation platform, operates at the application layer for testing IoT projects.

Network Topologies:

Star topology:

Simplified troubleshooting: The star topology allows direct troubleshooting, which is convenient for identifying and solving problems in the home automation system. This is particularly beneficial when working with platforms such as Blynk, as a centralized hub simplifies monitoring and management.

Easy device management: Adding or removing devices is seamless in a star topology, making it suitable for this home automation system. This is particularly important for the current centralized control approach, where a central hub manages communication with devices.

Mesh topology:

Redundancy for Reliability: The mesh topology introduces redundant paths that increase the reliability of the home automation system. This can be critical to maintaining continuous communication between devices and ensuring that even if one path fails, alternate paths are available.

Scalability without central dependency: The network topology facilitates scalability by allowing devices to be added without relying on a central hub. This is advantageous if system is to be expanded or equipment is to be deployed at different locations, providing flexibility in the network structure.

Hybrid topology:

Balanced flexibility: Hybrid topology offers a balanced approach that combines star simplicity with network redundancy. This flexibility allows customization based on specific requirements, making it well suited for a diverse home automation system.

Optimized for mixed components: In a hybrid topology, network design can be optimized based on the characteristics of the different components in the home automation system. This is advantageous when dealing with a combination of centralized and distributed devices, providing adaptability to different communication needs.

Current Toplogy:

The current system is a star topology connection between the ESP32 and the Blynk server over WiFi. ESP32 microcontroller serves as the central hub or controller in the system. It manages and coordinates communication between various sensors (DHT22, PIR, LDR, temperature sensor), actuators (relays, buzzer), and external platforms (Blynk, ThingSpeak).

Considerations for scaling up:

When scaling, If a more distributed deployment or a significant increase in the number of devices is anticipated, considering a mesh or hybrid topology provides the necessary scalability and adaptability for the future. Additionally, in the case of Google Colab, data analysis could include centralized data processing indicating a star or hub-and-spoke topology depending on the data flow.

6. Tools and technologies required for project development

Tools and Technologies:

<u>Blynk:</u>

Blynk is a platform that allows you to build IoT applications for various microcontroller platforms. It provides a smartphone app and a customizable dashboard to remotely control and monitor the device.

In the project, Blynk facilitates communication between the ESP32 and the Blynk server and enables remote control and monitoring of the home automation system via dashboard.

<u>ThingSpeak:</u>

ThingSpeak is an IoT analytics platform that allows you to collect, analyze and visualize data from IoT devices. It provides an API to retrieve data and integrate with other platforms.

In the project, ThingSpeak is used to store sensor data from the home automation system. It allows analysis and visualization of data and acts as a central repository of historical information.

<u>Wokwi:</u>

Wokwi is an online platform that provides a virtual environment for simulating and testing IoT projects. It allows you to visualize and test your circuits before deploying them to physical hardware.

In the home automation system, Wokwi is used for simulation and testing purposes, allowing verification of the functionality of code and circuit design before implementing it on real hardware.

<u>Google Collab:</u>

Google Colab has been used in the project to perform diagnostic, predictive and descriptive analysis of the data received from ThingSpeak. It has helped in Data visualization and statistical analysis, in addition to training machine learning algorithm i.e. Random Forest on the home automation system's data.

DHT library:

The DHT library is a software library that simplifies interaction with the DHT series of temperature and humidity sensors.

The DHT library is used to interface with the DHT22 sensor, allowing the ESP32 to read temperature and humidity data.

WiFi and Blynk Libraries:

These are libraries that provide functions and classes for establishing a WiFi connection and connecting to a Blynk server.

The WiFi and Blynk libraries are key to enable the ESP32 to connect to the Internet via WiFi and communicate with the Blynk server for remote control and monitoring.

ThingSpeak Library:

The ThingSpeak library is a library that facilitates communication with the ThingSpeak IoT platform.

The ThingSpeak library enables the ESP32 to send sensor data to the ThingSpeak cloud platform for storage and analysis.

LiquidCrystal_I2C library:

The LiquidCrystal_I2C library is a library for controlling LCD displays based on I2C.

This library is used to control an I2C connected LCD display and provides a visual interface to display temperature, humidity and other information.

ESP32 microcontroller:

ESP32 serves as a central processing unit that coordinates communication between various sensors, actuators, and external platforms. It controls the overall functionality of the home automation system.

DHT22 sensor (temperature and humidity):

It monitors and reports ambient temperature and humidity levels and provides essential data for climate control and comfort monitoring.

PIR sensor (passive infrared sensor):

PIR sensor detects motion, and enhances security features by triggering alerts or actions when motion is detected.

LDR (Light Dependent Resistor) and Temperature Sensor (Fire Detection):

LDR has been used for fire detection. The LDR and temperature sensor combination helps identify potential fire hazards by detecting low light levels and high temperatures.

Relay modules:

Relay modules act as switches to control electrical appliances. It allows remote control and automation of devices such as lights (LEDs in the project).

Buzzer:

It Provides sound alerts and notifications. It is used to signal events such as fire detection or security breaches, ensuring that users are notified even if they are not actively monitoring the system.

Together, these tools and technologies contribute to the development, testing and analysis aspects of the home automation system.

7. Expected impact of the project on society and the environment

7.1 Positive Impacts:

- **Enhanced Home Security**: The theft alert system enhances home security.

- **Energy Efficiency:** Energy savings are achieved in smart lighting control and optimized power consumption.
- **Early Warning System:** Thus, the fire alert system provides an early warning that may prevent accidents.

7.2 Societal Benefits:

- **Convenience:** The use of Blynk for remote monitoring and control makes it even more convenient.
- **Safety:** Safety features are added with theft and fire alerts.

7.3 Environmental Considerations:

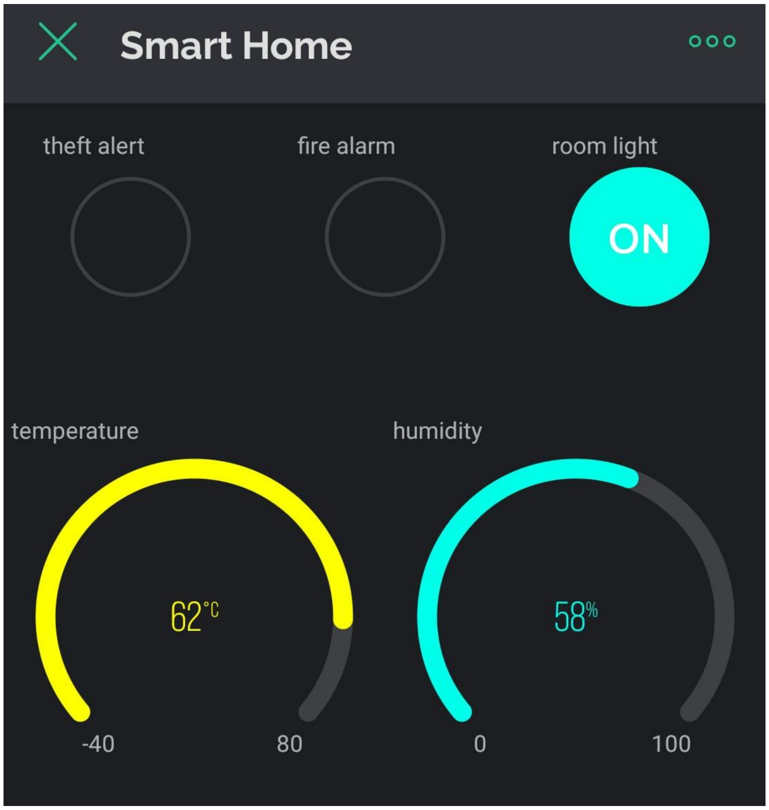
- **Energy Efficiency:** Optimized power consumption means less energy used.
- **Resource Conservation:** It is possible that remote monitoring will save resources by not having to have meaningless trips or taking action.

7.4 Overall Impact:

Home security, energy efficiency and safety The project contributes positively to society. In fact, there are environmental concerns and security aspects that must be considered carefully.

WEB Dashboard:

Mobile application:


Smart Home
theft alert
fire alarm
room light
ON
temperature
humidity
62°C
58%
-40
80
0
100


temperature
57°C
-40
80
humidity
49%
0
100
temperature
65
56
48
39
30
Live 1h 6h 1d 1wk 1Mo 3Mo
humidity
58
56
54
53
51
49
Live 1h 6h 1d 1wk 1Mo 3Mo

Thingspeak:

For real time data capturing