Smart Home Automation Using IoT

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What Is IoT (Internet of Thing)?

IoT is a network of interconnected physical devices embedded with sensors, software, and connectivity that enables them to collect and exchange data over the Internet.

Sensor

Sensors collect data from the physical environment

Connectivity

- Enables devices to communicate with each other and with the cloud
- Uses networks like Wi-Fi, Bluetooth, ZigBee, LoRa, 4G/5G

Data Processing & Analytics

- Stores, processes, and analyzes collected data
- Uses cloud computing, AI, and machine learning

User Interface & Applications

- Allows users to monitor and control devices
- Includes mobile apps, web dashboards, alerts

Application Overview

A complete end-to-end smart home system built on low-cost, open-source hardware and cloud infrastructure.

This pipeline enables real-time monitoring and rule-based control of home appliances — from anywhere, at any time.

Problem Statement & Objectives

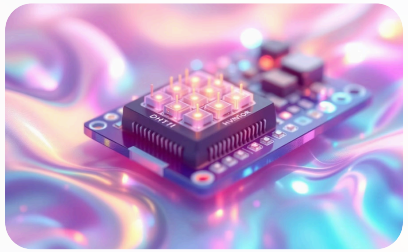
1. **Manual Control Only:** Users must switch devices ON/OFF physically every time.
2. **Energy Wastage:** Lights and fans stay ON even when no one is in the room.
3. **No Remote Access:** Cannot monitor or control home devices from outside.
4. **No Real-Time Monitoring:** No live data about temperature, motion, or light.
5. **Low Comfort & Convenience:** No automation; daily tasks require more effort.

Our Objectives

- Automate lighting, fans, and AC using sensor data
- Enable remote monitoring via a mobile app
- Reduce energy consumption through intelligent rules
- Validate the framework with a real-world case study

Data Capturing: Sensor Details

Three low-cost sensors form the perception layer of the system, each targeting a specific environmental parameter.

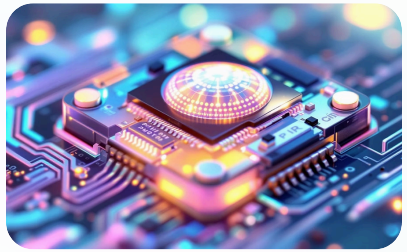


DHT11 — Temperature & Humidity

Range: 0–50°C / 20–90% RH

Output: Digital signal

Purpose: Trigger fan or AC when temp exceeds threshold

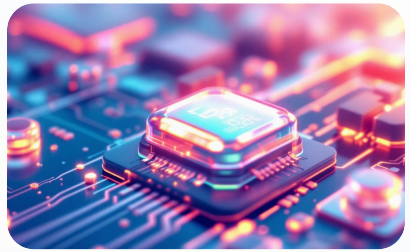


PIR — Motion Detection

Range: Up to 7 meters, 120° cone

Output: HIGH / LOW digital pulse

Purpose: Auto-on lights when occupancy detected



LDR — Ambient Light

Range: 1 lux – bright sunlight

Output: Analog resistance value

Purpose: Dim or disable artificial lights in daylight

Backend: Devices & Infrastructure

ESP32

ESP32 is a low-cost, low-power microcontroller with **built-in Wi-Fi and Bluetooth**. It is used as the **main controller** in IoT projects to read sensor data, process it, connect to the internet, and control devices like lights and fans.

Cloud (Firebase)

The cloud is an online server that **stores sensor data**, processes it, and allows **remote monitoring and control** of devices through the internet.

Relay Module

Switches electrical appliances (lights, fan, AC) ON/OFF

Mobile/Web App: User interface to monitor and control devices.

APIs/Protocols: MQTT/HTTP for data communication between ESP32 and cloud.

Exploratory Data Analysis (EDA)

Key Observations

- **Temperature Pattern:** Higher in afternoon, lower at night → helps automate fan/AC.
- **Motion Pattern:** More motion in evening/night → useful for automatic lighting.
- **Light Pattern:** Low light at night, high in day → enables auto ON/OFF lights.
- **Usage Peak Time:** Appliance usage is highest during evening hours → optimize automation schedules.
- **Idle Time Detection:** Long periods with no motion indicate rooms are unused → turn OFF devices to save energy.

Rule-Based Automation Model

Automation logic is encoded as **IF–THEN** condition-action rules evaluated in real time against incoming sensor readings.

Rule 1 — Temperature Control

IF Temp > 28°C **THEN** Switch ON fan relay; **IF** Temp > 32°C **THEN** Switch ON AC relay

Rule 2 — Occupancy Lighting

IF PIR = HIGH **AND** LDR < 300 **THEN** Switch ON room lights relay

Rule 3 — Daylight Saving

IF LDR > 600 **THEN** Switch OFF all light relays regardless of schedule

Rule 4 — Idle Standby

IF PIR = LOW for > 15 min **THEN** Switch OFF all non-critical appliances

Rule 5 —ML-Based Prediction Model

Predicts user behavior and automates devices automatically.

Learns from historical data (EDA) to improve accuracy over time.

Analysis (System Performance)

1. **Automation Efficiency:** Devices turn ON/OFF based on sensor data, reducing manual effort.
2. **Real-Time Monitoring:** Live sensor data helps quick decisions and better control.
3. **System Reliability:** ESP32 with Wi-Fi provides stable data transmission and control.

Results / Reduction (Impact & Savings)

1. **Energy Reduction:** Automatic switching reduces unnecessary power usage by ~30–40%.
2. **Cost Reduction:** Lower electricity consumption leads to reduced monthly bills.
3. **Time & Effort Reduction:** Less manual control needed; system works automatically.

Conclusion

This case study shows how sensor data, EDA, and rule-based models can automate home appliances using ESP32 and cloud services. The system reduces energy wastage, lowers costs, and improves user convenience, proving the practical impact of IoT in daily life."

Future Scope

1. **AI-Based Automation:** Use machine learning to predict user behavior and automate devices smarter.
2. **Voice Control Integration:** Connect with Alexa/Google Assistant for hands-free control.
3. **More Sensors & Devices:** Add gas, smoke, and security cameras for safety and security.
4. **Better Security:** Implement user authentication and data encryption for privacy.