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Smart Automation System for College Labs and Classrooms Using IoT with Flutter

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***Abstract*—The "Smart Automation System for College Labs and Classrooms using IoT with Flutter" presents an advanced approach to modernizing electrical appliance control within educational institutions. This system integrates IoT-enabled ESP32 microcontrollers with a Flutter-based mobile application to facilitate real-time, remote management of devices such as lights, fans, air conditioners, and computers across multiple rooms. Through a centralized server, it ensures seamless communication, reliable operation, and remote accessibility from any location with internet connectivity. The application provides real-time updates on temperature and device status, along with intuitive toggling features that enhance usability. Role-based authentication is implemented to grant access based on user roles—faculty control appliances in designated rooms, while administrators maintain campus-wide oversight. Designed with scalability and modularity in mind, the system supports simultaneous control of multiple devices, minimizes energy waste, and significantly reduces manual workload. Its flexible architecture allows easy integration of additional features such as scheduling, voice control, and connectivity with learning management systems. This solution not only improves operational efficiency but also supports sustainable, energy-conscious campus environments, setting a new standard for smart educational infrastructure.**

***Index Terms*—Authentication, Classroom Automation, College Labs, Device Management, Flutter, IoT, Microcontroller, Mobile Application, Real-Time Monitoring, Remote Control, Smart Automation, Temperature Control.**

I. INTRODUCTION

The Smart Automation for College Lab and Classroom using IoT with Flutter project focuses on transforming traditional educational spaces into intelligent environments by integrating advanced technologies. This system enables seamless control over various lab and classroom equipment such as fans, lights, projectors, and other electronic devices. By automating the operation of these components, the system significantly reduces manual intervention, allowing faculty members to focus more on teaching and improving the overall quality of education. The primary motivation for implementing automation in college settings is to enhance the educational experience by offering greater convenience and operational efficiency. Traditional classrooms often rely on manual control methods, which can be time-consuming and inconsistent. Automation addresses these limitations by enabling real-time control and monitoring of all connected devices, ensuring smoother transitions during lectures and promoting better resource management. The Internet of Things (IoT) plays a central role in connecting physical devices and enabling communication between them. Flutter is used to develop a cross-platform mobile application that serves as the central interface for users, offering a user-friendly experience across different devices. Additionally, Amazon Web Services (AWS) is used to host the backend services, ensuring secure and scalable server-side operations. Advanced wireless communication technologies are incorporated to extend connectivity beyond conventional Wi-Fi and Bluetooth, enhancing the system's reliability and range. This approach significantly reduces implementation costs while leveraging available resources. All devices can be controlled through a centralized mobile application, providing a simplified and unified control system that can be used in colleges.

II. MOTIVATION

The motivation behind this project arises from a recurring challenge observed in educational institutions, where faculty members are frequently required to remind or instruct students to manually operate electrical appliances such as lights, fans, and air conditioners during entry or exit from classrooms and laboratories. This repetitive and often overlooked task not only disrupts the continuity and efficiency of teaching but also leads to considerable and avoidable energy wastage, stemming from human forgetfulness or neglect. In response to this persistent issue, the project envisions the development of a comprehensive, user-centric mobile application-based automation system that empowers faculty to remotely control these appliances through their smartphones. By integrating smart automation with routine academic activities, the system introduces a vital layer of technological convenience and operational precision, reducing reliance on manual intervention while fostering an intuitive and streamlined user experience. The ability to control lights, fans, and air conditioners with a single tap significantly enhances time management, ensures a consistently comfortable learning environment, and contributes meaningfully to long-term institutional efforts toward energy conservation.

III. OBJECTIVES

The primary aim of our project is to develop an automation system that integrates IoT technology to control fans, air conditioners, and lights in college laboratories and classrooms. By utilizing smart devices managed through a user-friendly Flutter-based mobile application, the system provides faculty and staff with a versatile toolset enabling remote control of appliances across multiple rooms. The project emphasizes energy conservation by supporting real-time monitoring and remote control using a centralized server to ensure devices operate only when necessary. This approach reduces unnecessary energy consumption, helping institutions lower operational costs and promote sustainability. In addition to energy savings, the system enhances operational convenience by reducing the need for manual intervention in daily equipment usage. Faculty members can operate multiple appliances from a single interface, improving time efficiency and comfort. Designed for scalability, the system can easily expand to cover other campus facilities as needed. It also enables seamless retrofit of existing electrical infrastructure without major hardware changes, ensuring smooth integration and ease of use. Overall, this solution transcends traditional manual control, presenting a vision for efficient, convenient, and sustainable campus management. The innovations and practical benefits of this project position it as a key advancement in smart educational infrastructure, setting a foundation for broader implementation in future smart campuses.

IV. METHODOLOGY AND ARCHITECTURE

1. Platform Familiarization: The methodology initiates with a thorough exploration of IoT components, Flutter framework, and embedded systems integration. This step involves studying microcontrollers (e.g., ESP32), relevant communication protocols (such as MQTT or HTTP), and the Flutter environment to ensure seamless interaction between the hardware and mobile application.
2. System Architecture Design: The overall architecture is designed to ensure efficient communication between IoT hardware and the mobile application. The system consists of smart devices (lights, fans, ACs, PCs) connected via Wi-Fi-enabled microcontrollers. These devices are monitored and controlled through a centralized Flutter-based mobile app that communicates with the devices using real-time databases or RESTful APIs. Authentication mechanisms ensure secure access for different user roles (e.g., faculty, admin).
3. Hardware Integration and Control Logic:

Each lab/classroom device is connected to a microcontroller configured with digital I/O pins and sensors. Control logic is implemented in embedded C/C++ and deployed to the microcontroller using tools like Arduino IDE or Platform IO. Device states and sensor data (e.g., temperature, occupancy) are continuously monitored and updated to the server.

4. Mobile Application Development (Flutter):

A Flutter-based mobile app enables real-time control and monitoring of devices with room-wise management and toggle controls. It includes secure role-based authentication, real-time status updates, and displays temperature and occupancy data when sensors are integrated.

5. User Experience Assessment: The application is evaluated from an end-user perspective to ensure simplicity, accessibility, and effectiveness. Factors such as UI responsiveness, ease of control, and clarity of feedback are assessed through faculty/staff pilot usage and feedback

collection. Iterative improvements are made based on usability insights.

6. Testing and Optimization: The system undergoes thorough testing to assess responsiveness, reliability, and performance under conditions like device overload, network issues, and multi-user access. Feedback is used to improve latency and overall user experience.

Architecture-

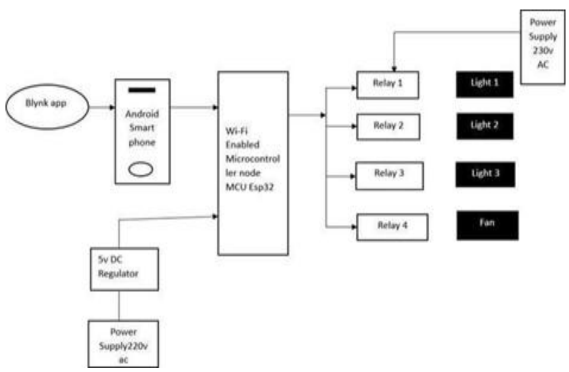

Fig: 4.1 Architecture

Diagrams-

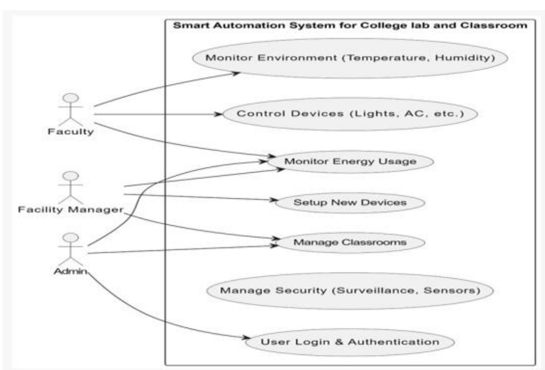

Fig: 4.2 Use Case Diagram

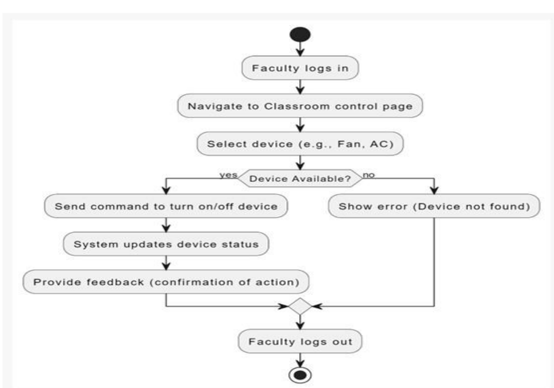

Fig: 4. 3 Activity Diagram

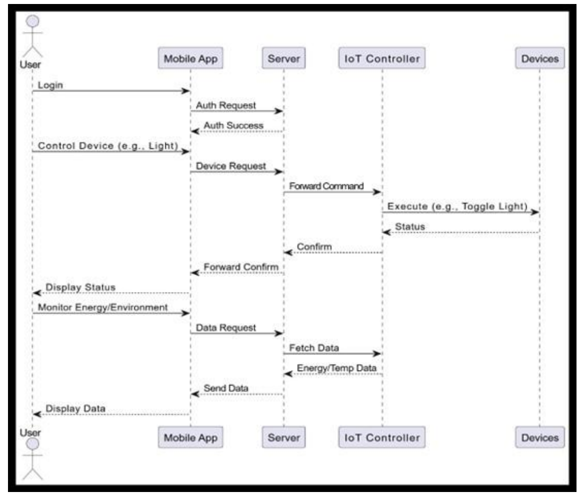

Fig: 4.4 Sequence Diagram

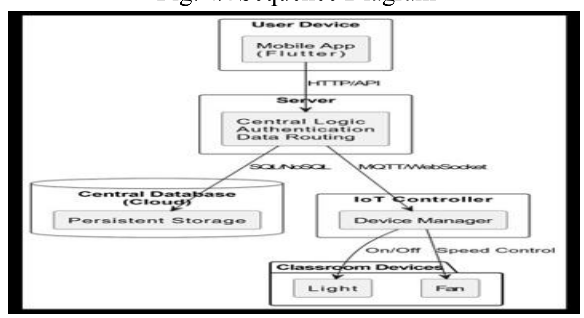

Fig: 4.5 Deployment Diagram

V. MPLEMENTATION AND WORKING

Working on a smart automation system with central server-based remote control involves a structured and integrated development approach. The system begins with a user-friendly Flutter mobile application that allows faculty and administrators to interact with connected devices. These interactions are processed through a centralized server that communicates with IoT hardware like the ESP32 microcontroller. The server manages authentication, command routing, and real-time device status updates. Reliable data exchange between the app, server, and hardware ensures efficient remote operation of appliances such as lights, fans, ACs, and computers across labs and classrooms. Robust network connectivity, secure protocols, and scalable architecture are key for maintaining performance and ensuring seamless device control. Continuous monitoring allows for system diagnostics, while modular design enables easy upgrades. This centralized approach supports real-time, remote, and secure appliance management, enhancing operational efficiency and sustainability in educational institutions.

Fig: 5.1 Login Screen

Fig: 5. 3 Home Screen

Fig: 5.2 Register Screen

Fig: 5.4 Edit Profile

Fig: 5.5 Accept User

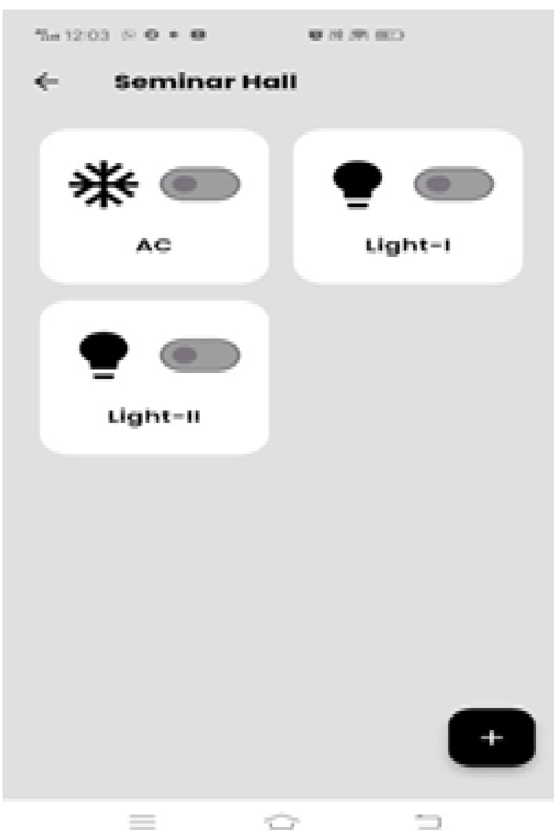

Fig: 5.6 Device Screen

VII. LITERATURE OVERVIEW

1. A Step Towards Home Automation Using IoT: Several studies highlight the evolution of home automation through IoT, aiming to improve convenience, efficiency, and security. Early systems using Bluetooth, ZigBee, and GSM faced limitations in range and compatibility. Modern approaches now favor Wi-Fi-enabled microcontrollers like NodeMCU (ESP8266), enabling remote control and real-time monitoring of appliances via web-based platforms. These advancements support scalable, interconnected smart home systems, replacing older isolated solutions with more user-friendly and integrated environments.
2. Smart Energy Efficient Home Automation System Using IoT: This study focuses on the development of IoT-based home automation systems that enhance energy efficiency, user convenience, and security. Technologies like NodeMCU (ESP8266), IFTTT, and Adafruit are used for remote control through web and voice interfaces. The paper highlights multimodal access options, including Google Assistant, and emphasizes the importance of designing systems that accommodate diverse user needs. It also outlines current challenges like connectivity, power efficiency, and data security, and suggests areas for future research.
3. Analysis and Design of a Context-Aware Smart Home System: This paper reviews the evolution of smart homes toward context-aware systems that intelligently adapt to users' needs. It introduces a five-layer architectural model ranging from sensor data collection to decision-

between users, devices, and automation systems. The study analyzes global trends and identifies major issues such as lack of interoperability, limited market penetration, and insufficient user-focused solutions. Proposed improvements focus on standardization and user-centric design to accelerate adoption.

4. Smart Energy Efficient Home Automation System Using IoT: This research discusses the creation of a smart home system with both web and voice control capabilities, allowing users to operate appliances remotely using static IPs. It combines energy efficiency with enhanced

security through the integration of surveillance cameras and sensors for intrusion detection. The system supports real-time monitoring and aims to reduce energy usage, especially in the context of rising global power demands. The approach offers a practical solution for creating secure, smart, and energy-conscious home environments.

5. Smart Energy Efficient Home Automation System Using IoT: This study focuses on the development of IoT-based home automation systems that enhance energy efficiency, user convenience, and security. Technologies like NodeMCU (ESP8266), IFTTT, and Adafruit are used for remote control through web and voice interfaces. The paper highlights multimodal access options, including Google Assistant, and emphasizes the importance of designing systems that accommodate diverse user needs. It also outlines current challenges like connectivity, power efficiency, and data security, and suggests areas for future research.

VIII. CONCLUSION

In conclusion, our Smart Automation System for College Labs and Classrooms Using IoT with Flutter aims to modernize the control of appliances such as fans, air conditioners, lights, and computers in educational settings. By integrating IoT technology with a Flutter-based mobile application and a centralized server, the system enables secure, real-time remote controlling and monitoring of multiple devices across labs and classrooms, streamlining daily operations. The user-friendly mobile application provides efficient device management with real-time temperature monitoring and seamless toggling functions. Designed for scalability, the system can easily expand to cover additional devices or campus facilities, offering a versatile and future-ready solution. It also supports retrofitting with existing electrical infrastructure, minimizing hardware changes and reducing manual effort.

By promoting energy conservation through optimized device usage, the system lowers operational costs and supports sustainable campus initiatives. Overall, this smart automation solution enhances convenience, efficiency, and energy management, helping educational institutions build smarter, greener environments.

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