SMART SEMINAR

(IoT-based Smart Seminar Hall Management System)

Project Report

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Contents

1 ABSTRACT

Managing seminar halls in large educational institutions presents significant logistical challenges. Traditional methods of booking, access control, and environmental management are manual, inefficient, and prone to conflicts. This often leads to double bookings, unauthorized access, and energy wastage due to lighting and air conditioning systems running in unoccupied rooms.

This project introduces an **IoT-based Smart Seminar Hall Management System** that automates scheduling, access, and appliance control. The system integrates a centralized web dashboard for real-time booking and monitoring with an ESP32-based hardware node installed in the seminar hall. Features include RFID-based secure access, automated lighting and cooling triggered by occupancy sensors (PIR and ultrasonic), and an "Automated Pre-Cooling" feature that activates the AC 30 minutes before a scheduled event. By leveraging IoT technology, this solution ensures efficient resource utilization, enhances security, and provides a seamless user experience for staff and students, aligning with the vision of a smart campus infrastructure.

2 INTRODUCTION

Seminar halls are vital hubs for knowledge dissemination, hosting lectures, workshops, and guest presentations. At institutions like ours, these facilities are in high demand. However, managing them is often decentralized and manual. Staff must physically visit a department to check availability, collect keys, and manually operate electrical appliances.

This manual approach has several drawbacks:

- **Scheduling Conflicts:** Lack of a real-time central database leads to double bookings.
- **Energy Wastage:** Lights and ACs are often left on after events, consuming significant electricity.
- **Security Risks:** Physical keys can be lost or duplicated, leading to unauthorized access.
- **Inefficiency:** The process of key collection and manual setup consumes valuable time.

The **Smart Seminar** project addresses these issues through the Internet of Things (IoT). By connecting physical assets (doors, lights, ACs) to a digital network, the system allows for remote management and automation. A web-based portal enables authorized users to check availability and book slots instantly. On the hardware side, an ESP32 microcontroller acts as the brain, interfacing with RFID readers for keyless entry and sensors for occupancy detection. This integration not only streamlines operations but also promotes sustainability.

3 PROBLEM STATEMENT AND OBJECTIVE

Current seminar hall management relies on manual registers and physical keys. This leads to inefficient utilization of space, administrative bottlenecks, and significant energy wastage. There is no real-time visibility into the status of the hall (whether it is occupied, booked, or vacant), and environmental controls (AC/Lights) are completely manual, often resulting in them running needlessly in empty rooms.

Objectives

The objectives of this project are:

1. **To automate the booking process** using a centralized web-based dashboard, eliminating scheduling conflicts.
2. **To implement secure, keyless entry** using RFID technology, restricting access to authorized personnel only.
3. **To minimize energy wastage** by automating lights and fans based on real-time occupancy detection using PIR and ultrasonic sensors.
4. **To enhance comfort** through "Smart Pre-Cooling," automatically turning on the AC 30 minutes before a booked session.
5. **To provide real-time monitoring** of environmental data (temperature and humidity) and occupancy status via the dashboard.
6. **To create a scalable IoT architecture** that can be easily replicated across other seminar halls on campus.

4 SYSTEM OVERVIEW

The Smart Seminar system is a comprehensive IoT solution designed to modernize the management of educational event spaces. It bridges the gap between physical infrastructure and digital management tools.

The system comprises three core components:

1. **The Web Dashboard:** A user-friendly interface built with React.js that serves as the command center. It allows users to view the calendar, book slots, and see live data from the hall (temperature, occupancy status).
2. **The Hardware Node:** Located within the seminar hall, this unit is powered by an ESP32 microcontroller. It acts as the central hub for all sensors and actuators.
3. **The Cloud Backend:** Uses Google Firebase to synchronize data instantly between the web dashboard and the hardware node.

Key Operations:

- **Booking:** A user books a slot on the dashboard. This data is synced to Firebase.
- **Automation:** The ESP32 constantly checks Firebase. If a booking is approaching (30 mins prior), it triggers the AC relay.
- **Access:** When a user taps an RFID card, the ESP32 verifies the ID. If authorized for the current slot, the door solenoid lock is released.
- **Conservation:** During the event, sensors monitor for motion. If the room becomes empty for a set period, the system automatically powers down appliances to save energy.

5 SYSTEM ARCHITECTURE AND WORKING

The system architecture is divided into three distinct layers, ensuring modularity and efficient data flow:

5.1 Perception & Actuation Layer (Hardware)

- **Controller:** ESP32 Microcontroller (Dual-core, Wi-Fi enabled).
- **Sensors:** RFID-RC522 (Identity), DHT11 (Temp/Humidity), PIR & Ultrasonic (Occupancy).
- **Actuators:** Relay Module (AC, Lights, Door Lock), Servo Motor (Air Freshener).

5.2 Network & Cloud Layer

The ESP32 communicates with the cloud via Wi-Fi. **Google Firebase Realtime Database** stores booking schedules, user permissions, and live sensor logs. It acts as the "state of truth," ensuring the dashboard and hardware are always in sync.

5.3 Application Layer

A React.js-based web application provides the user interface. Features include a calendar view for bookings, an admin panel for user management, and live status cards showing temperature, humidity, and room occupancy.

5.4 Working Principle

The system operates on a continuous feedback loop. The ESP32 polls sensors and reports data to Firebase. Simultaneously, it listens for changes in the database (e.g., a new booking or a manual override switch from the dashboard). When a booking is active, the system enters "Event Mode," enabling the RFID reader and climate controls. When no booking is active, it enters "Standby Mode," locking the door and disabling high-power appliances.

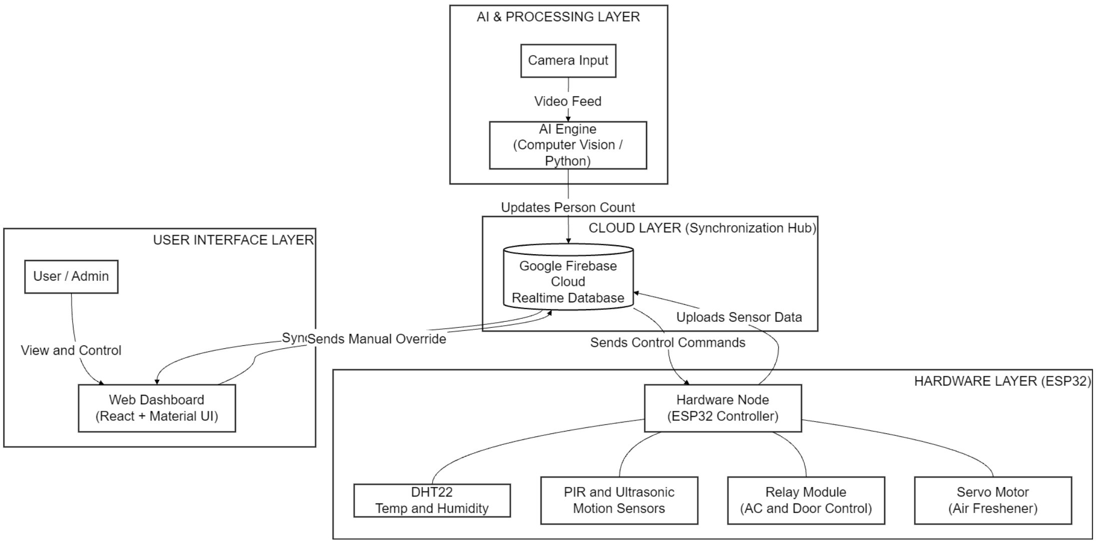

Figure 1: System Architecture Diagram

This diagram illustrates the high-level data flow between the Hardware Node (ESP32), the AI Engine (Computer Vision), and the Web Dashboard, all synchronized via the Google Firebase Cloud.

6 HARDWARE AND SOFTWARE DESCRIPTION

6.1 Hardware Components

- **ESP32 Development Board:** The core processor, chosen for its built-in Wi-Fi/Bluetooth and high processing power suitable for handling multiple sensor inputs simultaneously.

- **RFID-RC522 Module:** A low-cost, reliable reader for 13.56MHz contactless smart cards, used for authentication.
- **DHT11 Sensor:** Provides digital temperature and humidity readings to monitor room comfort.
- **Relay Module (4-Channel):** Acts as a bridge between the low-voltage ESP32 (3.3V) and high-voltage mains appliances (220V), controlling the AC, lights, and door lock.
- **Ultrasonic Sensor (HC-SR04):** Used in conjunction with PIR sensors to accurately detect the presence of people.

6.2 Software Components

- **Arduino IDE:** Used for firmware development. C++ code running on the ESP32 handles sensor logic, Wi-Fi connectivity, and hardware interrupts.
- **React.js:** A JavaScript library used to build the responsive and interactive web dashboard.
- **Google Firebase:** Provides the backend infrastructure, offering a NoSQL cloud database for real-time data syncing and authentication services.

7 RESULT AND BENEFITS

The Smart Seminar system was successfully prototyped and tested in a simulated environment. The integration between the RFID hardware, the cloud database, and the web dashboard functioned with minimal latency.

7.1 Observed Results

- **Seamless Booking:** Users could book slots via the web app, and the hardware node recognized valid bookings instantly.
- **Access Control:** The door lock opened only for registered RFID tags during valid booking times, rejecting unauthorized access.
- **Automation:** The "Pre-Cooling" feature successfully triggered the AC relay 30 minutes before the start time.
- **Data Visualization:** The dashboard displayed accurate real-time values for temperature and humidity.

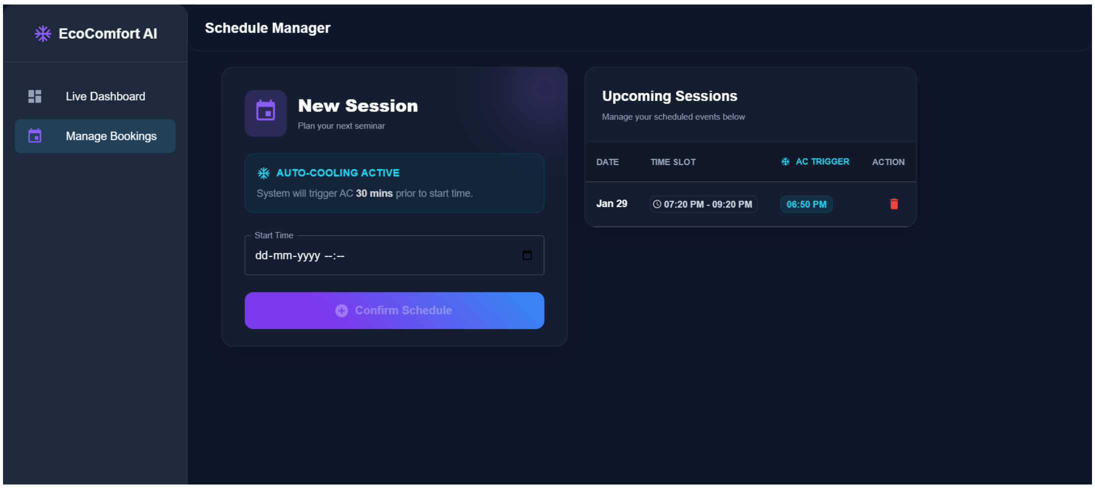

Figure 2: Seminar Booking Dashboard

The dashboard for User to book a seminar slot for a future date. It displays upcoming sessions details.

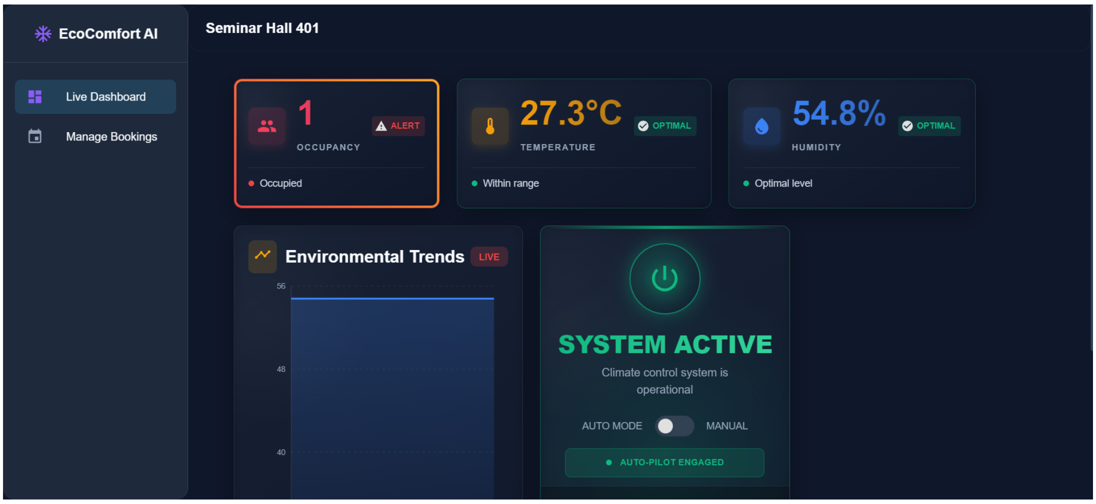

Figure 3: Web Dashboard - Live Monitoring

The user interface developed in React.js. It displays real-time cards for "Temperature," "Humidity," "Live Charts" and "Person Count." The "AC Master Control" toggle allows administrators to manually override the system logic directly from the browser.

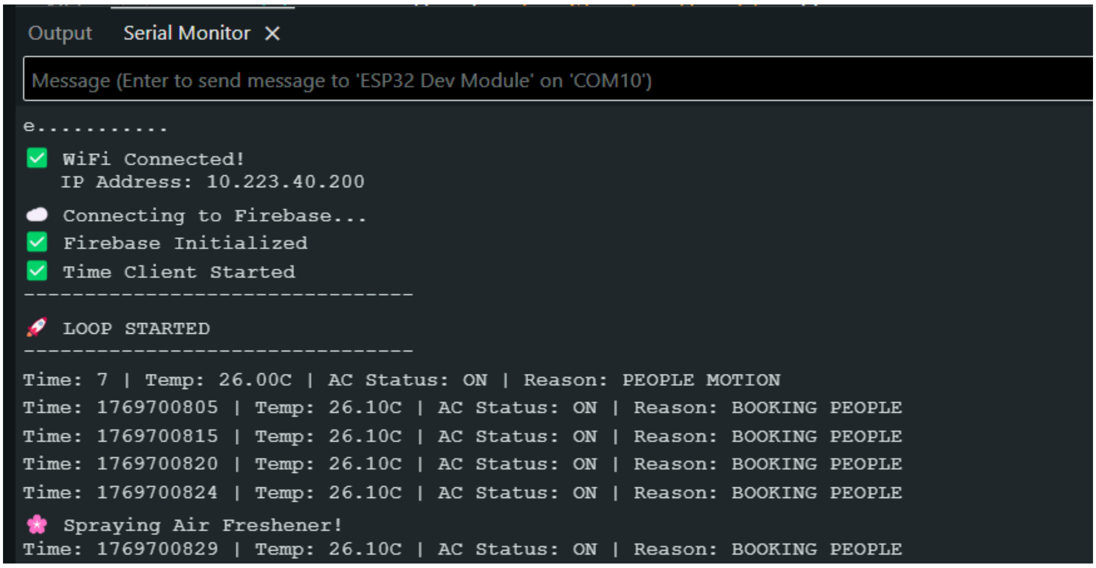

Figure 4: Serial Monitor Output (Debug Log)

The ESP32 console output showing the system's decision-making process. It lists the current Time, Temperature, AC Status (ON/OFF), and the specific "Reason" for the action (e.g., "BOOKING," "PEOPLE," or "IDLE").

7.2 Benefits

- **Operational Efficiency:** Eliminates the need for physical key management and manual scheduling.
- **Energy Savings:** Significantly reduces electricity bills by preventing appliances from running in empty rooms.
- **Enhanced Security:** Digital logs of who accessed the room and when provide a clear audit trail.
- **User Comfort:** Ensures the room is at a comfortable temperature before occupants arrive.

8 LIMITATION AND FUTURE SCOPE

8.1 Limitations

- **Network Dependence:** The system requires an active Wi-Fi connection to sync bookings. Real-time updates fail without internet access.
- **Power Dependency:** In the event of a power outage, the electronic locks and sensors would require a battery backup to function.

8.2 Future Scope

- **Mobile App Integration:** Developing a dedicated mobile app for push notifications regarding booking status.
- **AI Analytics:** Analyzing usage patterns to suggest optimal booking times or predict maintenance needs for AC units.
- **Biometric Integration:** Upgrading from RFID to fingerprint or facial recognition for higher security.
- **Smart Grid Integration:** Interfacing with the campus smart grid to load-shed non-essential appliances during peak power demand.

9 CONCLUSION

The **Smart Seminar** project demonstrates the transformative potential of IoT in educational infrastructure. By replacing manual, error-prone processes with intelligent automation, the system achieves a trifecta of benefits: efficiency, security, and sustainability.

The project successfully automates the entire lifecycle of a seminar event—from the moment a user books a slot online to the automatic preparation of the room's environment and secure access control. It addresses the critical issue of energy wastage in large institutions while providing a modern, convenient experience for staff and students.

10 REFERENCES

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