IoT-BASED BUILDING MANAGEMENT AND SAFETY SYSTEM

A BS Final Year Project by

Faheem Ur Rehman

706/FET/BSEE/F19

Khizer Mehmood

697/FET/BSEE/F19

Waqas Ghaffar

683/FET/BSEE/F19

Supervised by

Dr Adnan Umer Khan

Co-supervised by

Engr. Muzzamil Uz Zaman

Department of Electrical and Computer Engineering

Faculty of Engineering and Technology

International Islamic University, Islamabad

June, 2023

Certificate of Approval

It is certified that we have checked the project presented and demonstrated by **Faheem Ur Rehman 706-FET/BSEE/F19, Khizer Mehmood 697-FET/BSEE/F19, Waqas Ghaffar 683-FET/BSEE/F19** and approved it.

____

External Examiner

Dr Abdul Basit

Assistant Professor

____

Internal Examiner

Dr Baber Khan Jadoon

Lecturer

____

Supervisor

Dr. Adnan Umar

Assistant Professor

____

Co-supervisor

Engr. Muzzamil Uz Zaman

Lab Engineer

بسم الله الرحمن الرحيم

In the name of Allah (SWT), the most beneficent and the most merciful

A BS Final Year Project submitted to the

Department of Electrical and Computer Engineering

International Islamic University, Islamabad

In partial fulfillment of the requirements

For the award of the degree of

Bachelor of Science in Electrical Engineering

Declaration

We hereby declare that this work, neither as a whole nor as a part thereof has been copied out from any source. No portion of the work presented in this report has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning. We further declare that the referred text is properly cited in the references.

Faheem Ur Rehman
706-FET/BSEE/F19

Khizer Mehmood
697-FET/BSEE/F19

Waqas Ghaffar
683-FET/BSEE/F19

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Faheem Ur Rehman

Khizer Mehmood

Waqas Ghaffar

Project Title: **IoT-BASED BUILDING MANAGEMENT AND SAFETY SYSTEM**

Undertaken By:

Faheem Ur Rehman (706-FET/BSEE/F19)

Khizer Mehmood (706-FET/BSEE/F19)

Waqas Ghaffar (683-FET/BSEE/F19)

Supervised By: **Dr. Adnan Umer Khan**

Assistant Professor

Co-Supervised By:

Engr. Muzzamil-Uz-Zamman

Lab Engineer

Date Started: August, 2022

Date Completed: July, 2023

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- Arduino
- Android Studio
- Fritizing
- Python

Abstract

Many industries, including building management and safety, have been transformed by the Internet of Things (IoT). This thesis investigates the creation of a building management and safety system based on the Internet of Things that incorporates sensors, IoT devices, and data analytics methods. The system attempts to improve resource utilization, increase operational effectiveness, and guarantee occupant safety.

A distributed network of sensors, actuators, and gateways is put into place using a thorough review of the literature, the design of the system architecture, and the creation of the necessary hardware and software. It is possible to monitor and manage building infrastructure in real-time, which facilitates improved occupant comfort, energy management, and the reduction of safety hazards.

Advanced analytics techniques are used by the system to analyze the data that has been acquired, find abnormalities, and initiate the necessary actions. Key characteristics include environmental sensing for temperature and air quality as well as energy monitoring and optimization.

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List of Abbreviations

SoC	System on Chip
FYDP	Final Year Design Project
OBE	Outcome Based Education
IoT	Internet of Things
BMS	Building Management System
LED	Light Emitting Diode
AC	Alternating Current
DC	Direct Current
GUI	Graphical User Interface
CCTV	Closed Circuit Television
RTDB	Real Time Database
SDK	Software Development Kit
IDE	Integrated Development Environment
API	Application Programming Interface
UX	User Experience
APK	Android Application Package
GPIO	General Purpose Input/output
RLY	Relay
NC	Normally Closed
NO	Normally Open
LCD	Liquid Crystal Display
PSC	Power Supply Controller

Chapter 1
Introduction

1.1 Motivation

The motivation behind this research project stems from the need for more efficient and intelligent building management systems that can enhance energy efficiency, occupant comfort, and safety. Traditional building management systems often rely on manual processes that are time-consuming, prone to errors, and result in suboptimal resource utilization. By integrating IoT and sensor technologies, along with computer vision techniques, this project aims to contribute to the advancement of building management and safety. One of the main motivations is to optimize energy consumption in buildings. Energy efficiency is a critical concern, both from an environmental perspective and in terms of cost savings. By utilizing IoT-based systems and sensors, building managers can gain real-time insights into energy usage patterns, identify energy wastage, and implement measures to optimize energy consumption. This can lead to significant energy savings and a reduced carbon footprint.Another motivation is to enhance occupant comfort and well-being. Smart buildings equipped with IoT-based management systems can provide personalized experiences for occupants. By monitoring environmental parameters such as temperature, humidity, and lighting levels, the system can automatically adjust settings to create an optimal and comfortable environment. This can contribute to increased productivity, improved health, and overall satisfaction for building occupants. Safety is another crucial aspect addressed by this research project. Fire detection is of paramount importance to ensure the safety and well-being of building occupants. By incorporating computer vision techniques and a web camera, the system can effectively detect fire or smoke incidents in real-time. Early detection enables swift response measures, such as activating fire suppression systems, notifying emergency services, and evacuating occupants promptly. This can significantly reduce the risk of injuries, property damage, and potential loss of life. The integration of a mobile application developed using the Flutter framework further enhances the usability and convenience of the system. Users can remotely control and monitor various aspects of the building's operations through their mobile devices. This provides flexibility and ease of access, empowering users to manage the building's settings and security features from anywhere, at any time. The outcomes of this research project have practical implications for building management and safety industries. The proposed IoT-based system, along with its sensor network and mobile application integration, can serve as a blueprint for developing intelligent building management and safety systems in various contexts. The findings and insights gained from evaluating the system's performance in terms of energy efficiency, user satisfaction, and fire detection accuracy can guide future advancements in this field.

1.2 Project Overview

The rapid advancements in technology have significantly transformed the way buildings are managed and operated. With the advent of the Internet of Things (IoT), buildings have become smarter and more efficient in terms of energy consumption, operational processes, and safety systems. IoT-based building management and safety systems have emerged as innovative solutions that integrate sensors, data analytics, and real-time monitoring to optimize building performance, enhance occupant comfort, and ensure a secure environment. Smart buildings leverage IoT technologies to connect various devices and systems within the building, enabling them to communicate and exchange data. This connectivity allows for seamless integration and automation of various functions such as lighting, HVAC (Heating, Ventilation, and Air Conditioning), security, occupancy monitoring, and energy management. By collecting and analyzing data from multiple sensors placed strategically throughout the building, managers can make informed decisions, identify inefficiencies, and improve overall building performance. Traditional building management systems often face challenges in meeting the increasing demands of modern buildings. Manual monitoring and control processes are time-consuming, error-prone, and inefficient, leading to suboptimal resource utilization. Moreover, ensuring the safety and security of building occupants is a critical concern that requires robust and reliable systems. Current fire detection methods may have limitations in terms of accuracy and early detection, potentially compromising occupant safety. To overcome these challenges, there is a need for an intelligent building management and safety system that leverages IoT and sensor technologies to provide real-time monitoring, control, and automation capabilities. This system should address the limitations of traditional approaches by enabling efficient resource management, enhancing occupant comfort, and ensuring prompt and accurate fire detection. The primary objective of this research project is to develop an IoT-based building management and safety system that integrates various sensors, including infrared (IR), ultrasonic, DHT11, and MQ2, to monitor and control different parameters within the building. These sensors will enable the system to collect real-time data on environmental conditions such as temperature, humidity, gas concentration, and occupancy. By continuously monitoring these parameters, the system can make intelligent decisions regarding energy usage, ventilation, and occupant comfort. In addition to sensor integration, the system will be integrated with a mobile application developed using the Flutter framework. The mobile application will serve as the user interface for building management, allowing users to conveniently control and monitor various aspects of the building's operations. Through the application, users will have the ability to adjust lighting levels, control HVAC systems, monitor security features, and visualize real-time sensor data. This integration of the sensor network with the mobile application will enable seamless data acquisition, communication, and control, empowering users to manage the building remotely and in real-time. One crucial aspect of building safety is fire detection. To address this, the proposed system will implement a fire detection system using computer vision techniques and a web camera. Specifically, the HSV (Hue, Saturation, and Value) method in Python will be employed to analyze video data and detect fire or smoke. By continuously monitoring the visual feed from the web camera, the system can identify potential fire incidents and trigger appropriate alerts and response protocols. Early detection of fire incidents can significantly reduce the risk of property damage and ensure the safety of building occupants. To evaluate the performance of the IoT building management and safety system, comprehensive testing and analysis will be conducted. The system's energy efficiency will be assessed by monitoring and analyzing energy consumption patterns before and after the system's implementation. User satisfaction will be measured through surveys and feedback collection, assessing user experience, ease of use, and overall satisfaction with the system. Fire detection accuracy will be evaluated by comparing the system's detection results with known fire incidents, analyzing the system's ability to detect fires promptly and accurately.

1.3 Problem Statement

Traditional building management systems often face challenges in meeting the increasing demands of modern buildings. Manual monitoring and control processes are time-consuming, error-prone, and inefficient, leading to suboptimal resource utilization. Moreover, ensuring the safety and security of building occupants is a critical concern that requires robust and reliable systems. Current fire detection methods may have limitations in terms of accuracy and early detection, potentially compromising occupant safety. To overcome these challenges, there is a need for an intelligent building management and safety system that leverages IoT and sensor technologies to provide real-time monitoring, control, and automation capabilities. This system should address the limitations of traditional approaches by enabling efficient resource management, enhancing occupant comfort, and ensuring prompt and accurate fire detection.

1.4 Project Objectives

- To design an efficient building management system.
- Design an efficient building safety system.
- Design an efficient building safety system for the prevention of accidents.
- To create a dashboard that can be accessed through Android app

1.5 Brief Project Methodology

Methodology in a project thesis refers to the systematic approach and techniques used to collect, analyze and interpret data for the purpose of answering the research questions and achieving the research objectives. It outlines the steps that will be taken to carry out the research, including the research design, sampling techniques, data collection methods, data analysis procedures, and ethical considerations. The methodology section of a project thesis is crucial because it helps to establish the credibility of the research by providing a clear and transparent account of how the research was conducted. A well-designed and well-executed methodology can provide a solid foundation for the research and ensure that the results are reliable and valid.

1.5.1 Introduction

This project aims to design a smart building management system that is equipped with IoT-based technology to enhance safety and improve user experience. The objective of the project is to

The project will be divided into the following phases:

1.5.2 Planning Phase

The planning phase of our project involves the following steps:

- Defining the project goals and objectives
- Identifying the required resources, including hardware and software
- Creating a project timeline and budget
- Establishing a project team and their roles and responsibilities

1.5.3 Research Phase

The research phase involves the following steps:

- Conducting a literature review on IoT-based BMS system.
- Evaluating available technology and components that can be used in the project
- Identifying potential challenges and their limitations

1.5.4 Design Phase

The design phase involves the following steps:

- Selecting and integrating the necessary sensors for monitoring
- Designing the self-working mechanism
- Selecting and integrating the necessary software for data collection and analysis

1.5.5 Implementation Phase

The implementation phase involves the following steps:

- Building the smart BMS prototype
- Testing the prototype for functionality and performance
- Making necessary adjustments and improvements

1.5.6 Deployment Phase

The deployment phase involves the following steps:

- Conducting field tests to evaluate the performance of the smart BMS in real-world scenarios
- Collecting user feedback and making necessary improvements
- Finalizing the design and making recommendations for further development

1.5.7 Project Deliverables

The project deliverables include:

- A fully functional smart BMS prototype
- A detailed report on the project, including the design process, component selection, testing and evaluation, and recommendations for further development
- A presentation on the project, highlighting its features and benefits

1.6 Conclusion

The proposed project aims to design a iot based BMS that can enhance safety, improve user experience, and monitor different parameter of building. The project methodology includes five phases, including planning, research, design, implementation, and deployment. The project deliverables include a fully functional prototype, a detailed project report, and a presentation highlighting the project's features and benefits.

Chapter 2
Literature Review

2.1 Introduction:

The purpose of this literature review is to examine the advancements and challenges associated with building management systems (BMS) in order to enhance efficiency and automation. This review addresses key issues faced by current BMS, such as the lack of standardized security measures and the control of older devices without backwards compatibility. By analyzing existing research, this review aims to highlight significant efforts made in this field and shed light on potential solutions.

2.2 Review of Relevant Studies:

This paper explored the potential of smart buildings based on IoT concepts and predicted rapid evolution in the next five years. They emphasized how IoT can enhance functionality, energy efficiency, and cost-effectiveness, transforming buildings into smart structures. They also discussed the adoption of function virtualization principles in core carrier networks [1].

This Paper focused on solving the challenges of interconnection and concurrent communication in building operations. They proposed a building operation system platform based on IoT and cloud computing, providing monitoring, control, data processing, and management functions. Their framework encompassed intelligent device levels, networking levels, an IoT platform level, and modularized service levels [2].

In this paper developed a home automation system utilizing IoT technologies, cloud computing, and machine learning. Their system employed a real-time cloud database to record and display data on a mobile application interface, enabling convenient access and control for users [3].

This paper introduced an AR-based Smart Building & Town Disaster Management System to address fire accidents in urban areas. By utilizing AR technologies, their system aimed to reduce the risk of large damages and casualties. They proposed the use of various devices such as electric leak detectors, temperature and humidity sensors, network cameras, and gas detectors to ensure occupant safety [4].

This paper examined the adoption of smart buildings and identified areas of benefits including convenience, security, energy management, and healthcare. They highlighted the existing gap between the potential benefits and the widespread adoption of smart buildings [5].

This paper focused on energy consumption in buildings, particularly in Southern Africa, where heating, ventilation, air conditioning (HVAC), and lighting contribute significantly to energy usage. They emphasized the importance of control systems to optimize energy efficiency and reviewed various control algorithms and systems for building automation in the region [6].

This paper discussed the concept of intelligent building management systems (IBMS) that integrate multiple building components and technologies for efficient information flow. They highlighted the scalability of IBMS, ranging from home heating systems to comprehensive intelligent buildings that control HVAC, lighting, safety, security, and maintenance [7].

This paper predicted the rise of smart buildings in the coming years, emphasizing the role of IoT in enabling automation and improved functionalities. The paper traced the evolution of buildings from traditional materials to the current automation era, highlighting the potential for remote control and monitoring of smart buildings [8].

This paper addressed the energy consumption challenges posed by buildings and the importance of implementing energy-efficient technologies for intelligent energy management. They emphasized the significance of appropriately designed and implemented energy-efficient technologies to enhance building performance and reduce energy crises[9].

2.3 Summary:

This literature review provides a comprehensive overview of the research conducted on building management systems. It highlights the advancements made in the field, such as the integration of IoT, cloud computing, and AR technologies, as well as the importance of energy-efficient solutions. However, challenges in standardization, compatibility, and widespread adoption of smart buildings still persist. The findings from this review will contribute to the understanding of the current state of building management systems and serve as a foundation for further research and development in this area.

Chapter 3

Hardware Modules

Hardware modules are designed to be modular, which allows for flexibility, scalability, and ease of maintenance in hardware design. Modules can vary widely depending on the specific application or system. They can include components such as processors, memory chips, input/output interfaces, sensors, actuators, communication modules, power supply units, display modules, or any other hardware component that serves a specific function within a larger system. By using modular hardware designs, designers and developers can create complex systems by combining and integrating these building blocks in a %plug-and-play% manner, reducing development time and effort. Additionally, modular hardware design allows for easier troubleshooting, repair, and upgrades of individual modules without affecting the entire system

3.1 Microcontroller

ESP32 is a versatile microcontroller developed by Espressif Systems. Designed for IoT applications, it has a dual-core processor, built-in Wi-Fi and Bluetooth, low power consumption, abundant I/O interfaces, and support for high-speed SD cards. With security features, various development frameworks, and an attractive cost-to-performance ratio, the ESP32 is widely used in projects ranging from home automation to industrial automation and sensor networks.

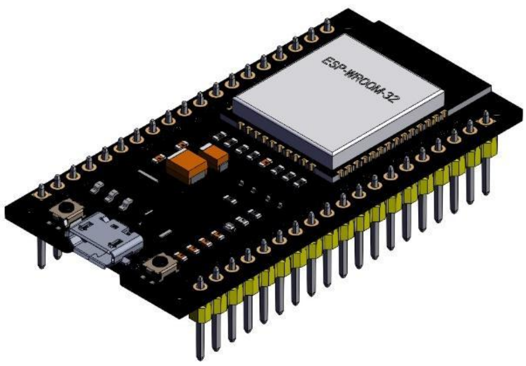

Figure 2

3.2 Four /Two Channel relay

A four-channel relay is an electrical device that can control the switching of multiple independent circuits using a single control signal. Each channel of the relay can switch a separate circuit or load. The relay has four separate switching channels, each with its own input and output connections. When a control signal is applied to a particular channel, it connects or disconnects the corresponding circuit, depending on the state of the relay. This allows the relay to independently control four different loads or circuits. Four-channel relays are widely used in automation systems, home appliances, industrial controls, robotics, and other applications where multiple circuits need to be controlled simultaneously or independently.

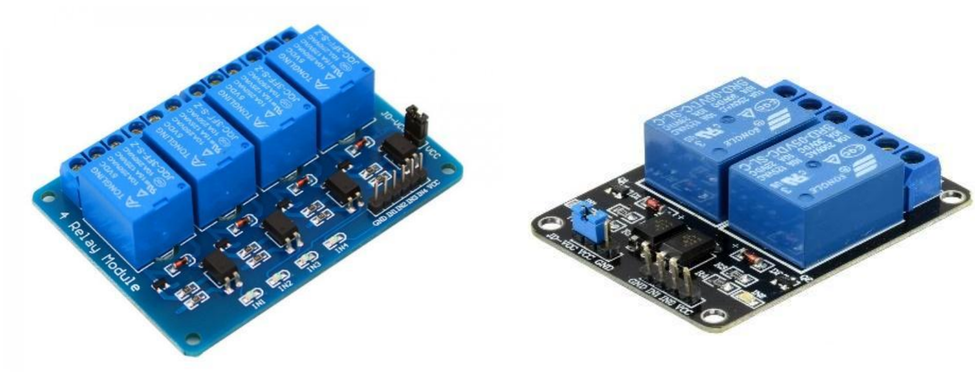

Figure 3

3.3 MQ-2 Gas Sensor

The MQ2 gas sensor is a widely used sensor for detecting various gases, including flammable gases, smoke, and VOCs. It operates based on a chemiresistor principle, providing an analog output that can be measured by a microcontroller. The sensor's sensitivity can be adjusted, but it requires a preheating time for accurate readings. It operates at 5V DC and has some limitations, such as cross-sensitivity to certain gases, which may require additional calibration or filtering techniques for accurate detection. Proper adherence to the datasheet and guidelines is crucial for reliable gas detection.

Figure 4

3.4 DHT 11 sensor

The DHT11 sensor is a commonly used sensor for measuring temperature and humidity in a variety of applications. This is an affordable and easy-to-use sensor that provides accurate readings through a relatively simple interface. The sensor uses digital signals to output temperature and humidity data, making it compatible with most microcontrollers. It has a wide operating voltage range and requires only one data pin for communication. Commonly used in home automation, weather stations, and environmental monitoring systems, the DHT11 sensor provides a cost-effective solution for temperature and humidity measurements.

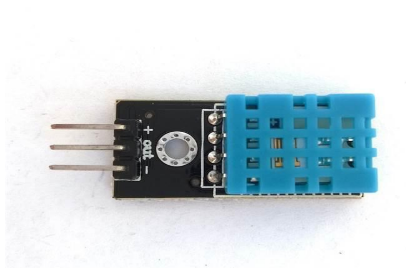

Figure 5

3.5 IR Sensor

An IR (infrared) sensor is a common electronic component used to detect infrared radiation in the environment. It works on the principle of receiving and detecting infrared rays emitted by objects. A sensor consists of a transmitter and a receiver. Transmitters emit infrared radiation and receivers detect reflected or emitted infrared radiation. When an object comes within range of the sensor, infrared light is reflected or emitted, which is detected by the receiver. IR sensors are widely used in various applications such as proximity detection, object detection, motion detection, and remote control systems. They provide a contactless and reliable method of detecting the presence or movement of an object using infrared technology.

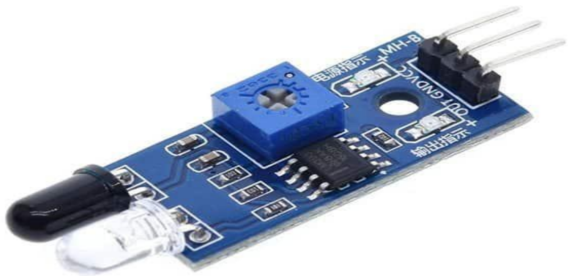

Figure 6

3.6 12V water Pump

The 12 Volt Water Pump is a compact and versatile device that operates from a 12 Volt DC power supply. It is specifically designed for pumping water and is widely used in applications such as RVs, boats, camping facilities and off-grid systems. Pumps typically have a small motor and impeller mechanism that creates a suction force that forces water through the system. 12 volt water pumps are suitable for remote or mobile water pumps, due to their low voltage requirements, they can be easily integrated into battery or solar power systems. Its compact size, efficient performance and compatibility with various power sources make it a practical solution for water transfer and circulation in low pressure system.

Figure 7

3.7 Bug Converter

A bug converter, also known as a step-down converter or voltage regulator, is a device used to convert a higher voltage level, such as 220 volts, to a lower voltage level, such as 12 volts. Widely used in various electronic applications where low voltage is required to power devices and components. The Bug Converter converts incoming 220 volt AC power into a regulated 12 volt DC output commonly used to power electronics, home appliances, or automotive equipment. Bug converters ensure a reliable and stable power supply, protect connected devices from voltage fluctuations, and provide a safe and efficient power conversion solution.

Figure 8

3.8 Power Supply

A 230 volt power pack is an electrical energy system that operates at a voltage level of 230 volts. This is the standard voltage level used in many countries around the world. 230 volt power adapters are commonly used in home and commercial applications to power lights, home appliances, electronics, and various electrical devices. Typically, this is an alternating current (AC) power source that complies with region-specific voltage and frequency standards. The 230 Volt Power Adapter is designed to provide a stable and reliable power supply, ensure safe operation of electrical equipment and meet the power needs of a wide variety of applications.

Figure 9

3.9 Led Bulb

An LED bulb is a type of light bulb that uses a light-emitting diode (LED) as the primary light source. LED lamps are becoming increasingly popular due to their energy efficiency, long life and versatility. Compared to traditional incandescent bulbs, these bulbs consume significantly less energy, making them environmentally friendly and cost effective. LED bulbs come in a variety of shapes and sizes, making them easy to replace existing lighting fixtures. It can produce bright, focused light and radiate different colors and color temperatures. Also, LED lamps generate less heat, which reduces the risk of fire. LED bulbs have become a popular choice for residential, commercial and industrial lighting applications due to their efficient performance and long life.

Figure 10

Chapter 4

Block Diagram and Methodology

4.1 Block Diagram

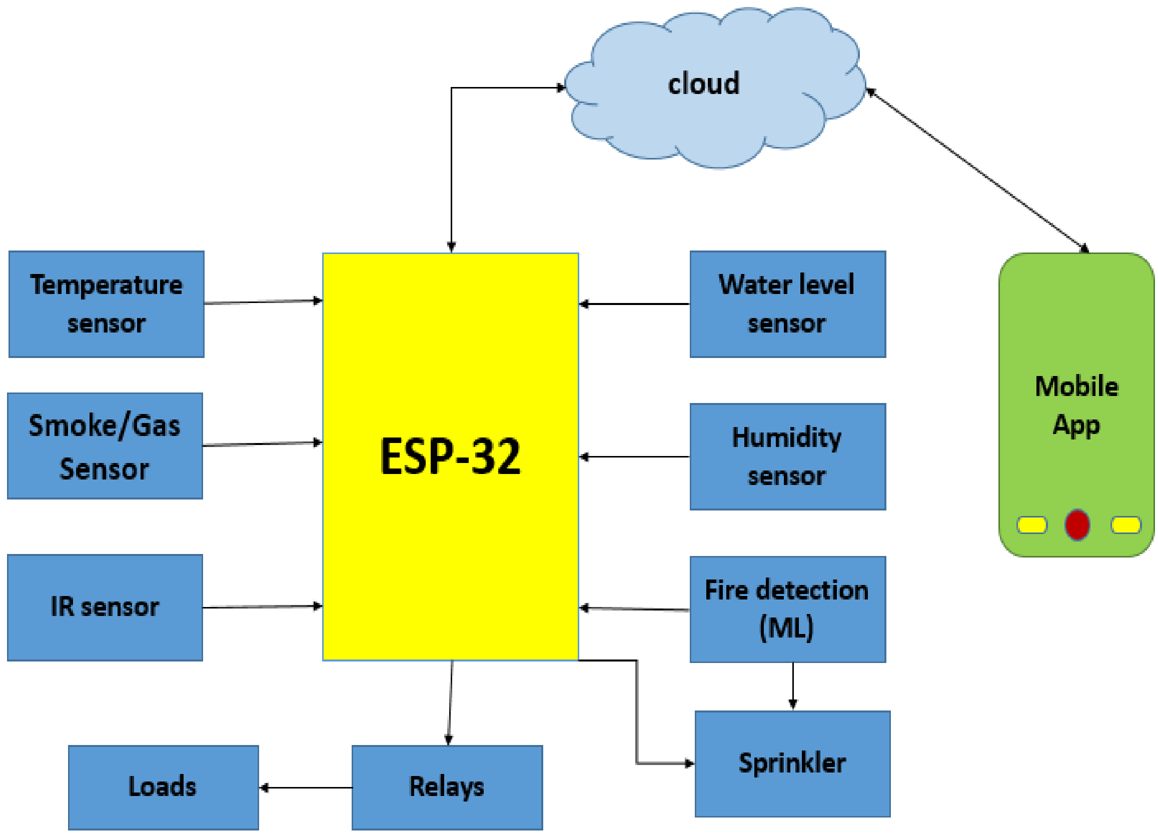

Figure 11

The IoT-based Building Management and Safety System is designed to monitor and control various environmental parameters within a building while ensuring safety measures are in place. The system utilizes a range of sensors to collect data, an ESP32 microcontroller to process and transmit the data, and a cloud platform accessible through an Android app for remote monitoring and control.

The block diagram illustrates the key components of the system. The water level sensor, humidity sensor, temperature sensor, smoke and gas sensor, and IR sensor (for fire detection) are responsible for monitoring the building's environmental conditions and detecting potential hazards.

The data from these sensors is transmitted to the ESP32 microcontroller, which acts as a central processing unit for the system. The ESP32 processes the sensor data and communicates with the sprinkler system to activate it in case of fire or other emergencies.

The ESP32 also shares the collected data with the cloud platform. The cloud platform serves as a centralized storage and management system for the sensor data. It enables remote access, monitoring, and control through an Android app.The Android app allows users to view real-time sensor data, monitor the building's environmental conditions, and control the sprinkler system remotely.

Overall, this IoT-based Building Management and Safety System offers a comprehensive solution for monitoring, controlling, and ensuring the safety of a building through the integration of sensors, microcontrollers, cloud platforms, and mobile applications.

Chapter 5

Hardware Implementation

Building management and security systems use IoT technology to monitor and control various aspects of the building environment.

On the first floor is an ESP32 module connected to a 2-channel relay to control 2 lights.

The ESP32 module on the first floor also contains temperature and humidity sensors for monitoring environmental conditions.

Upstairs there is another ESP32 module and a two-channel relay controlling two lights. In addition, a gas sensor is installed on the second floor to detect gas leaks.

On the 3rd floor he has one lamp and a DC fan that uses a buck converter to convert 220V to 12V.

The fan motor is controlled by a 12V power supply.

Also on the third floor are water level sensors, humidity sensors, and temperature sensors connected to ESP32 modules.

His ESP32 module on the third floor has four channels of relays for controlling various devices. The system uses a cloud platform to collect and store sensor data from all floors.

The cloud platform acts as a centralized management system for remote monitoring and control.

Users can access the cloud platform via her Android app and monitor real-time environmental conditions.

Systems on each floor collect data from temperature and humidity sensors to ensure optimum conditions.

A gas sensor on the second floor detects a possible gas leak and triggers safety protocols.

Lighting on each floor can be controlled remotely via relay modules and cloud platform.

A water level sensor on the 3rd floor monitors the water level and issues an alarm when the water level overflows or falls.

A DC fan on the 3rd floor provides efficient ventilation and is controlled by an ESP32 module.

ESP32 modules on each floor share data with a cloud platform for centralized monitoring and analysis.

If a fire is detected, the system activates her 3rd floor sprinkler system via her ESP32 module and 4-channel relay. Overall, IoT-based building management and security systems ensure efficient monitoring, control, and security measures in high-rise buildings, improving occupant comfort and security.

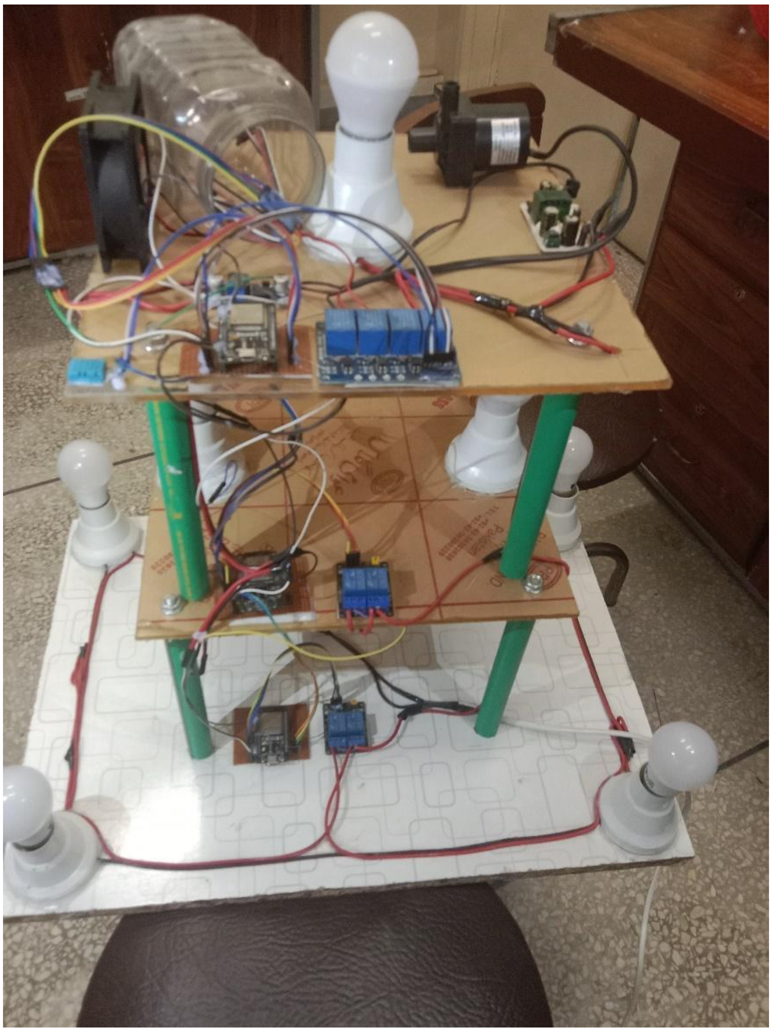

Figure 12

Chapter 6

IoT and App Development

Background

6.1 Firebase

Firebase is a platform created by Google, used to develop mobile-phone or web Applications and for machine communication. The reason behind choosing this platform is, ease in use and open source availability. In our project it is the online storage component by which our controllers are able to communicate with each other.

6.2 Working

Project contain main controller (esp32) which is responsible to take decision that which source of energy is to be used. The component that get information from firebase or store information in firebase is Esp 32. Esp. 32 is communicating with cloud which send/ receive data to/from firebase.

6.3 Firebase sign up

As this is Google platform so we are not required to make another account for it. It directly works with google g-mail account. We just need to go to firebase website and insert our g-mail 28 ID. By clicking on:

https://console.firebase.google.com/project/building-automation-1ba0f/database/building-automation-1ba0f-default-rtdb/data.

we get a page like this.

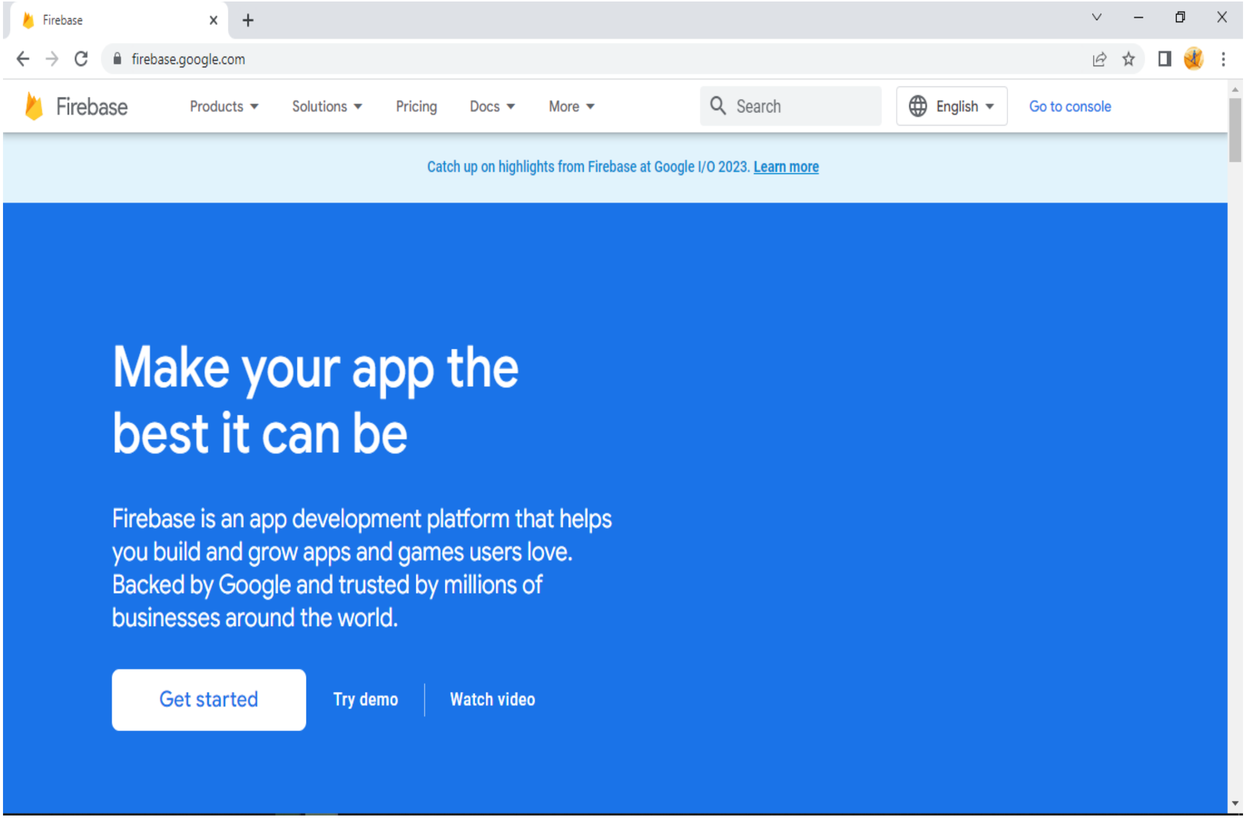

Figure 13

Then click on console, create project, enter the project name, accept terms & conditions of the firebase then click on continue. In this way we created our project.

6.4 Connection with Esp 32

For sharing of information through Firebase server we get the host code by clicking on project and then on the left side Real Time Database, for one of the Firebase host, the other is Firebase Auth.

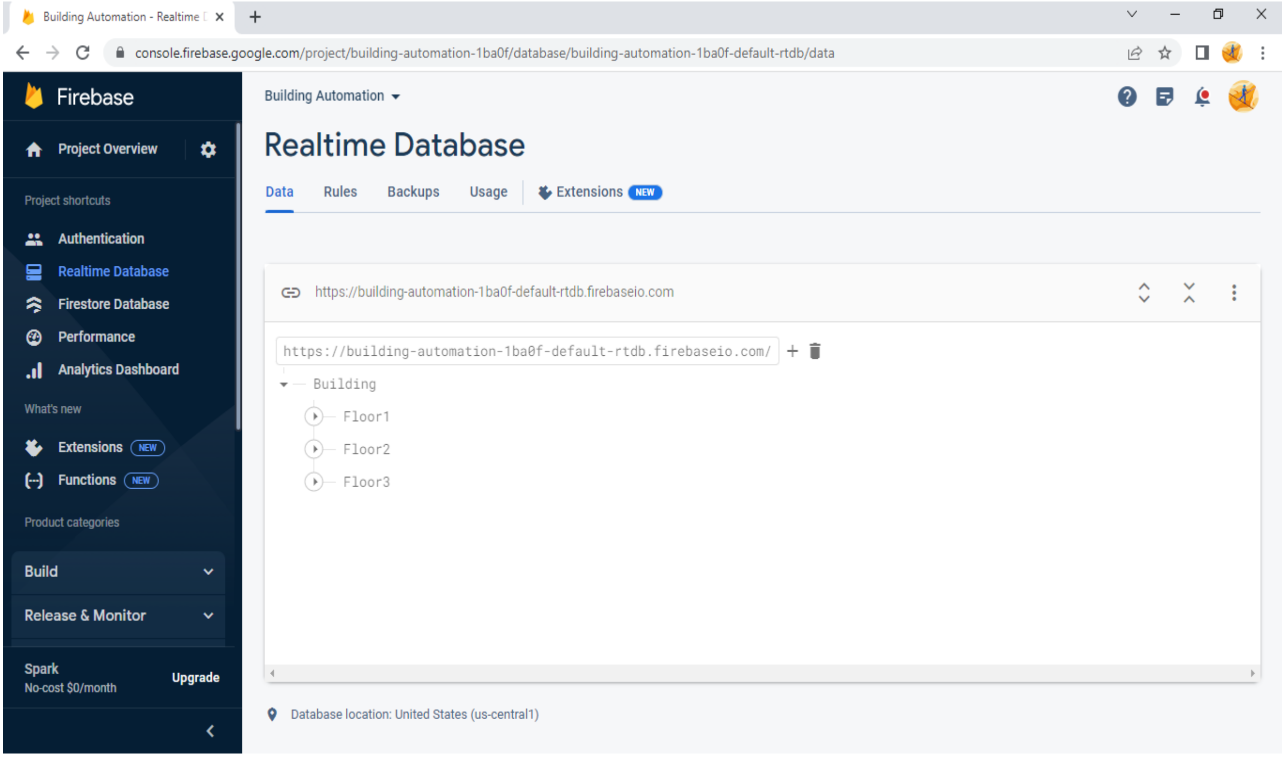

Figure 14

6.5 Getting Firebase Authentication Code

Click on the settings wheel icon next to your project name at the top of the new Firebase Console. s

Project settings.

Click Service Accounts tab.

Click Database Secrets.

There will be non-displayed secret code click Show

This is the Firebase Authentication code.

After synchronization and completion of the project we get the following information in Firebase project.

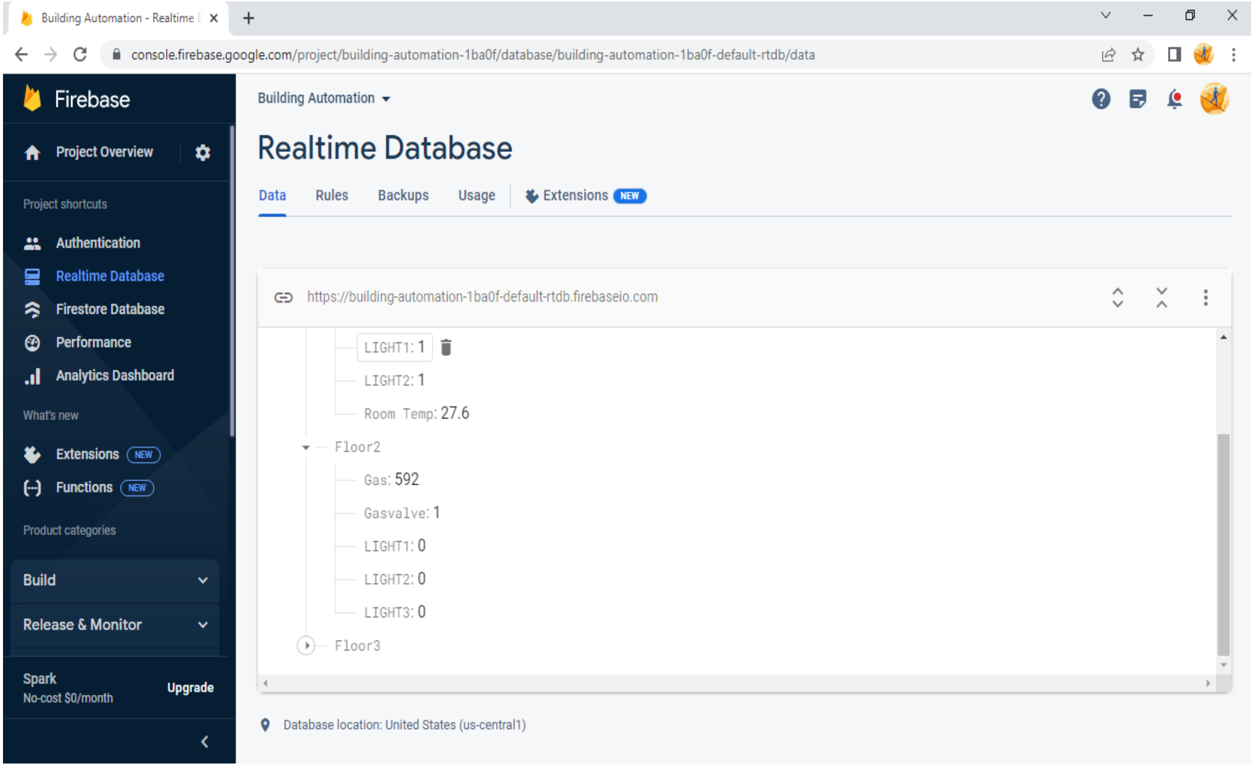
Building Automation - Realtime
console.firebase.google.com/project/building-automation-1ba0f/database/building-automation-1ba0f-default-rtdb/data
Firebase
Project Overview
Project shortcuts
Authentication
Realtime Database
Firestore Database
Performance
Analytics Dashboard
What's new
Extensions NEW
Functions NEW
Product categories
Build
Release & Monitor
Spark
No-cost $0/month
Upgrade
Building Automation
Realtime Database
Data
Rules
Backups
Usage
Extensions NEW
https://building-automation-1ba0f-default-rtdb.firebaseio.com
LIGHT1: 1
LIGHT2: 1
Room Temp: 27.6
Floor2
Gas: 592
Gasvalve: 1
LIGHT1: 0
LIGHT2: 0
LIGHT3: 0
Floor3
Database location: United States (us-central1)

Figure 15

6.6 App Development

SmartBuild is an IoT-based building management and security system developed in Flutter. This allows you to monitor different aspects of your building in real time, including: B. Temperature levels, occupancy and fire/smoke alarms. The app instantly sends security alerts to users' smartphones, enabling quick response and action. Users can also remotely control functions such as temperature settings, lighting and access control. SmartBuild prioritizes energy efficiency by providing insight into energy usage patterns. This app collects and analyzes data to create comprehensive reports and analytics. With its easy-to-use interface and cross-platform capabilities, SmartBuild provides an efficient solution for managing buildings and enhancing security measures.

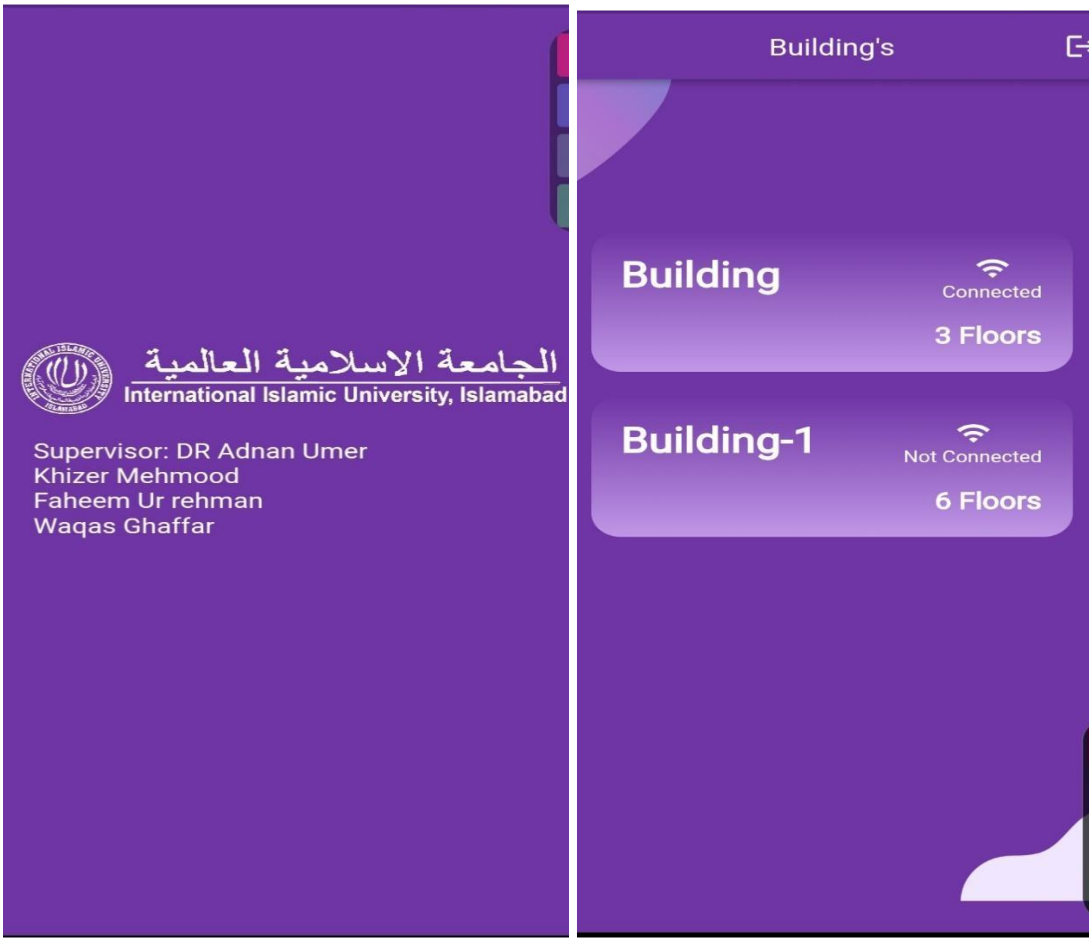

Figure 16

Figure 17

Figure 18

Figure 19

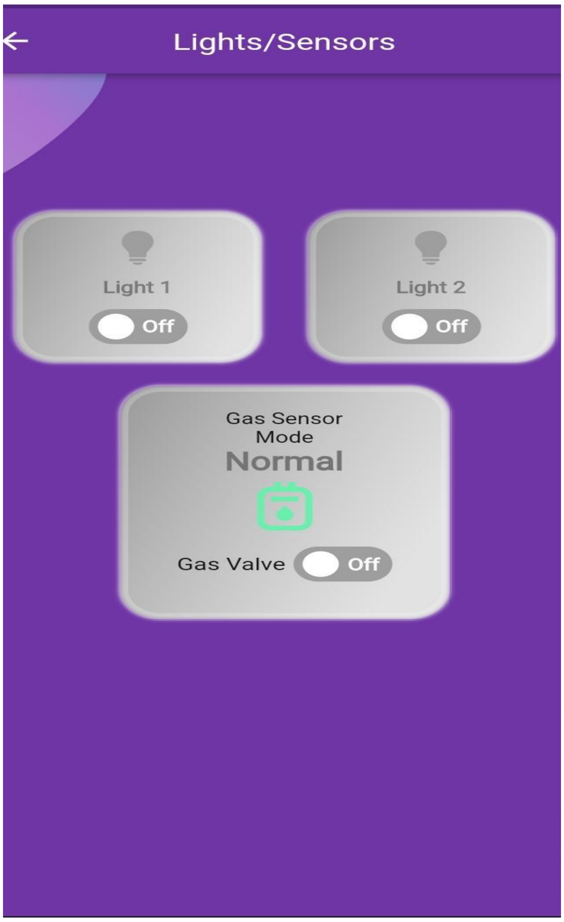

Figure 20

Figure 21

Chapter 7

Conclusion and Future Recommendations

7.1 Conclusion (Heading Level One)

In summary, the described IoT-based building management and security system represents an efficient and comprehensive solution for managing and ensuring the security of high-rise buildings, leveraging IoT technology, the system can remotely Enables monitoring, control, and real-time data analysis. Integration of various sensors, microcontrollers, relays, cloud connectivity and Android apps.

On the ground floor, an ESP32 module allows two-channel relays to control two lights, as well as temperature and humidity sensors for environmental monitoring. Similarly, on the second floor, another ESP32 module controls two lights with two-channel relays and a gas sensor that detects potential gas leaks.

The 3rd floor has lights and a DC fan. This fan uses a buck converter to convert 220V power to 12V DC power, and the 12V power makes motor control easier. In addition, water level sensor, humidity sensor and temperature sensor are connected to ESP32 module with 4-channel relay. The floor is also equipped with smoke and gas sensors and his IR sensor for fire detection, reporting to the sprinkler system and his ESP32 module for immediate response.

Collected sensor data is shared with a cloud platform that acts as a central storage and management system. Users can remotely access the cloud platform via her Android app, monitor real-time sensor data and environmental conditions, and control lighting, fans and sprinkler systems. IoT-based building management and security systems offer a holistic approach to ensure efficient management, enhanced security measures, and convenient control options. The system leverages IoT technology and cloud connectivity to improve building automation, security and occupant comfort, while enabling remote monitoring and control for streamlined building management.

In addition, a gas sensor is installed on the second floor to detect gas leaks.

The third floor has one lamp and a DC fan that converts 220 V to 12 V using a buck converter.

The fan motor is controlled by a 12V power supply.
Also on the third floor are water level sensors, humidity sensors, and temperature sensors connected to ESP32 modules. The ESP32 module on the 3rd floor has 4 channels of relays for controlling various devices.
The system uses a cloud platform to collect and store sensor data from all floors.
The cloud platform acts as a centralized management system for remote monitoring and control. Users can access the cloud platform via her Android app and monitor real-time environmental conditions. Systems on each floor collect data from temperature and humidity sensors to ensure optimum conditions. A gas sensor on the second floor detects a possible gas leak and triggers safety protocols.
Lighting on each floor can be controlled remotely via relay modules and cloud platform.
A water level sensor on the 3rd floor monitors the water level and issues an alarm when the water level overflows or falls.A DC fan on the 3rd floor provides efficient ventilation and is controlled by an ESP32 module. Her ESP32 modules on each floor share data with a cloud platform for centralized monitoring and analysis. If a fire is detected, the system activates the sprinkler system on the 3rd floor via an ESP32 module and a 4-channel relay.

Overall, IoT-based building management and security systems ensure efficient monitoring, control, and security measures in high-rise buildings, improving occupant comfort and security.

7.2 Future Recommendations (Heading Level One)

- Enhanced Energy Efficiency: The system will evolve to optimize energy consumption by utilizing machine learning algorithms to adapt lighting, heating, and cooling systems based on occupancy patterns and environmental conditions.

- Predictive Maintenance: Advanced analytics and predictive algorithms will enable the system to detect potential equipment failures or maintenance needs, allowing proactive actions to be taken before issues occur.

- Integration with Renewable Energy Sources: The system will integrate with renewable energy sources such as solar panels or wind turbines to reduce the building's carbon footprint and increase sustainability.

- Advanced Security Features: The system will incorporate advanced security measures, including facial recognition, access control, and video surveillance, to enhance building security.

- Indoor Air Quality Monitoring: The system will monitor indoor air quality, including CO2 levels and volatile organic compounds (VOCs), to ensure a healthy and comfortable environment for occupants.

- Occupancy Analytics: Data collected from sensors will be analyzed to provide insights into occupancy patterns, space utilization, and resource optimization, allowing for efficient building management.

- Integration with Smart Grid: The system will integrate with the smart grid infrastructure to optimize energy usage based on real-time electricity pricing and demand response programs.

- Integration with Voice Assistants: Voice assistants like Amazon Alexa or Google Assistant will be integrated into the system, allowing occupants to control various aspects of the building through voice commands.

- Augmented Reality (AR) for Maintenance: AR technology will enable technicians to visualize equipment status, instructions, and maintenance procedures through wearable devices, improving maintenance efficiency.

- Advanced Fire Detection and Suppression: The system will incorporate advanced fire detection technologies, such as early smoke detection, thermal imaging, and intelligent fire suppression systems, to enhance safety measures.

- Water Conservation: IoT-enabled water management systems will monitor water usage, detect leaks, and optimize water consumption, leading to improved water conservation within the building.

- Integration with Smart Parking: The system will integrate with smart parking solutions, allowing for efficient parking space allocation and vehicle tracking for building occupants.

- Integration with Emergency Response Systems: The system will integrate with emergency response systems, enabling seamless communication with emergency services and providing real-time updates during critical situations.

- Integration with Building Information Modeling (BIM): BIM technology will be integrated with the system, allowing for real-time synchronization between the physical building and its digital representation for improved management and maintenance.

- Integration with Health and Wellness Monitoring: The system will incorporate health and wellness monitoring features, such as tracking indoor air quality, lighting conditions, and providing personalized recommendations for occupant well-being.

- These future predictions highlight the potential advancements in IoT-based building management and safety systems, focusing on improved energy efficiency, occupant comfort, sustainability, and enhanced safety measures through the integration of emerging technologies and data-driven insights.

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Annexure 'A'

Title of Annex, if any