Virtual IOT Based Smart Classroom Occupancy and Energy Monitoring System using Data Analytics

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ABSTRACT

An Internet of Things (IoT)-based virtual automation project called the Smart Classroom Occupancy and Monitoring System was created to enhance environmental monitoring, energy efficiency, and classroom management in educational settings. Using virtual IoT devices, the system seeks to automatically identify classroom occupancy and track environmental factors like temperature and device status. The concept offers a clever way to cut down on energy waste and improve classroom comfort without the need for human interaction by combining sensors, automation, and data analytics.

In order to replicate IoT-enabled devices like motion sensors, temperature sensors, smart lights, and smart fans in a classroom setting, the system is developed using Cisco Packet Tracer. A home gateway connects these devices, allowing for automation and real-time communication. The system automatically turns on the required equipment when occupancy is detected, and it turns off electrical appliances to save energy when the classroom is vacant. The indoor climate is kept comfortable for teachers and pupils thanks to temperature-based automation.

Microsoft Excel is used for organized data storage and preprocessing of the environmental and device status data gathered from the simulation. After that, Microsoft Power BI Desktop imports the dataset to produce analytical reports and interactive dashboards. Data-driven decision making is made possible by the visualizations' assistance in comprehending occupancy trends, temperature fluctuations, and power usage patterns across time.

All things considered, the Smart Classroom Monitoring System shows how IoT and business intelligence tools may be used practically in managing educational infrastructure. In addition to automating classroom operations, the project offers analytical insights that can facilitate future development into a full Smart Campus Monitoring System that encompasses seminar halls, labs, and other academic buildings.

KEYWORDS

Smart Classroom, Internet of Things (IoT), Occupancy Detection, Environmental Monitoring, Smart Campus, Classroom Automation, Temperature Monitoring, Motion Sensor, Energy Management, IoT-based Monitoring System, Data Visualization, Smart Infrastructure.

1. INTRODUCTION

Digital technology's quick development has drastically changed a number of industries, including education. The Internet of Things (IoT), which allows linked objects to communicate, monitor, and automate various activities in real time, is one of the most influential technologies of the past few years. IoT technology can be employed in educational institutions to build smart learning environments that effectively monitor and manage classroom resources. Sensors, automation equipment, and data analytics tools are all integrated into a smart classroom system to improve energy economy, classroom management, and environmental condition monitoring.

Electrical equipment like fans and lights are frequently handled by hand in traditional classrooms, which can result in wasteful power use when the space is vacant. Furthermore, there is typically no automatic system in place to keep an eye on security, temperature, or classroom occupancy. Increased energy waste and ineffective resource use are the results of this lack of cognitive monitoring. Therefore, it is crucial for modern educational institutions to install an automated system that can monitor classroom conditions and manage devices based on real-time environmental data.

By automating classroom operations with IoT technologies, the Smart Classroom Occupancy and Monitoring System aims to solve these problems. The system detects classroom occupancy and environmental conditions using virtual IoT devices like motion sensors, temperature sensors, smart lights, and smart fans. Cisco Packet Tracer is used to configure these devices in a simulation environment after they are connected via a gateway. Based on temperature changes and occupancy detection, the system automatically turns on or off electrical equipment, saving manual labor and increasing energy efficiency.

Microsoft Excel, which aids in organizing sensor data including occupancy status, temperature readings, and device activity logs, is used to store the data produced by the IoT simulation in an organized manner. Microsoft Power BI Desktop is used to further analyze and visualize this dataset in order to produce analytical reports and interactive dashboards. These visualizations offer insightful information on trends in the environment over time, device usage frequency, and classroom utilization patterns.

All things considered, the Smart Classroom Monitoring System shows how IoT technology and data analytics may enhance infrastructure efficiency and classroom administration. The system helps save energy, improve security, and make better use of resources by automating device control and offering real-time monitoring capabilities. Additionally, this initiative establishes the groundwork for the eventual creation of a full Smart Campus system that can use intelligent automation and data-driven decision making to monitor labs, seminar halls, and other academic buildings.

2. PROBLEM STATEMENT

Classrooms in many educational institutions are still run manually using antiquated techniques, with no intelligent monitoring system in place to control electrical devices like lights, fans, and other equipment. There is frequently no way to immediately determine whether a classroom is occupied or vacant in such settings. Electrical gadgets may therefore be left on even when no staff or students are present, resulting in wasteful energy use and ineffective resource use. In addition to raising operating expenses, this lack of automation leads to energy waste.

The lack of real-time environmental monitoring in traditional classroom settings is another significant issue. Typically, there is no regular monitoring of crucial metrics like classroom occupancy and temperature levels. Maintaining a suitable learning environment for pupils becomes challenging without constant observation. There is no automated system in place to react to temperature changes in the classroom or limited ventilation and modify the environment appropriately.

In conventional classrooms, security monitoring presents additional difficulties. Due to the lack of an automated surveillance system coupled with environmental monitoring devices, unauthorized entrance or unexpected movement within the classroom may go undiscovered. It is challenging to guarantee the security of classroom equipment and infrastructure in the absence of intelligent monitoring solutions.Institutions also frequently lack the analytical tools necessary to examine patterns of gadget usage and classroom utilization. Administrators cannot readily examine how often classrooms are used, how much energy is used, or how environmental conditions change over time without adequate data gathering and visualization. Institutions are unable to make well-informed judgments about infrastructure development and resource management due to a lack of data-driven insights.

An intelligent system that can automatically identify classroom occupancy, monitor environmental conditions, operate electrical devices, and provide analytical insights through data visualization is therefore required. By combining sensor-based monitoring, automation, and data analytics, the Smart Classroom Occupancy and Monitoring System using IoT tackles these issues and builds a more effective, safe, and energy-conscious learning environment.

3. OBJECTIVES

- The Smart Classroom Occupancy and Monitoring System's primary goals are: To create a smart classroom monitoring system that uses motion sensors to automatically determine whether a classroom is occupied.
- Must keep an eye on environmental factors, such as classroom temperature, to ensure that teachers and students have a suitable learning environment.
- To minimize needless energy use by automating electrical appliances like fans and lights based on occupancy sensing.
- To put in place temperature-based automation, in which windows and fans run on their own according to the temperature.
- To increase energy efficiency by making sure that while the classroom is vacant, all electrical equipment are turned off.
- To improve classroom security by turning on security cameras in the event that motion is detected.
- To test smart classroom automation by building a virtual IoT simulation environment with Cisco Packet Tracer.
- To use Microsoft Excel to organize and save data from classroom monitoring.
- To use Microsoft Power BI Desktop to analyze data in the classroom and provide insights through interactive dashboards.
- To use charts and graphical reports to show occupancy trends, temperature fluctuations, and device usage patterns.
- To provide an automated smart classroom management solution in order to lessen the need for manual monitoring.
- To create an extensible model that can be used in the future to keep an eye on labs, lecture halls, and other buildings in a smart campus setting.

4. LITERATURE REVIEW

With the growth of the Internet of Things (IoT), which allows objects to exchange data and communicate over interconnected networks, the idea of smart environments has attracted a lot of attention. The application of IoT technology in educational institutions to provide intelligent learning environments has been investigated by a number of researchers. Device automation, resource optimization, and classroom condition monitoring are the goals of smart classroom systems. Systems that enhance energy efficiency, comfort, and security inside educational infrastructures can now be developed thanks to the integration of sensors, network connection, and data analytics.

The use of IoT-based monitoring systems to identify classroom occupancy and automatically control electrical devices has been the subject of numerous studies. A common method for figuring out if a room is inhabited or empty is occupancy detection with motion sensors. Automated systems can reduce needless energy use by controlling lights, fans, and other electrical appliances based on the detected occupancy state. Such automated systems can drastically cut down on electricity waste and increase building and classroom operational efficiency, according to research.

Environmental monitoring in smart classrooms is another crucial topic covered in earlier studies. To keep teachers and students comfortable indoors, temperature and air quality monitors are frequently utilized. Automated ventilation systems and smart cooling mechanisms can be activated when environmental conditions exceed predefined thresholds. Before deploying IoT-based smart systems in real-world settings, academic research has made extensive use of simulation tools like Cisco Packet Tracer.

The significance of data analytics and visualization in intelligent monitoring systems has also been emphasized by recent studies. Software programs like Microsoft Excel and Microsoft Power BI Desktop can be used to store and analyze data gathered from IoT sensors in order to create interactive dashboards and reports. Administrators can better comprehend usage trends, environmental trends, and energy consumption levels with the aid of these infographics. Institutions can make well-informed judgments to enhance infrastructure management and create intelligent smart campus systems by combining IoT monitoring with data analytics.

5. SYSTEM ARCHITECTURE

The Smart Classroom Occupancy and Monitoring System's overall structure and how its various components interact with one another are described in the system architecture. To enable automatic monitoring and control of classroom gadgets, the architecture integrates IoT sensors, network connection, data storage, and data visualization tools. The system has a tiered design in which environmental data is gathered by sensing devices, sent by the network layer, then processed and displayed for users by the application layer.

The classroom setting is equipped with a variety of IoT sensing devices at the initial level of the design. Motion sensors, temperature sensors, smart lights, smart fans, doors, windows, and security cameras are some of these gadgets. While the temperature sensor continuously checks the classroom's temperature, the motion sensor is in charge of determining whether students or faculty are present. As actuator devices, the smart fan and light react automatically to changes in their surroundings. Cisco Packet Tracer is used to configure and simulate these devices in order to create a virtual smart classroom environment.

The network and communication layer is the second layer of the architecture. In this layer, a wireless network connects every IoT device to a central home gateway. The central controller that oversees sensor and actuator device connectivity is the home gateway. Data is sent to the gateway, which analyzes it and initiates the necessary actions, when a sensor detects a change in the surrounding environment. For instance, to save energy, the gateway automatically turns on the light and fan when it detects motion and turns them off when it doesn't.

Data management and storage are the main topics of the architecture's third layer. Microsoft Excel is used to store the environmental and device status data produced by the IoT simulation in an organized manner. Date, time, occupancy status, temperature values, light status, fan status, door status, and camera activity are among the parameters included in the dataset. Excel storage makes it easier to keep well-organized records that are simple to process and examine.

The data visualization and analysis layer is the last layer in the system architecture. To generate interactive dashboards and analytical reports, the gathered dataset is imported into Microsoft Power BI Desktop. To illustrate trends in classroom occupancy, device usage, and environmental changes over time, a variety of charts, graphs, and performance metrics are produced. Administrators may more effectively monitor classroom conditions and make well-informed decisions about infrastructure use and energy management with the aid of these visual insights.
In order to construct an intelligent smart classroom monitoring system with automated device control, environmental monitoring, and analytical reporting capabilities, the system architecture includes IoT sensing devices, communication networks, data storage platforms, and visualization tools.

6. METHODOLOGY

Using IoT simulation and data analytics tools, the Smart Classroom Occupancy and Monitoring System methodology outlines the methodical procedure used to design, develop, and execute the suggested system. System design, device configuration, data collecting, data storage, and data visualization are some of the phases that make up the technique. For the smart classroom monitoring system to be implemented successfully, each step is crucial.

Designing the smart classroom environment is the initial stage in the technique. At this point, Cisco Packet Tracer is used to set up a virtual classroom. The simulation workspace is equipped with a variety of IoT devices, including motion sensors, temperature sensors, smart lights, smart fans, doors, windows, and cameras. The central controller that links every device via a wireless network is a home gateway. To enable communication between the devices and the gateway, the wireless network settings, including the password, authentication method, and SSID, are set up.

Device registration and configuration come next when the devices are set up. Cisco Packet Tracer's IoT server configuration allows each IoT device to be registered to the home gateway. Automation rules are developed to control the devices based on sensor input after they are linked to the network. For instance, the system automatically turns on the fan and light when it detects motion inside the classroom. In a similar vein, the devices are shut off to save energy when the classroom is empty. When the temperature rises above a predetermined level, temperature-based criteria are also used to turn on the fan or open the window.

Data gathering and storage are the next steps in the approach. The device status and ambient circumstances are captured as dataset entries during the simulation procedure. Date, time, room number, occupancy status, temperature, light status, fan status, and camera activity are some of the characteristics that make up these data values. Microsoft Excel is used to arrange and store the gathered data in a structured manner. Excel aids in appropriately managing the dataset and getting it ready for additional analysis.

Data analysis and visualization constitute the methodology's last phase. To generate interactive dashboards and analytical reports, the prepared dataset is imported into Microsoft Power BI Desktop. To illustrate trends in classroom occupancy, temperature fluctuations, and device usage patterns, a variety of charts are created, including bar charts, line graphs, pie charts, and stacked charts. These dashboards assist improved decision-making, reveal patterns in energy use, and shed light on classroom behavior.In order to create an effective smart classroom monitoring system that enhances classroom automation, energy efficiency, and infrastructure management, the methodology combines IoT simulation, data management, and analytical visualization.

7. MODULE DESCRIPTION

To ensure systemic operation, the IoT-based Smart Classroom Occupancy and Monitoring System is separated into multiple functional parts. Every module is made to carry out a certain function, such as gathering, processing, storing, analyzing, and visualizing data. These modules' integration facilitates effective environmental monitoring in the classroom.

7.1 Simulation Module for IoT

The IoT Simulation Module is in charge of utilizing IoT devices to create a virtual classroom. Cisco Packet Tracer, which has the ability to mimic smart devices like motion sensors, temperature sensors, smart lights, smart fans, doors, windows, cameras, smartphones, and home gateways, is used to construct this module. The temperature sensor keeps an eye on the temperature of the classroom, while the motion sensor assesses occupancy levels and whether students are present. Other smart devices, such as windows, doors, fans, and lighting, function automatically in response to predetermined circumstances. Without the use of actual hardware, this module makes it possible to simulate real-time classroom surveillance.

7.2 Module for Data Collection

Gathering environmental data from the virtual IoT sensors in the classroom simulation is the responsibility of the Data Collection Module. Parameters including occupancy count, temperature, light intensity, power usage, and the state of operation of lights, fans, doors, and windows are all included in the data that is gathered. The temperature sensor captures the ambient temperature, while the motion sensor senses movement within the classroom to assess occupancy. The monitoring system uses this gathered data as its main input for additional processing and analysis.

7.3 Module for Data Storage

The gathered classroom environmental data must be stored in an organized fashion for further analysis by the Data Storage Module. Microsoft Excel is used in the suggested system to store the data gathered from the IoT simulation. Date, time, room number, occupancy level, temperature, light level, power usage, door status, window status, light status, and fan status are all included in the Excel information. It is simpler to retrieve and process data for analytical purposes when it is stored in an organized manner, which guarantees correctness and consistency.

7.4 Module for Data Processing

Before the gathered data is utilized for display, the Data Processing Module is in charge of arranging and verifying it. This module verifies that the input values are logically correct and that there are no errors or inconsistencies in the data. To preserve data integrity, validation methods like range testing for temperature readings and occupancy limitations are used. The format of the processed data makes it simple to incorporate visualization tools for additional research.

7.5 Module for Data Visualization

The processed classroom monitoring data must be transformed into graphical dashboards and reports via the Data Visualization Module. Because Microsoft Power BI Desktop is used to construct this module, interactive visualizations like bar charts, line charts, pie charts, column charts, and card visuals can be created. These dashboards offer information on power consumption levels, device usage patterns, temperature trends, and classroom occupancy levels. The data's graphical format facilitates efficient decision-making and makes it easier for users to comprehend classroom settings.

7.6 Module for Automation

The Automation Module is in charge of regulating how classroom equipment operates in response to environmental factors. The IoT simulation is set up with preset rules to automate device functions. For instance, the system automatically activates the fans and lights in the classroom when it detects motion. Likewise, the fan is turned on and the window is opened for ventilation when the temperature rises above a predetermined level. To save energy, the system turns off the fans and lights when it detects no motion. This module decreases manual intervention and increases classroom energy efficiency.

7.7 Module for Monitoring

Users can view real-time device status and classroom ambient conditions with the Monitoring Module. Users can keep an eye on temperature levels, occupancy status, and the condition of lighting, fans, doors, and windows using a smartphone interface inside the simulated environment. By enabling the camera to track unwanted access when motion is detected while the classroom door is closed, this module improves security.

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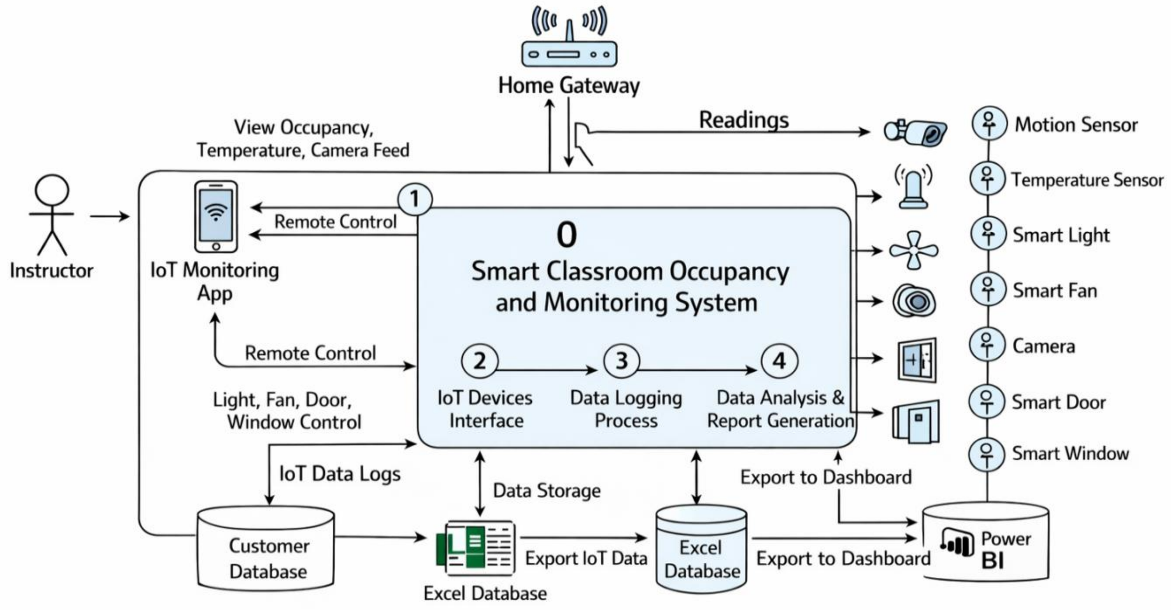
8. DATA ANALYTICS USING POWER BI

Excel data is analyzed and visual insights are produced using Power BI. After being imported, the data is analyzed and cleaned in Power BI. To illustrate trends in classroom occupancy and energy usage, a variety of visualizations are made, including tables, pie charts, line charts, and bar charts.Additionally, Power BI has forecasting capabilities that use historical data to estimate future energy consumption. Administrators can discover wasteful classroom utilization, idle energy consumption, and peak usage hours with the aid of these information.



9.IMPLEMENTATION DETAILS

IoT simulation, data management, and data visualization tools were used to develop the Smart Classroom Occupancy and Monitoring System. Cisco Packet Tracer was used to construct the smart classroom environment, which included placing various IoT devices in a virtual classroom configuration, including motion sensors, temperature sensors, smart lights, smart fans, doors, windows, and security cameras. To serve as the central controller for all IoT devices, a home gateway was set up. In order to facilitate communication between the sensors and the gateway, the devices were linked via a wireless network by setting up the SSID, authentication method, and password.

Each IoT device was registered with the home gateway using the IoT server configuration settings after the network connection was established. After then, automation rules were developed to regulate devices in response to environmental factors identified by the sensors. For instance, the technology automatically activates the lights and fans to provide a comfortable atmosphere when motion is sensed within the classroom. To save energy, the system turns these devices off when it detects no motion. Additionally, temperature-based automation was put in place so that when the classroom temperature rises or falls above a predetermined threshold, the fan or window will start up automatically.

Microsoft Excel was used to capture and arrange the data produced by the IoT simulation, including factors like occupancy status, temperature readings, and device activity. After that, the dataset was imported into Microsoft Power BI Desktop to generate analytical reports and interactive dashboards. To visualize occupancy trends, temperature fluctuations, and device usage patterns, a variety of charts and graphs were created. This implementation shows how an effective smart classroom monitoring and management system can be created by combining IoT simulation with data analytics technologies.

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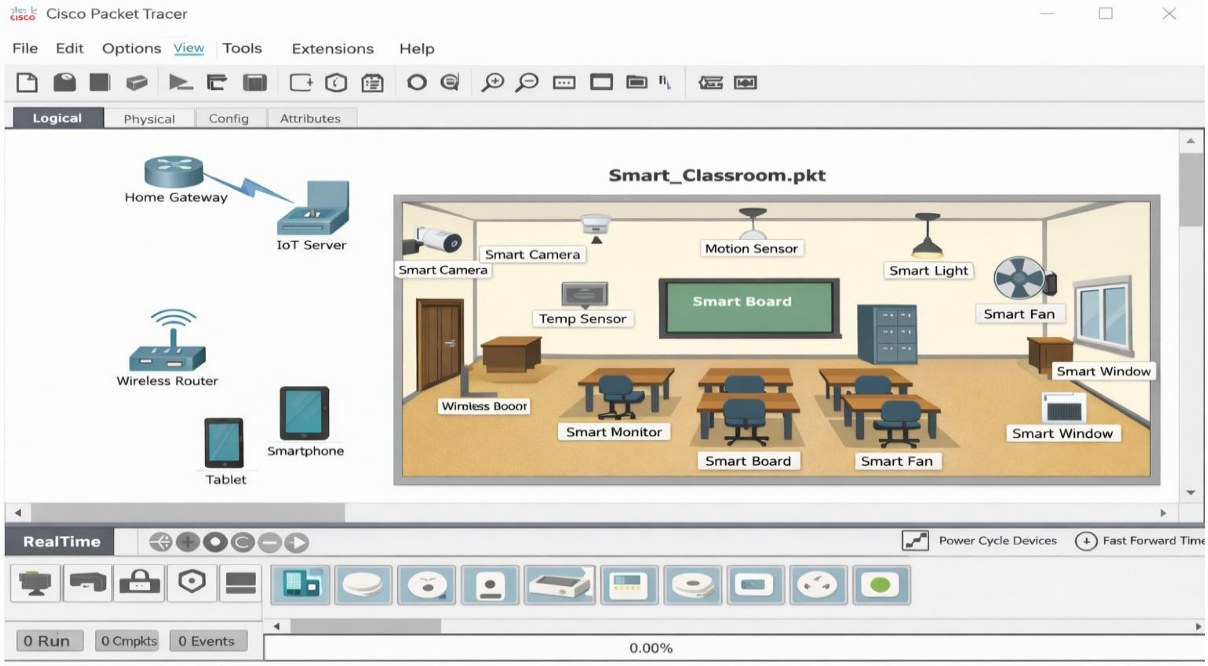
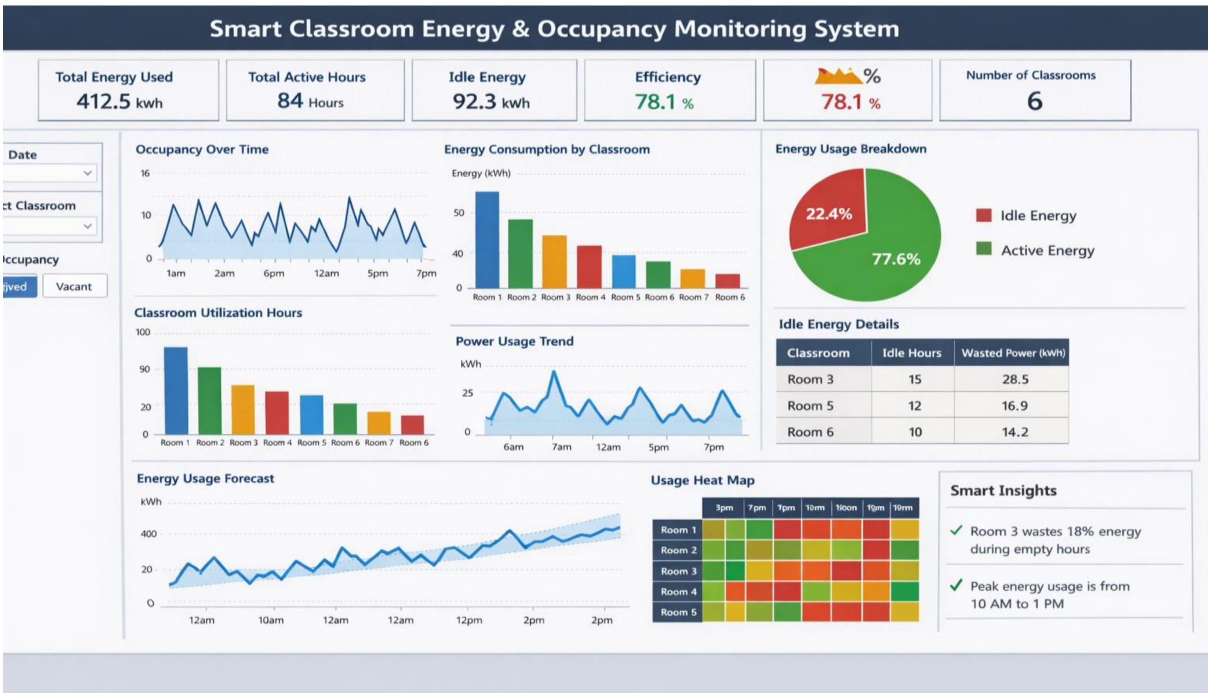
10. RESULTS





11. ADVANTAGES

11.1 Efficiency of Energy

Depending on how many students are in the classroom, the system automatically turns lights and fans on or off. This enhances overall energy efficiency and lowers needless power consumption.

11.2 Occupancy Detection Automation

Students' presence in the classroom is detected via motion sensors. Devices like lights, fans, and cameras are automatically turned on without human input when motion is detected.

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11.3 Monitoring in Real Time

Through IoT monitoring applications, the system enables educators or administrators to keep an eye on real-time classroom parameters including temperature, device status, and occupancy.

11.4 Enhanced Comfort in the Classroom

The classroom environment is continuously monitored by temperature sensors. In order to keep pupils comfortable, the fan automatically goes on and the windows open when the temperature rises.

11.5 Increased Safety

When motion is detected while the door is closed, cameras instantly turn on, enhancing classroom security and monitoring unwanted entry.

11.6 Capability of Remote Control

Users can remotely manage classroom equipment including lights, doors, windows, and fans with a smartphone linked to the Internet of Things network.

11.7 Analyzing and Visualizing Data

To comprehend occupancy trends, temperature patterns, and device usage, data gathered from IoT devices can be saved in spreadsheets and examined using dashboards in Microsoft Power BI Desktop.

11.8 Simple Testing and Simulation

Cisco Packet Tracer makes it simple to test and simulate the system before deploying it in a real-world setting, which lowers deployment risks.

11.9 Scalability

The system can be extended to monitor multiple classrooms, laboratories, and seminar halls in the future.

11.10 Economical Resolution

In educational institutions, IoT automation minimizes manual monitoring efforts and lowers electricity expenses.

12. APPLICATIONS

12.1 Smart Classrooms in Academic Establishments

Schools, colleges, and universities can utilize the system to keep an eye on classroom occupancy, manage electrical equipment, and create a welcoming learning atmosphere.

12.2 Intelligent Campus Administration

As part of a smart campus infrastructure, the system can be expanded to control several spaces, including labs, lecture halls, libraries, and meeting rooms.

12.3 Systems for Energy Management

By automatically regulating lights, fans, and other electrical equipment based on occupancy recognition, it assists institutions in lowering their electricity consumption.

12.4 Safety and Monitoring

By monitoring classroom activities and identifying unwanted access, the integration of cameras and motion sensors enhances security in educational buildings.

12.5 Monitoring of the Environment

By automatically modifying ventilation and cooling systems, temperature sensors contribute to the maintenance of ideal environmental conditions in classrooms.

12.6 Remote Monitoring of Classrooms

With smartphones linked to IoT networks, teachers or administrators can keep an eye on the circumstances in the classroom from a distance.

12.7 Data Analytics for the Use of Resources

Dashboards in Microsoft Power BI Desktop can be used to evaluate data gathered from IoT devices in order to better plan infrastructure and examine usage trends in classrooms.

12.8 Research and Instructional Initiatives

Students researching automation, IoT, and smart infrastructure systems can use the system as a lesson model.

12.9 Systems for Building Automation

Similar technology can be used to automate lighting, ventilation, and monitoring systems in conference rooms, offices, and smart buildings.

12.10 Intelligent Energy-Saving Initiatives

This method can be used by educational institutions to lower operating expenses and encourage sustainable energy use.

13. CHALLENGES

13.1 Complexity of Device Configuration

It can be difficult to configure several IoT devices in the simulation environment, including sensors, cameras, lighting, and fans. Careful setup and testing may be necessary.

13.2 Problems with Network Connectivity

Stable network configuration is necessary for devices and the gateway to communicate properly. Device connectivity may be impacted by any wireless configuration errors.

13.3 Data Reliability and Accuracy

Sensor readings determine the system's accuracy. The automation rules and system performance may be impacted by inaccurate or inconsistent sensor data.

13.4 Challenges of System Integration

It may be necessary to properly style and manage data when integrating IoT simulation, data storage, and data visualization technologies like Cisco Packet Tracer, Microsoft Excel, and Microsoft Power BI Desktop.

13.5 Limited Experiments in the Real World

The project might not accurately reflect real-world circumstances like hardware malfunctions or network delays because it is carried out in a simulation environment.

13.6 Issues with Scalability

Adding extra classrooms, labs, or seminar spaces to the system may necessitate more intricate network setups and data administration.

14. CONCLUSIONS

This project's Smart Classroom Occupancy and Monitoring System effectively illustrates how Internet of Things (IoT) technology may be integrated to enhance classroom management, energy efficiency, and security monitoring in a learning setting. Without the need for human interaction, the system was built to automatically monitor classroom conditions like temperature and occupancy status and adjust electrical equipment like lights, fans, doors, and windows. This automation guarantees the best possible use of classroom resources while reducing energy waste.

Device automation and the simulation of real-time classroom settings were made possible by the deployment of the virtual IoT environment using Cisco Packet Tracer. Through a centralized house gateway, a variety of smart devices, including motion sensors, temperature sensors, lighting, and fans, were connected to track changes in the environment and react dynamically in accordance with pre-established automation rules. Based on real-time data, the system could automatically turn electrical appliances on or off and recognize whether people were in the classroom.

Microsoft Excel was used for organized data management and pre-processing of the environmental and device status data gathered from the simulation. In order to create interactive dashboards and analytical reports, the produced dataset was subsequently loaded into Microsoft Power BI Desktop. Understanding trends in classroom occupancy, temperature fluctuations, and device usage habits over time was made easier by the visualizations.

The technology offered valuable insights into classroom utilization and energy consumption patterns through the use of analytical dashboards. IoT simulation and business intelligence technologies were integrated to provide effective monitoring, better decision-making, and increased operational control.

In conclusion, for contemporary educational institutions looking to implement smart infrastructure, the Smart Classroom Monitoring System works well. In addition to improving classroom administration, the system sets the stage for future growth into a comprehensive Smart Campus Monitoring System that can use IoT-based automation and cognitive data analytics to manage labs, seminar halls, and other institutional resources.

15. FUTURE SCOPE

Currently, this project's Smart Classroom Monitoring and Automation System uses structured data storage, virtual IoT devices, and analytical dashboards to monitor and manage a single classroom setting. There is a lot of room for improvement and extension in the future, even though the system effectively displays occupancy detection, temperature monitoring, device automation, and energy analysis

The system is currently limited to classroom monitoring. Other significant parts of the organization, including laboratories, lecture halls, conference rooms, libraries, staff rooms, and administrative offices, could eventually be monitored and managed using the same architecture. A comprehensive Smart Campus Monitoring System can be created by incorporating more IoT sensors and network devices into the simulation environment using Cisco Packet Tracer.

For instance, the system can be improved in labs to track electrical load consumption, humidity levels, gas leak detection, and equipment utilization. To protect students, special sensors might be installed to identify potentially dangerous environmental conditions. Similar to this, occupancy sensors can be used in seminar halls and auditoriums to monitor the number of attendees and adjust the lighting, air conditioning, and audio systems according to the size of the crowd. This would greatly increase resource use and energy efficiency.

Centralized monitoring, in which every campus building is linked to a single control dashboard, can also be incorporated into the system in the future. Microsoft Power BI Desktop can create institution-wide dashboards that compare energy usage across classrooms, labs, and seminar halls rather of just evaluating data from individual classes. This would assist management in locating regions with high energy use and implementing remedial measures.

Using real-time cloud-based data storage in place of human data entry in Microsoft Excel is another significant improvement. Data can be automatically updated and synchronized without human involvement by integrating cloud platforms like IoT cloud servers. Therefore, classroom automation is not the only future use case for the Smart Classroom Monitoring System. It can be developed into an all-inclusive Smart Campus Management System with sophisticated analytics, automation, security, and energy-saving capabilities that can monitor classrooms, labs, seminar rooms, libraries, and administrative buildings.

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