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IOT-Based Seat Occupancy Monitoring for Office and Campus administration

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Abstract : *Intelligent space utilization has become highly critical in offices and campuses alike in this day and age of smart infrastructure and data-driven management. This paper presents an IOT-based seat monitoring system to help address the challenges of occupancy tracking, space management, and administrative oversight. The IoT-based Seat Monitoring System aims at easing office and campus administration through automation of attendance checking and detection of occupancy. The system incorporates a refrigerator door switch attached to the chair to sense seat occupancy, a microcontroller ESP32 for real-time data processing, and Telegram for the instant notification feature. If a person sits on a chair, it presses the switch and immediately sends a message from ESP32 via Telegram that occupies the seat-identifying whether a principal, staff, or student is there on the premises.*

This design emphasizes the criteria for simplicity and low power consumption, achieved by choosing components economically, and can thus be easily deployed on a large scale across offices, classrooms, and administrative areas. The system works on the basis of a network of embedded devices and IOT models, identifying occupied and unoccupied seats without any compromise in privacy. It aggregates data in real time and offers analytics on dashboards about occupancy trends, peak usage hours, underutilized areas, and seat booking patterns with cloud-based analytics. This information enables administrators to take more informed decisions regarding space utilization, planning cleaning routines, and conserving energy.

IndexTerms **- IoT, Seat Occupancy Monitoring, Smart Campus, Occupancy Detection, Telegram Notifications.**

I. INTRODUCTION

Today's office and college environments require space optimization and proper allocation of resources. Traditional ways of tracking seat utilization involve either manual observation or the use of old-age technology that involves a huge consumption of time, inaccuracy, and inefficiency. Integration of IOT with switches can revolutionize the whole process. The use of IOT for seat occupancy tracking solutions involves the use of real-time analysis and computer vision. This new method will enhance the process of utilizing spaces and will be effective in energy conservation, security, and user experience.

The development of IoT technologies has enabled traditional infrastructures to evolve into smart infrastructures that can optimize efficiency and automation. The efficient use of space and occupancy monitoring have emerged as key problems in modern workplaces and schools owing to the rise in the number of users and changing seating patterns. Conventional manual approaches for measuring and analyzing space usage are not only slow but also inaccurate and ineffective, thus making it essential to develop smart automated systems that can measure and report occupancy data efficiently. This is one of the reasons for building this system, and that is due to the rising significance of automation within office and campus management. For educational institutes and offices, it is necessary for the administrator to keep track of whether there are rooms available or occupied, or faculty cabins, labs, or computer stations. Manual methods are time-consuming and are not very efficient. With the use of IoT technology to automate the monitoring system, the need for any manual process can be avoided.

Another significant feature of this system involves the ability to manage intelligent space management. In offices and schools, for example, it happens that some spaces are always crowded, while others are left completely empty because there are no tools for tracking the level of occupancy of the spaces. With this system, continuous occupancy data collection is ensured, and later on, the collected data can be used to analyze space usage patterns, time of peak occupancy, and underused seats, among other features. This system also provides for the creation of smart campuses and smart offices by enabling connected devices to collaborate for efficiency and increased comfort of use. Smart systems have become vital in contemporary learning institutions and businesses because they provide automated processes, convenience, and timely decision making abilities. The incorporation of IoT technology in occupancy sensing is a significant move towards building intelligent management systems that will be able to cater to the varying needs of the users.

1.1 NEED OF THE STUDY.

In recent times, there has been a rise in the construction of offices, educational institutes, and common working places. Due to this rapid increase in the number of offices, educational institutes, and common working places, there has been a need for effective space optimization and smart management of the infrastructure. The current process of monitoring seat occupancy and attendance is mostly a manual and time-consuming process. It becomes difficult for the administration to keep track of the availability of the seats, attendants, and effective management of the infrastructure. The creation of smart campuses and smart office systems has made the requirement of real-time occupancy monitoring more important than before. With the absence of such a system, there have been various instances where the institutes have faced problems due to inefficient space optimization and improper distribution of people.

The IoT-Based Seat Occupancy Monitoring System proposed herein solves these problems in terms of offering an automatic seat occupancy detection process by means of cost-effective sensors and embedded systems. This helps save time since any change in occupancy can be notified immediately to the relevant authorities via wireless and cloud-based notification processes.Energy savings and sustainable building management is yet another crucial issue that should be considered in carrying out this research project. In most buildings, appliances keep running regardless of whether there are people in those areas or not. Through the integration of this concept with energy-saving systems, a significant amount of energy savings could be achieved.

The research is also essential to facilitate the integration of IoT technology into practical use cases within administration. The system shows how embedded computing devices, wireless networks, and cloud services can be integrated to build smart monitoring solutions. The research aims to facilitate the creation of intelligent infrastructure, which would help increase productivity, enhance safety, optimize resources, and make users' interactions more convenient in the office environment. Additionally, the need for privacy-preserving monitoring systems is increasing. In contrast to occupancy monitoring systems based on cameras, the proposed approach employs basic switch sensors to monitor occupancy and does not collect any private data or images of individuals. In conclusion, the research is needed to help design an affordable, effective, scalable, and efficient occupancy monitoring system that could improve office administrative productivity, optimize resource utilization, and advance sustainable infrastructure development.

II. PROPOSED METHODOLOGY

A proposed methodology for IOT-based seat occupancy monitoring includes the installation of telegram application to detect occupancy in offices and campuses, gathering data about occupancy patterns to analyze and predict future occupancy. The system will be integrated with existing facilities management systems to provide real-time monitoring, allowing for changes to be made that optimize energy consumption,space utilization, and the experience of the occupants.

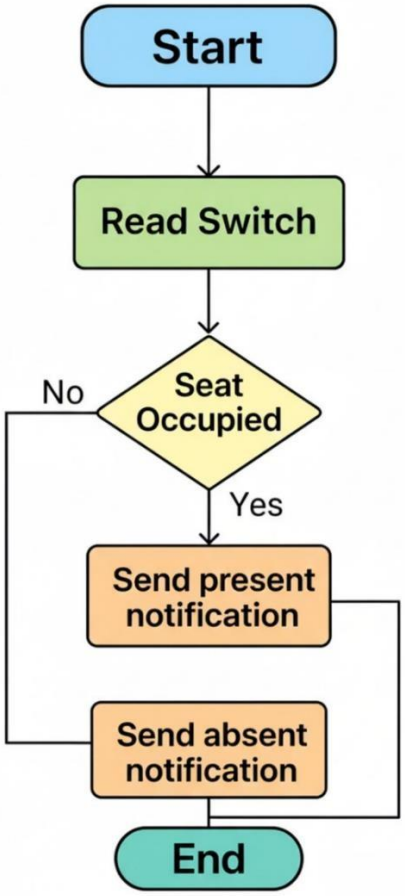

Fig.1 Flow chart of AI enabled chair occupancy

The figure below illustrates the architectural structure of the proposed Seat Monitoring System. It starts with the Refrigerator door switch, which captures the pressure data. The switch is connected to ESP32 Microcontroller, which processes the captured data coming from the sensor. Furthermore, ESP32 transfers the processed data to the Telegram Application to get notified by the notifications. After transmission, the data gets stored and organized for further analysis. Once the data is processed, the refined data is sent back to the user for monitoring purposes. The architecture of the whole system comprises four main components, which include the sensing module, the processing and control module, the communication module, and the notification and monitoring module. Through this architecture, seat occupancy is detected, data processed, information transmitted using wireless communication, and immediate updates are given to the administrators.

This component is expected to sense either the presence or absence of any individual in the seat. In the new model, a refrigerator door switch sensor will be incorporated to sense either the occupancy or vacancy. This switch will be fitted beneath or at the back of the seat such that whenever there is occupancy or vacancy of the seat, the switch will change its state. On applying pressure on the

seat, the switch will be activated and send signals that show occupancy.In addition, this methodology will facilitate automation in energy management. The occupancy data produced by the methodology can be combined with intelligent lighting, ventilation, and cooling systems. In the absence of occupants, electrical appliances will be able to automatically go into power-saving or standby mode, which will prevent wastage of energy and save on electricity bills.The sensor's output is linked to the microcontroller ESP32 that acts as the processor of the whole system. The ESP32 will read the data coming from the sensor and determine the occupancy status of the seat. ESP32 was chosen due to the fact that it comes with integrated wireless internet features, consumes less energy, has a small size, and is ideal for use in IoT applications.

The ESP32 works under programmed logic where the change in switch status is monitored. In case there is any change from the vacant to occupied state, the ESP32 triggers an event and alerts the user using the Telegram app. Likewise, in case there is a change from the occupied state to vacant state, another alert is raised to indicate this change of state. The notification contains the occupation information, accompanied by timestamps.In this case, the Telegram application is incorporated into the system through Telegram Bot API services. In essence, an app known as Telegram bot is designed and programmed in such a way that it receives the messages sent by the ESP32 via the internet. With this method, the process of monitoring occupancy becomes easy since it involves the usage of Telegram application, which is both efficient and convenient for users.This methodological approach would also entail the use of a cloud environment for handling and analyzing data. Data regarding occupancy gathered from various seats can be uploaded into a centralized cloud-based database for future analysis. The cloud system stores past data about occupancy in relation to occupancy duration, time of peak occupancy, most used seats, and underutilized seats.Such data may be used to derive certain patterns or trends in the behavior of the building occupants. For instance, using the occupancy data, building managers will be able to ascertain the classrooms that are often in use, office cabins that rarely host people, and study rooms that are often crowded at a particular hour in time. Such data is useful when making intelligent scheduling decisions.Building on this picture, it is clear that a typical IoT pressure measurement and analysis system takes a path illustrated by this flowchart, where Fridge switch stands for the device that performs the role of measuring the changes in physical pressure in the environment, which include both fluid and air pressures. The detected pressure change is then converted to a message that is passed to the ESP32 processor.

As a key part of the processing device, the ESP32 can be mentioned. This is an economical processor with an incorporated Wi-Fi and Bluetooth transmitter that is often employed in connection with IoT devices. The ESP32 processor will receive, process, and filter the data received from the switch. In addition, this part of the device will prepare it for wireless transmission.Then comes the transmitter module that can be implemented by any technology: Wi-Fi, Bluetooth, or LoRa according to needs. The module is responsible for transmitting the data obtained from the ESP32 to the Telegram application.The suggested seat monitoring system using IoT technology operates on the basis of an efficient and very simple mechanism. The switch of the fridge door is attached to the chair, which when pressed indicates that someone is sitting on the seat. In turn, the ESP32 keeps tracking the status of the switch indicating whether the seat is occupied or not. As soon as the switch is pressed, the occupied seat is detected and notified by the Telegram message to the administrator.If the switch fails to be triggered, then the system considers the absence of anyone occupying the chair, thereby sending out an "absent" message. This process repeats itself in a loop fashion in order to allow real-time monitoring. It is a very effective and economical method of automatic attendance tracking without any form of human interference, especially for office and campus administration. After the generation of these signals, they are relayed to ESP32, which is a powerful and versatile microcontroller with Wi-Fi and Bluetooth connectivity capabilities. The ESP32 functions as the local controller and processor for input received from the sensors; it analyzes the input and processes it in order to refine it further before relaying it to other elements of the system.

After the processing of the collected data, the next step is the implementation of the Telegram program. Usually, this module is either installed inside the ESP32 or connected externally. This provides the system with the ability to transmit data over the Internet. The gathered data will be transferred to the Telegram program, which is a crucial component in many IoT-based solutions. The technique used for detecting the occupancy of the chair in this project involves a simple refrigerator door switch attached to an ESP32 microcontroller. This microcontroller monitors the status of the switch, which determines whether the seat is occupied or vacant. If the microcontroller detects that the seat is occupied, then it triggers an alert message on a preconfigured Telegram chat via WiFi. Likewise, it sends an alert message when the user gets out of the seat. In this case, real-time communication eliminates the need to check manually, making the system efficient in offices, labs, admin offices, and other campus buildings. This method is cost-effective and easy to install and expand to monitor multiple seats at once.The methodology will also incorporate the use of cloud computing technology for storing occupancy data and generating reports. Occupancy data obtained from various seats will be stored in an online database to be analyzed. The analysis will include variables such as occupancy time, peak periods, popular seating locations, and least utilized zones. These analyses will help the management plan the utilization of space.
In order to enhance energy conservation, the system will integrate the use of occupancy data with automated lighting and air-conditioning systems. In case there is no occupancy at a particular seat or room, the power supply system will shift to saving power mode.Not just seat sensing, the device could be used to provide information on seating trends, attendance records per day, or even predictions that could assist in resource planning. The modular setup means that the sensor could easily be extended to a number of chairs or rooms. The connection to dashboard or cloud systems means that it is easy to monitor from one place. Moreover, the alerting function could help not only for administration but also for security purposes as access would be granted only to authorized users. In conclusion, the small power requirement of the ESP32, combined with the durability of the fridge switch, ensures that the system will be operational for many years to come.The final processed data is provided to the end user via a Mobile Dashboard. This mobile app can be accessed by users anywhere in the world using their smartphones.

III. PRACTICAL IMPLICATIONS ANIMPACT

The use of IOT-based seat occupancy monitoring systems provides significant benefits related to decision-making processes and management of office and campus environments. By monitoring the use of spaces in real time, it is possible to improve the use of available space, save energy consumption, and allocate resources accordingly.Apart from providing various operational benefits, such

as cost savings and increased efficiency, the implementation of IOT-based seat occupancy monitoring contributes to creating comfortable working environments. The technology not only makes facilities more effective but also improves user experience. Due to this reason, organizations are able to create comfortable and productive environments.One of the most significant applications of the proposed system would be the automatic monitoring of occupancy. In typical office or campus settings, authorities have no choice but to monitor manually or use attendance registers to check if seats or rooms are being used or not. These traditional methods of checking occupancy can be inefficient and prone to errors. However, with the proposed system, these challenges will be avoided since the IoT system will automatically detect occupancy and relay the information via wireless communication networks.The system offers significant advantages in office management through real-time monitoring of employee attendance and utilization of office space. Given the growing popularity of hybrid work policies and flexible seating in contemporary offices, businesses need advanced systems for the effective management of communal office spaces. The suggested system helps managers and employees recognize empty seats within seconds, facilitating the adoption of hot-desking and flexible seating principles. Employees are able to locate empty seats without spending time looking for available seats.

The system also enhances administrative coordination and accountability. For instance, in educational institutions, the administrators will immediately learn whether the principal, the faculty member, or the staff members are on the campus. The same applies to office environments where the administrator will be able to monitor workstation and worker occupancy. Such timely communication ensures that organizations coordinate activities among various departments and personnel.Efficient use of physical space is yet another significant practical application. Currently, most organizations have spaces that are overcrowded, and at the same time, other spaces are underused due to a lack of any occupancy monitoring system. The continuous monitoring of occupancy data provided by the system enables administrators to establish which spaces are occupied frequently and those that are less occupied. The information is useful for proper allocation and reorganization of space within the facility. Consequently, there will be maximum utilization of existing infrastructures without any need for further expansion.There are other consequences of this system that include energy conservation. Electricity wastage is very common since lights, fans, and air conditioning units continue working despite the absence of anyone in the room. Through the integration of occupancy data with smart energy systems, there will be an automatic control mechanism for the turning of electrical appliances on or off according to the occupancy condition. This system further adds to the provision of efficient safety and security management. With the help of occupancy detection technology, the occupants within the premises can be monitored in terms of the number of people occupying a certain area. In emergency situations, such as a fire, it will be easier to respond since it will be easier to locate those who are still inside the building.

The automation capabilities of the system are especially helpful in education settings where professors and managers need to supervise several classrooms, laboratories, and office cabins at once. The automation of the seat occupation detection makes the task of checking attendance less burdensome and helps professors concentrate on their core duties. The students and teachers will also reap the benefits of increased coordination in accessing the seat occupancy information.Office premises, on the other hand, can greatly benefit from automation when it comes to contemporary workplace management practices, such as flexible seating and hybrid work models. Organizations are increasingly adopting the practice of hot-desking and shared seating as a way of improving the use of infrastructure and cutting costs. However, managing the shared seating can become difficult, leading to losses of time and money. In this context, the proposed system offers instant seat occupancy updates which enable workers to find an empty workspace in no time.There exist significant practical applications for the use of IOT-enabled seat occupancy monitoring systems within the office and campus settings. These technologies, which make it possible to analyze data gathered in real-time through the use of switches, sensors, cameras, and artificial intelligence applications, allow for greater efficiency through optimized spaces, lower energy expenses, and improved performance across the board. In offices, such solutions provide staff members with relevant information regarding open desks needed for flexible workplace operations. On campuses, they allow for the control over space occupancy within classes and facilities. Besides that, these IOT-based technologies will guide future construction activities and even ensure compliance with health and safety rules due to the need for crowd monitoring.

The system makes valuable contributions towards energy saving and sustainable infrastructure management. With the integration of information about occupancy into the lighting, ventilation, and air conditioning systems, electrical appliances are enabled to function only if there is an occupancy of space. In doing so, energy is saved, utility costs are reduced, and the environmental objective of promoting sustainable buildings is also achieved.The proposed system is cost-effective and easy to implement for both smaller and larger organizations due to its affordability and simplicity. The use of inexpensive hardware components like ESP32, as well as refrigerator door switches as sensors, makes the implementation costs lower without compromising the accuracy of monitoring performance. In contrast with other camera-based methods, the proposed approach guarantees user privacy since there will be no image capturing involved.Another aspect that can be considered relevant to the discussion on the proposed system is the possibility to implement Internet of Things concepts into practical applications for solving infrastructure problems. By combining several components, including sensors, wireless communication, and cloud messaging service, an intelligent monitoring system may be developed and used to enhance automation.In the case of educational institutions, the application of the system becomes equally vital. Such institutions typically have problems in ensuring class occupancy and tracking attendance among other issues. The suggested system will enable automatic class occupancy detection and provide information about whether students, lecturers, or any other individual present. As such, the burden of attendance tracking becomes easier for the institution. Instead of spending much time managing the problem of class attendance, lecturers will be able to concentrate on delivering lessons effectively.In addition, the ability to expand and integrate with emerging technologies is made possible by the modularity and scalability of the system design. Emerging technologies that can be integrated include RFID authentication technology, biometric attendance systems, cloud-based dashboards, mobile apps, and artificial intelligence (AI) analysis software.

Maintenance-wise, the system aids in effective facility management because it allows managers to identify trends in how the infrastructure is used. Areas that have high foot traffic might need more maintenance, cleaning, or even furniture updates than those which have low activity. This way, maintenance costs are not wasted on facilities that do not need them.Moreover, another critical practical implication of the system is its support for evidence-based decision-making. The cloud analytics platform provides occupancy statistics and trends, which help the management team with planning and developing infrastructure based on occupancy trends.

Decisions about classroom scheduling, space availability, seat arrangement, and resource management can be made based on occupancy statistics.Furthermore, the system encourages the use of technology in education and business settings. It proves the feasibility of using IoT, embedded systems, wireless communication, and cloud computing technologies to solve administrative issues. The system's flexible structure makes it possible to integrate advanced technologies like RFID, biometric devices, AI analytics, and mobile applications into the system.

Scalability is another crucial benefit of the proposed solution. Since the system relies on relatively inexpensive and portable hardware, it can be extended beyond one location, building, department, or campus without significant changes to the existing infrastructure. Thus, the system can be installed by small companies, large corporations, and educational institutions.Another important implication of the system is smart space utilization. Many institutions face inefficient utilization of their infrastructure because of poor information on seat utilization and occupancy patterns. Some rooms and seat locations may be overcrowded, whereas others are not occupied enough. However, the proposed system gathers occupancy data continuously, allowing users to analyze occupancy patterns in the future. This data can help administrators optimize seating arrangements and manage institutional assets better.Aside from these functional and organizational advantages, the IoT-Based Seat Occupancy Monitoring System will also be beneficial to the process of digitalization within organizations and institutions. With the rise of smart offices and campuses, there is a growing demand for intelligent and advanced infrastructures. In this respect, the use of automation and other digital technologies will help organizations and institutions achieve efficient operations, communications, and data management within daily operations. With real-time seat occupancy data and remote monitoring capabilities, the system will enable organizations to shift to data management and smart infrastructure construction. The adaptability, ease of maintenance, and ability to integrate with future technologies will allow this system to serve as a valuable tool for future organizations and institutions.In addition, the insights gained from occupancy analytics through the system are helpful when it comes to long-term strategic planning. In other words, by analyzing the occupancy data, one may determine such things as the peak times for using various facilities, seat usage changes during different seasons, among other things. These data could be used to make relevant decisions concerning infrastructure development, including expansion or renovation of certain areas.

An IoT-based system for tracking occupancy and detecting people's presence in a particular workplace proves to be a handy solution since it makes office automation possible as well as saves time in many ways. It is quite a simple but effective combination of components which consist of ESP32, a refrigerator door, andsending notifications to Telegram. The system will not only save money since it works effectively while using cheap components, but it will also give a huge benefit to organizations or institutions. The latter will have the ability to determine whether the most significant and important members of staff are present on their workplaces, as well as will improve coordination and accountability within the institution.

IV. RESULTS

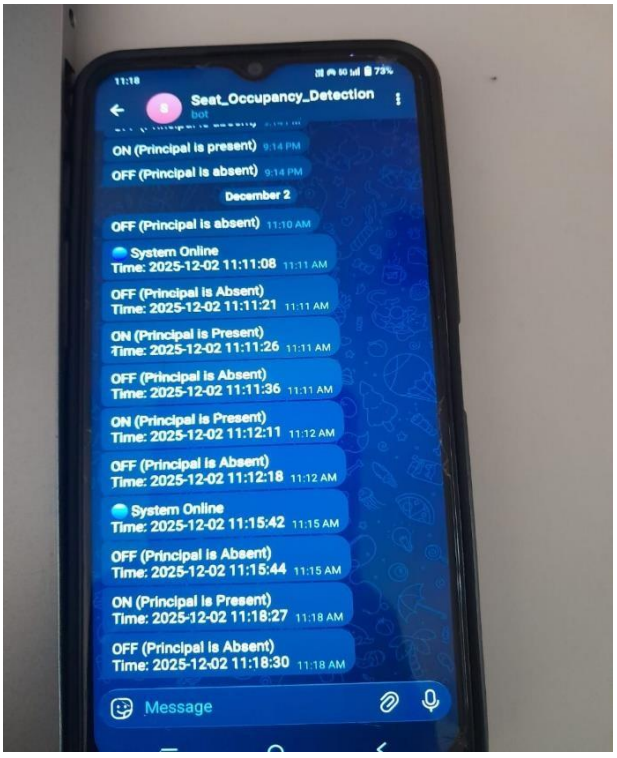

Fig.2 Results of seat occupancy detection

The designed IoT-based seat occupancy monitoring system was successfully deployed and tested using an ESP32 microcontroller, a refrigerator door switch sensor, and Telegram cloud-based messaging services. The system could efficiently monitor any changes in seat occupancy status and instantly notify about it every time there was a change in the seat occupancy status.While deploying the system, the refrigerator door switch sensor was attached to the chair in a way that could accurately detect whether the chair is occupied by a user or not. In case the chair was occupied by a person, the sensor was triggered, and an alert was generated for the ESP32 microcontroller. This information was instantly sent through the Telegram app using Wi-Fi communication services.

Another significant outcome of the system that can be noted from the test results is its ability to respond in real-time. After the changes in occupancy were detected, notifications were sent within a matter of seconds. There was hardly any time lag between detecting the change in occupancy status and sending out a notification, which shows that the ESP32 wireless communication module worked effectively and efficiently in conjunction with Telegram. Implementation proved that the switch sensor in the refrigerator door was an efficient device for the determination of the occupancy status of the room owing to its simplicity. Whenever pressure was exerted or withdrawn from the chair, the switch sensor responded to the change appropriately. The sensor produced occupancy statuses consistently, enabling the ESP32 microcontroller to distinguish between occupied and unoccupied statuses efficiently. In the experimental test, the switch sensor successfully detected the occupancy of the chair by the user and then detected when the user left the chair. As soon as the person sat on the chair, the ESP32 processed the information and instantly sent a message through the Telegram app that read "ON (Principal is Present)." In the same way, after the person left the chair, the system sent out a message that read "OFF (Principal is Absent)."

The occupancy monitoring logs provided by the system were another example of how useful this solution is not only for tracking but also for analytical purposes and even infrastructure planning. Based on the occupancy data, the administration will be able to pinpoint times of high usage, areas of high occupancy, and poorly used spaces. The developed Internet of Things-based seat occupancy monitoring system was successfully developed and tested using an ESP32 microcontroller, the refrigerator door switch sensor, wireless network, and Telegram cloud messaging. The prototype proved to be capable of detecting seat occupancy and transmitting occupancy information wirelessly to the relevant authorities promptly and reliably. In terms of performance, power usage, reliability, and hardware design, the developed prototype system is viable enough to be applied in practice for office and university environments.When it comes to hardware components, there was the ESP32 development board with the addition of the door switch sensor installed on the refrigerator. Door switch sensor served as the occupant detection sensor. Every time the occupancy status had been changed, the ESP32 development board registered that change and interpreted it accordingly as the occupancy status. Then, through the Wi-Fi connection, the occupancy status was delivered to the Telegram application through cloud messaging.

The findings of the implementation process revealed that the door switch occupancy sensor was highly efficient in detecting occupancy events even though it had a simple configuration. The switch was able to trigger any time pressure was put on or off the chair. It produced a reliable signal that assisted the ESP32 in detecting occupancy and vacancy events efficiently. The use of a simple switch helped reduce the complexity of the system. The ESP32 was capable of handling real-time sensor operations and wireless communication simultaneously. The ESP32 had an in-built Wi-Fi functionality that made it possible to establish internet connection without using any other communication devices. The ESP32 communicated consistently with the Telegram server during the testing phase, and it sent notifications at very low latency levels.It was found that the system can deliver instant response to the user with no delays from the moment when the occupancy is detected until the message is transmitted. Testing indicated constant wireless communication between the ESP32 and the Telegram platform via Wi-Fi connections. The system could consistently monitor the occupancy state without any interruptions, thus becoming ready for prolonged use in office or campus settings.

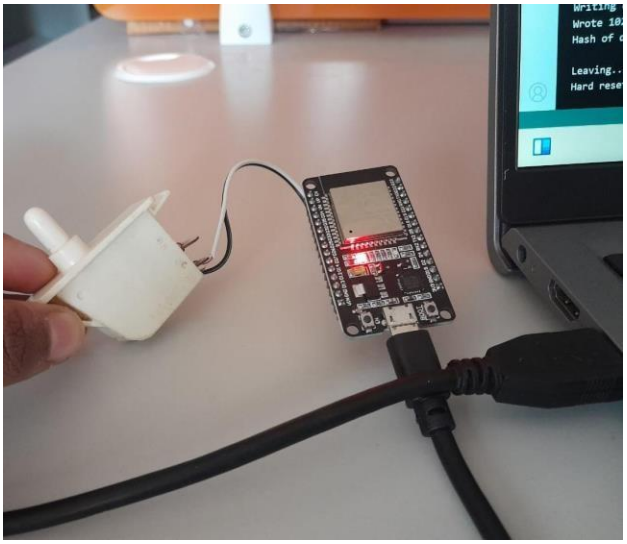

Fig.3 Hardware Setup of the project

Notification logs produced through Telegram also worked as a basic tool for tracking attendance. It would be easy to track the presence of certain people like principals, teachers, or staff in particular places.In conclusion, the entire performance assessment revealed that the IoT-based seat occupancy monitoring system has accomplished all the intended goals of automation, real-time notifications, and intelligent monitoring. This system has shown consistent hardware functionality, effective wireless communications, efficient notification services, and scalability for real-world application.

In summary, the findings of the experiment have confirmed that the proposed system is indeed feasible, cost-effective, and efficient as a solution to the problem of occupancy monitoring in smart office spaces and learning environments. Combining embedded systems, wireless communication, IoT, and cloud messaging technologies makes it possible to create an intelligent infrastructure management system that enhances efficiency, improves convenience, promotes sustainability, and facilitates better administration decisions.

V. CONCLUSION

The IoT-Based Seat Occupancy Monitoring System that is described in this study has offered a feasible, efficient, and intelligent approach for managing offices and campuses today. The proposed project clearly shows how embedded systems, wireless communication, cloud-based messaging services, and IoT technologies could be combined to automate seat occupancy monitoring processes. The use of inexpensive hardware components including ESP32 microcontroller and refrigerator door switch sensors has enabled the designed system to accurately detect seat occupancy conditions at affordable costs and with easy implementation.From the performance results, it was clear that the operation was accurate and consistent. Specifically, the refrigerator door switch detector was able to detect the occupation and absence of occupants, while the ESP32 processor was able to process the information from the sensors and transmit information about the status of occupation through wireless connection to a Telegram app without delays. This means that it was possible for the administrators to keep track of occupant statuses without having to be physically present within the institution.

The proposed system also supports sustainability and energy conservation initiatives. In many offices and educational institutions, electrical appliances such as lights, fans, and air-conditioning systems continue operating even when spaces are unoccupied, leading to unnecessary energy consumption. By integrating occupancy monitoring with smart energy management systems, electrical devices can automatically operate according to occupancy conditions. This reduces energy wastage, lowers electricity costs, and promotes environmentally sustainable infrastructure management practices.Another important advantage of the proposed system is its privacy-friendly design. Unlike camera-based occupancy monitoring systems that require image processing and video surveillance, the proposed solution uses a simple switch sensor to detect occupancy without collecting personal visual information. This protects user privacy while still providing reliable occupancy monitoring functionality. Additionally, the use of low-cost sensors and embedded hardware reduces system complexity and implementation cost, making the solution practical even for institutions with limited budgets.

The scalability and adaptability of the technology enhance its applicability even further. A number of occupancy monitoring units can be easily placed inside classrooms, laboratories, lecture halls, libraries, office cabinetry, or shared spaces without altering any significant infrastructure. Since the ESP32 has a wireless capability, monitoring can be done centrally via the cloud and mobile app. Therefore, the technology is applicable for usage in small offices and large learning institutions as well.

Additionally, this system helps enhance safety and security management. Occupancy data obtained in real time will help monitor crowd densities, know where people are located when an emergency arises, and regulate occupancy in shared spaces. These features are particularly useful during evacuation situations, restricted access, or health-related safety management processes. Hence, this system is not only efficient but safe too.

From a technological perspective, the project demonstrates the practical application of IoT technology in solving real-world administrative and infrastructure management problems. The integration of sensors, wireless communication, cloud-based messaging, and embedded systems creates a smart and connected monitoring environment capable of improving automation and decision-making. The project highlights the growing importance of IoT in smart campuses, smart offices, and intelligent infrastructure development. The modular architecture of the proposed system also creates opportunities for future enhancements and technological integration. Future developments may include RFID-based identification systems, biometric authentication, AI-based occupancy analytics, mobile application interfaces, cloud dashboards, and machine learning algorithms for predictive occupancy analysis. These enhancements can further improve automation, security, personalization, and intelligent decision-making capabilities.AI and predictive analytics can also be integrated into future iterations of the system to predict trends in occupancy levels and seat distribution optimization as well as maximize infrastructure usage through occupancy-based analyses of past data. The mobile application would serve as an interface for providing users with up-to-date seat availability information, while the cloud dashboard will help create comprehensive graphical reports and performance analysis tools for managers. Automatic control of lightening, air conditioning, and other security-related systems in response to occupancy levels is also possible through smart-building integration.

Ease of implementation as well as low cost make the system very accessible for use by educational institutions, corporates, libraries, hospitals, co-working places, and other organizations. Thanks to the relatively compact, energy-efficient, and cheap nature of the hardware required, the system can be easily scaled to operate in any number of classrooms. In summary, the IoT-Based Seat Occupancy Monitoring System has been able to achieve its objective of developing a system that is effective, affordable, and intelligent enough for monitoring seat occupancy in offices and education institutions. The system not only promotes efficient administration but also resource management and sustainability, among other benefits such as cost savings and user convenience. This project exemplifies how IoT technologies can be used to convert conventional administrative systems to smart administrative platforms. Through intelligent seat occupancy detection and automatic notification systems, the developed platform is a step towards building future smart infrastructure that will be adaptable in various situations. Successful deployment and testing of the system prove that it is an efficient and practical system for occupancy management and building intelligent infrastructure.

In summary, the IoT-Based Seat Occupancy Monitoring System is a substantial development in the domain of smart office and campus management. With its features of cost-effectiveness, scalability, automation, instant communication, and intelligence in monitoring, it is an effective tool that can help to boost performance and optimize infrastructure use in the present-day organizations. This system not only solves current occupancy management problems but also paves the way for future developments.

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