

DESIGN AND IMPLEMENTATION OF IOT BASED HOTEL ROOMS OCCUPANCY REPORTING SYSTEM

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Abstract Advances in technology applications are becoming more visible in everyday activities as the globe becomes more technologically skilled and evolved. Being able to receive and execute control is critical in the age of Internet of Things technology and control. This pattern eventually led to the development of an Internet of Things (IoT) system for reporting room occupancy as a promising technique or system for determining the availability of rooms and buildings. This method lowers human mistake, mismanagement, and energy use, all of which directly translate to decrease hotel running costs, possibly to zero. As a result, it is conceivable that the number of guests staying in Nigerian hotels has risen significantly. If this is the case, good management will most certainly result in an immense rise in profits. However, sharp practices among hotel employees tend to divert the profit met for the owners, thus this project is designed to automatically report hotel occupancy easily accessible to owners. An infrared detection circuit was used detect human movement and a lithium-ion battery that supplied 3.7 volts was used as the power supply for the circuit while a GPRS module (a SIM 800L GSM module) was utilized to receive and transmit data messages via radio waves, and an LGT8F328P microcontroller controlled every other component in the circuit. An android application was developed and installed on a mobile phone to gather all of the real-time readings and events that take place throughout the project's system. The programming of the microcontroller was done using the Arduino Integrated Development Environment (IDE) software and C++ programming language. When the project was turned on, I saw that all of the LEDs turned on automatically. The first two LEDs (brown and green) were automatically turned on, as were the corresponding room LEDs. After that, the green LED turned off. When the infrared LEDs' visibility is obscured, their input to the phototransistors in each room and the LEDs attached to each room automatically turn on, indicating that the rooms are occupied and vice versa. The various room compartments' check-ins and check-outs are tracked, managed, and updated using the proposed hardware. The data is then transmitted to the IoT cloud and eventually to the Android application

Keywords: IOT, Infrared, GSM Technology, Module

I. Introduction

The room occupancy status is mostly dependent on traditional documentation methods in developing nations like Nigeria. The ability to monitor and manage the respective room occupancies from any location via the internet

is essential in the current era of Internet of Things (IoT) technology and control. This pattern subsequently led to the implementation of IoT systems for reporting room occupancies as a potentially useful method or system for determining the availability of buildings and rooms, thereby lowering the risk of human error, embezzlement, or mismanagement.

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lowering labour costs and energy consumption, both of which directly translate into lower hotel operating expenses and possibly even the elimination of building expenses. In [1], an IOT-based technology for reporting room occupancy status was designed and implemented. Hospitality service firms are investing heavily in IT to modernize their technology infrastructure. Hotels in the midscale category (7.3%), upscale hotels (6.1%), and luxury hotels (5.6%) had the highest IT spending. The majority of the cash will be utilized to digitize the platform, benefiting both service providers and guests. The Internet of Things and smart devices are driving technological breakthroughs in the hospitality service sector. Guest-facing technologies are supporting the transition of guest interactions to on-screen and online interfaces, which is convenient for visitors while also providing an opportunity for service providers. Guest-facing systems allow service providers to collect important data and feedback while also making it more convenient for guests. As a result, visitor interactions are transitioning to on-screen and web interfaces [2]. Hospitality service companies have used back-of-house management systems to digitalize their operations, which has increased managerial performance, revenue growth, sustainability, and cost of products sold [3]. Guest-facing systems are the primary communication interfaces between guests and a digitalized hospitality service platform. Passengers must be able to manage their trip experiences using these systems' simple user interfaces. Internet-based back-of-house management systems offer the potential to boost revenue per available room by speeding up housekeeping and maintenance operations [4]. Hotel internet management systems could improve housekeeping service

scheduling by integrating in-room technologies and guest preference profiles. The scheduling might significantly improve guest satisfaction, optimize worker resource utilization, and successfully reduce hotel room downtime. Employers could save 10% to 20% on payroll expenditures by deploying housekeeping management systems and software [3]. Additionally, these management systems may help with the maintenance of smart systems on-site and in rooms. These systems might aid in the almost instantaneous discovery of flaws and failures, enabling timely maintenance. The significance of the Internet to the hotel industry was covered in [5]. [6] explored how the hospitality management industry's future is being shaped by advancements in Internet of Things (IoT) technology. Modern technologies in the hospitality sector were examined by [7], which also demonstrated how enhancing guest experiences and hospitality service platforms can improve the sector as a whole. It also highlighted some of the difficulties faced by employees and visitors alike in the hospitality sector. In order to provide localized information and services, security and privacy, among other things, it suggested using body area sensors along with a few other technologies. According to the authors, IoT technologies can significantly enhance the hospitality sector by introducing services like body area sensors, building automation and monitoring systems, and energy management.

Smart hospitality systems were focus in [8]. The study covered the use of cloud computing and internet of things (IoT) systems to enable business partners in the hospitality sector to connect and operate smartly. It suggested integrating a smart ecosystem by utilizing internet technologies to produce data, analyze system revenues, and integrate sensors and

content extractors for the hospitality ecosystem. IoT technologies were designed and put into practice as a safety enhancement system in the research paper [9]. The goal of the paper was to help older adults when they needed assistance using the bathroom system by enhancing bathroom safety through the use of IoT. [10] The relevance of IoT technology in the hospitality sector, as well as various ways in which it can continue to develop new smart building solutions through its affordable installation and operation, were covered in the discussion of how IoT fosters innovation in the sector. It also included examples of how IoT has made life easier for people, like smart building integrations with education and health care systems. The benefits of integrating IoT technologies into room systems were eventually highlighted in the paper. These consist of heightened security and safety with smart rooms, enhanced guest comfort and convenience, and better hotel maintenance procedures. Additionally, some disadvantages of IoT-based smart systems were highlighted. These include a heavy reliance on reliable power sources and a robust internet connection via Wi-Fi. The research paper of [11] applied the use of IoT technology and embedded system technologies for Hotel room management systems. Its main focus was to tackle the issues on reservation and funds accountability by using the technology of IoT & embedded systems to generate accurate reports pertaining to the respective rooms occupancy (that is, reservation) and funds transparency. The system architecture consisted of AT mega 328p Microcontroller, ESP8 Wi-Fi-module, ES-130B Keyless door lock, and MPR121 Keypad. This system was designed wirelessly to communicate with the room doors in order to generate the room status. The authors advised that for future

advancement, there should be incorporation of embedded sensors to the objects such as doors, panels, so as to get more accurate inputs for the respective rooms.

[12] investigated an Internet-based wireless home automation system for multifunctional devices. Instead of utilizing conventional switching techniques, the authors suggested a framework for a communication protocol that functions amongst various devices in a home automation system. A single modeling language (UML) was used to model the connections to the system and the links among the different nodes (i.e., the user interface, the database, and the web-based connections). In the hardware system architecture, RF wireless technologies were combined with the PIC16F877 microcontroller. The hardware system design made use of an RF wireless PIC16F877 microcontroller to deliver a signal via a MAX232 serial port to the web server. The technology, however, was only shown to regulate light switching in a domestic context. On the basis of a 3D virtual environment, an approachable HAS was proposed [13]. The paper proposed creating a realistic 3D view interface as an improvement over the existing one. Devices in the home were also controlled by a home server. Using this 3D virtual world, a user can control and keep an eye on household devices with an easy-to-use interface that functions realistically and intuitively anywhere, anytime, over the Internet. The expensive price and lack of internet connectivity are the system's drawbacks. In the research paper [14], the steps taken to design and construct a low-cost modular monitoring system prototype for hospitalized patients through the use of IOT were detailed. In order to facilitate quicker and more effective medical interventions in emergency situations, this system was designed

using low-power specialized sensor arrays for movement, SpO₂, temperature, and EKG. Interfaces for these sensors were designed using the Internet of Things architecture: a central control unit exposes a Web interface based on Restful, which guarantees platform agnostic behavior and offers an adaptable method for incorporating additional components. The research in [15] suggested a comprehensive conceptual approach to the creation and implementation of an Internet-of-Things (IoT) system. The plan was to use a sizable long-term care facility as a test bed for the concept. The authors proposed the following: a big data analysis system model, the design of an Internet of Things implementation, the selection and application of sensors, and the integration of a wireless sensor local network system. A sensor study found that while off-the-shelf sensors were available for IoT applications, many of them required software configuration and hardware modification to integrate into small range network systems. Numerous hubs and gateways of varying degrees and types could be used to connect small-range wireless sensor network protocols to larger network systems, such as the Internet. The study produced a big data system design concept and a pilot test. Large-scale big data based on information gathered from sensors that detect bathroom activity was also analyzed and tested using a variety of software programs and open-source platforms. An IOT application was used to conduct a test in a toilet prior to implementation. Emphasizing the exciting potentials of ambient technology in the hotel industry to enhance service quality and offer distinctive travel experiences was the main objective of the research work in [16]. In order to achieve this, the researcher proposed an intelligent hotel room that integrates a range of

technologically advanced artifacts, gadgets, and software agents to create an ambient ecosystem that constantly monitors its environment and modifies its behavior to offer "intelligent" and customized services to its visitors. A fully equipped simulation laboratory was used to test the intelligent hotel room. It was also mentioned that a second type of test, utilizing a pilot in-vivo installation at a hotel, was conducted a few months after the project was designed to guarantee the final implementation. A comprehensive user-based study was conducted using the pivot in-vito. In order to assess the effectiveness of the reasoning technique and ascertain how visitors use the system in actual situations, the test evaluation involved dozens of visitors with varying ages and technological backgrounds who were duly observed engaging in routine daily activities. The evaluation's findings was applied to improve the usability of the different applications and broaden the current set of rules. IOT system research for application architecture was the main focus in [17], a home automation system consisting of a smart phone, wireless communication, cloud networking, and an embedded system was presented in [20]. It enabled users to monitor and control a variety of lighting and home appliances from a distance. An app on a smartphone served as this system's user interface. ATmega328 IC was in charge of a number of the systems that the smart home system in the research study used. The design was centered on how an Android phone and a home automation app interacted. It was mentioned that the ATmega328 IC, which would power additional embedded devices and sensors, could receive signals from the Android phone and use them to communicate with the user. With the help of a mobile application, the Arduino acts as a

command center for the household appliances, receiving commands from the Internet. An Android-compatible smartphone or the internet could be used to manage and monitor home sensors thanks to the Internet-based home server in the suggested system, which processed orders from the client using Arduino.

II. Materials and Methods

A. IoT technology standards

This section covers the comparison of the most commonly used standards and protocols. It also examines the differences between open source and broadly specified standards. In today's world, industries have developed a plethora of

standards and procedures [21]. The Internet of Things (IoT) is a communication platform for microcontroller-based devices that are small and light. Each business and organization has its own approach to bringing IoT-based solutions to market. Some organizations utilize ZigBee-based routers to interact with their in-house-made devices, while others use Wi-Fi as their primary wireless network, and Bluetooth is also extensively used in IoT network design. The standardization is based on contemporary times, with Wi-Fi, ZigBee, and GSM modules being used to create a dedicated small network of Internet of Things as indicated in Table 1.

Table 1: Technology protocol comparisons

	WI-FI	ZIGBEE	GSM Module (800L)
Technology	To send data, it will need to use a router with a longer range.	It's designed to transport a little amount of data over a short distance.	Wireless technology used to transfer data over long distances so far it has access to internet network
Networking Type	Centralized Hub networking	Mesh networking standard	GSM/GPRS Module networking
Power Consumption	High	Low	Somewhat low
Speed	Up to 5Gbps	250Kbps	270.833 kbs
Cost	Relatively High	Somewhat High	Cheaper
Data transfer type	Live stream music and videos, images, downloads and message texts.	Similar to WI-FI	Live stream music, web browsing, downloads images, etc.
Implementation	Implementation also Technical	Highly technical for general users to understand and implement the technology.	Somewhat simpler than the Zigbee and WI-FI.
Availability	Readily available	Somewhat scarce	Readily available

B. Working principle of door lock systems

This work reviews the door lock system since it is a crucial step in determining the status of the room's occupancy. A mechanism to count and detect the number of movements within the rooms where it is installed will be developed, and PIR sensors will be attached to each room door. In the past, there existed specialized systems that allowed for the identification and confirmation of a visitor's room occupancy status, mainly through direct communication with the appropriate residential premises [22]. Using a hands-free phone to call the set is made possible by the architecture of the entrance. The gate, which was operated by phone, allowed visitors entry into the interior. In order to identify visitors, the most recent system [23] relied on video door phone inspection. This project involved the creation of a digital network video door phone using a novel power line communication chip. Additionally, they improved aisle safety and broadcast audiovisual data. The first security measure was the lock and key system. In this system, the security protocol was "single key for a single lock." This method was initially believed to provide the highest level of security. But this assumption was soon refuted by the fact that multiple keys could be made for a single lock [24]. Vehicles follow similar patterns; early modern vehicles used non-electronic keys to limit access to the open and start positions. The car owner is allowed to start and operate the vehicle by turning the key if it matches. Key duplication is a simple way to compromise this kind of security measure, despite the fact that it offers some protection against theft [25]. The limitations mentioned above necessitate the use of an intelligent lock system. We are interested in a small portion of the universe called a system [26], in this case a lock. One of the most

crucial traits of a truly intelligent system is learning, or the capacity to enhance one's own functionality through interaction and exploration of the environment [27]. According to [27], a typical intelligent lock system should have the following features: provides a system for managing, controlling, and monitoring the environment. stops unauthorized entry. permits door opening via a web interface, a keypad, or a proximity card. There are sensors to keep an eye on things like temperature, humidity, smoke, and the presence of liquids or water. RFID technology was employed in [28] research to develop a digital door lock security system. After receiving the tag information, the reader submits it to the database for validation. The data is stored for later use if it is accurate. The central server queries the database and retrieves the required data after receiving the reader's query. The reader creates a log and computes the timestamp (date and time) after receiving the response from the server. The system instructs the stepper motor to open and close the door by sending a control signal to the parallel port after the tag information has been verified. The system's creation of a log, which includes user data but lacks alerting and notification features, is another crucial security feature. To make the system better, security features like a buzzer and a GSM module can be added. The research project in [29] created a digital code lock system with a status display using GSM and wireless communications technology. RF modules and a digital keyboard with a controller interface are used to achieve wireless communication. Using an LCD module to display the system's status and GSM technology to send an acknowledgement to the user, the user will be able to lock or unlock the system with a password. It is a very safe system that can be utilized for home security;

nevertheless, neither the system nor the controller's programme have a code generation process or a notification mechanism. The research in [30] produced a lock system that activates on its own when the driver gets out of the vehicle. It requires a specific motion with the hand-held wireless key fob in order to be disarmed. The 3D gesture can be reprogrammed at any moment and is executed in midair. The gravitational force generated by the air gesture is detected and identified by a 3-axis MEMS accelerometer. Therefore, without performing the coded motion, a stolen key fob cannot be used to unlock the car. An external memory that is nonvolatile holds the password. The key fob transmits a unique encrypted code that varies every time the motion is made to determine if the gesture is valid. An external memory that is nonvolatile holds the password. The key fob transmits a unique encrypted code that varies every time the motion is made to determine if the gesture is valid. While it's a clever approach to car security, it doesn't have an alarm system or other warning mechanisms like SMS. Security features like notification systems and face recognition software should be implemented gradually to increase security dependability.

C. Design analysis

This includes the many phases involved, as well as the description and purpose of each component that makes up each stage, design calculations for component selection in each stage, circuit diagrams and various sections, and components assembly.

The design analysis of this project includes the usage of an energy supply source, in this instance a lithium-ion battery. It provides 3.7 volts to the rest of the circuit's components. The infrared light emitted by the human body is detected by the room occupancy, which in this project uses three HC-SR501PIR motion sensors. All of the actions in the system's architecture are connected, coordinated and controlled by the LGT8F328P microprocessor. The Internet of Things (IOT) device (Thing Speak Cloud) connects the complete system to an internet network via the GSM module EDGE network and transfers data from the entire system to the IOT cloud. This system can be subdivided into four major units as follows: GSM Module; Microcontroller unit (LGT8F328P); Power supply; PIR Sensors and IOT Application Software.

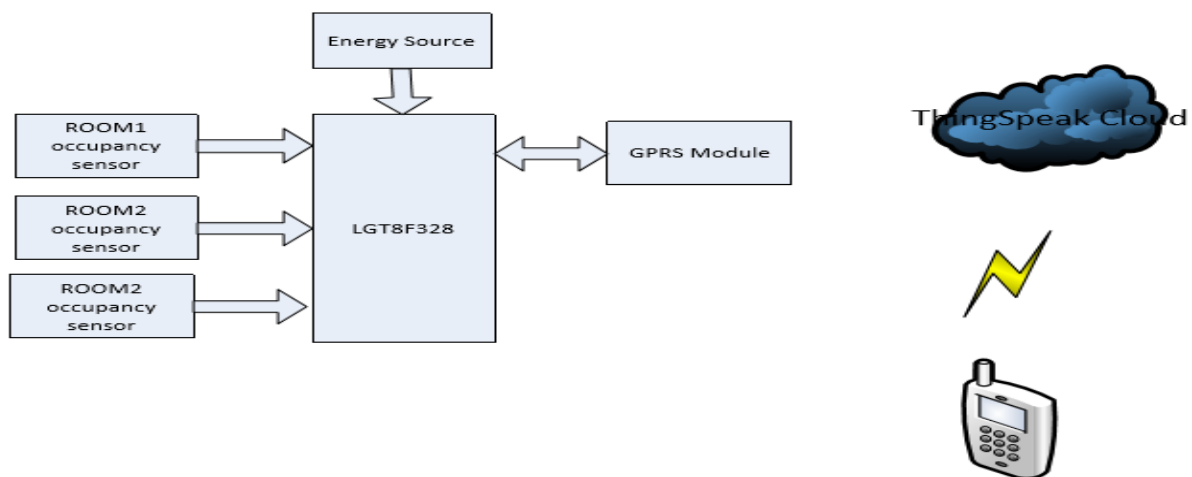


Figure 1: Block diagram of the DTMF Based Home Automation using GSM module

D. System design operation

Each room's PIR sensor detects the infrared light radiated by a warm object. The sensor will be installed on the hotel room ceiling, where it will be able to detect the presence of human objects. The PIR sensor sends a signal to the microcontroller each time it detects a human body. The human body detection algorithm in this project is as follows: We considered that if motion is sensed twice in 5 minutes, the system marks the room for that 5-minute period. We consider 12 samples per hour ($60 \text{ minutes} \times 12 = 5 \text{ minutes}$) for cloud storage purposes. So, for the data transmission to the cloud, we need 12 bits to store data per hour; the maximum data per hour is $2^{12} = 4096$. Thereafter, the GSM module picks up the data from the microcontroller and sends it using its EDGE

microcontroller and sends it using its EDGE network to the IOT (think Speak Cloud). For the user to have access to the information (which in this project is depicted using a bar chart), they will need to log on to the authorized Android application. The Android application serves as the tracking system, whose status agrees with the aim and objectives for designing this project.

NOTE:

The maximum data value in decimal per room is 4096. The data sending format for the proposed 3-room hotel is "hr#ROOM1value#ROOM2value#ROOMvalue" where hr is the representing hour. The room status occupancy is analyzed at a 5-minute interval, and it denotes "0" to show no room occupancy and "1" to show room occupancy.

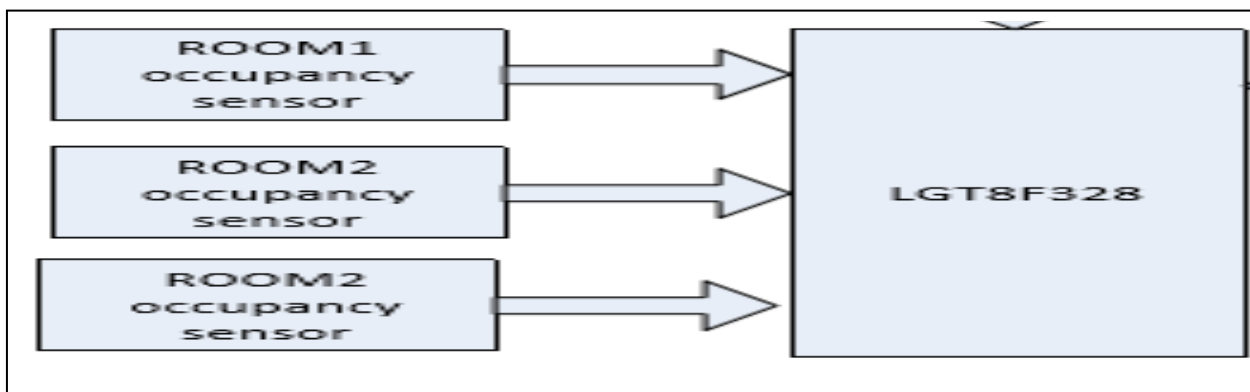


Figure 2: The block diagram of the IR Detector connection as regards to the project

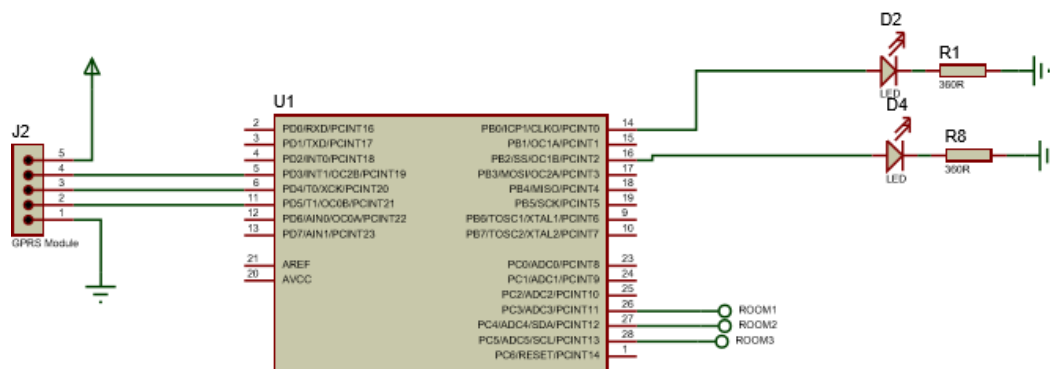


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III. Results and Discussion

The system design was implemented using C programming languages and the Arduino IDE software. The circuit schematics were created using Proteus software. When the project was turned on, I saw that all of the LEDs turned on automatically. The first two LEDs (brown and green) were automatically turned on, as were the corresponding room LEDs. After that, the green LED turned off. When the infrared LEDs' visibility is obscured, their input to the phototransistors in each room and the LEDs attached to each room automatically turn on, indicating that the rooms are occupied. While the infrared signal to the phototransistor of each separate room was occluded, the green-colored LED blinked. This blinking indicates that a message has been transmitted to the microcontroller, which will then send an input to the GSM module. The GSM module's output will be transferred to the cloud and viewed via the registered app. Also, when I lifted my hands away from obstructing the infrared signals, the green-colored LEDs in the various rooms were triggered, and then the LEDs in each room switched off promptly. The infrared LED and phototransistor send a signal to the LGT8F328P microcontroller whenever it detects a movement of the human body.

A. Results from human body detection algorithm during the project testing

It assumed that if motion is detected twice in 5 minutes, the system will mark the room for that time period. It use 12 samples every hour (60 minutes $\times$ 12 = 5 minutes) for cloud storage. So, for data transmission to the cloud, we require 12 bits to store data per hour, with a maximum of $2^{12} = 4096$. The binary ticker values are 1 (ON) and 0 (OFF). Table 2 shows the relevant data from the project testing at 4:00 AM.

The maximum data value in decimal per room is 4096. The data sending format for the proposed

3 room hotel is
 “hr#ROOM1value#ROOM2value#ROOMvalue” where hr is the representing hour. For example, at 4:00AM. The ROOM 1 is occupied for 45mins in an hour, ROOM2 is occupied for 10mins in an hour and, ROOM3 is occupied for 42mins in an hour.

Then we have: “02#4096#0031#0063”. This is data to be sent to the cloud via GPRS module. The result analysis of this project arose from the values and observations gotten during the testing operations carried out on this project. The image below is adapted from the graphical analysis and representation of the project on its Registered Android App.

B. Risk Management

This is the process of identifying, creating, and implementing a plan to reduce the risks associated with project designs. This project's risk management strategy focuses on identifying and managing activities and events that could have a negative impact on the project's design and implementation. The first issue (or risk) was that I wasn't initially able to design the project utilizing the Proteus and Arduino IDE software platforms due to the complexity of the project's design. Also, due to a lack of understanding of the components, their qualities, and their connections, it was difficult to carry out the connection successfully, which thereby caused a delay in the project's construction. This was also addressed with the help of some embedded system engineers. Anyone with access to the registered app could access the data and even forge the data on the room occupancy status. This is also a risk associated with this project. Also, another risk is that if an object falls within the range of the infrared LED, the phototransistor will automatically assume the compartment has been occupied.

Table 2: Data from project testing

Hour	60 minutes			45 minutes			30 minutes			15 minutes		
Tick Per 5 Minutes in Binary	1	1	1	1	0	1	1	1	0	1	1	1
Tick Per 15 Minutes in Decimal	15			10			10			15		
Decimal value for total complete per Hour (2 ¹² in base 10)	4096											
Comment (ROOM 1)	The room is occupied for 45 minutes											
Hour	60 minutes			45 minutes			30 minutes			15 minutes		
Tick Per 5 Minutes in Binary	0	0	0	0	0	0	1	0	0	0	1	0
Tick Per 15 Minutes in Decimal	0			0			5			5		
Decimal value for total complete per Hour (2 ¹² in base 10)	4096											
Comment (ROOM 2)	The room is occupied for only 10mins in that hour											
Hour	60 minutes			45 minutes			30 minutes			15 minutes		
Tick Per 5 Minutes in Binary	1	1	0	1	1	1	0	1	1	1	0	0
Tick Per 15 Minutes in Decimal	10			15			15			5		
Decimal value for total complete per an Hour (2 ¹² in base 10)	4096											
Comment (ROOM 3)	The room is occupied for only total 42mins in that hour											

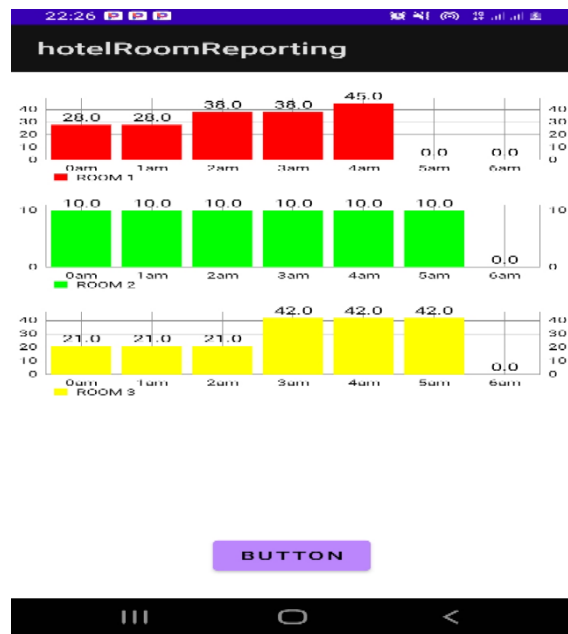


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Figure 5: The project's internal design during testing.

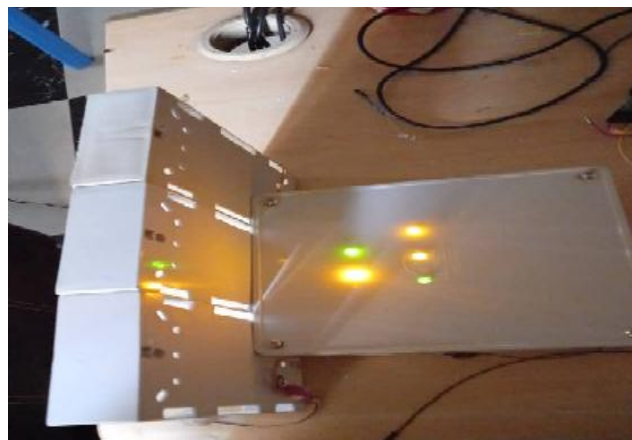


Figure 6: The project's complete design after testing

IV. Conclusion

The goal of this project was to improve the information gathered through an evaluation of other connected project works via literature surveys and then advance on the drawbacks of some of the connected works. The project was effective in achieving its aim and objectives during its rigorous, extensive testing. The project's simplicity of the control circuit made it more reliable and somewhat easy to build. The project also shows the intrinsic importance of IOT technology and how it can help process data as quickly as possible. The project proves to be inclined wireless control inclined by using the platform for reporting room occupancy status for the respective hotel rooms via the use of its registered Android application on smart mobile devices. The project proves to remotely track and report the check-ins and check-outs of rooms from any part of the world via the internet and the Android application that controls the system. The project proves to permit occupancy attendance and reports to be permanently stored on the cloud for easy access,

with minimal use of conventional paper for recording. The project permits the managers to use the registered phone app to track the room occupancy status at a 5-minute interval instead of using the conventional room-knocking or key card's manual verification process. The system is implemented practically, and the expected results are obtained.

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