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Short Paper

Development of a Centralized Controlling System with Real-time Monitoring: Internet of Things, CCTV, Public Address, and FDAS: 4-Systems in One Dashboard System using Raspberry Pi

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Abstract

Purpose – The main purpose of this study is to develop an innovative approach for real-time control and monitoring of the facilities of an institution and it aims to minimize further casualties in case of untoward incidents and minimize the electrical cost.

Method – The study utilized descriptive methods by identifying the currently installed systems through observation, interviews, and surveys. The report proposed a novel strategy for centralized control and real-time monitoring for the institution using the developmental research approach.

Results – The study aimed to modernize a management system of facilities in an institution. The focus was to integrate all four (4) different systems into one dashboard. Findings showed the effectiveness of this innovative system, particularly at controlling and real-time monitoring using the Internet of Things, CCTV, Public address system, and FDAS; receiving a Highly Efficient rating and easy to manage compared to the traditional separate systems.

Conclusion – This research was able to create a working prototype that can control and monitor the facilities. This has achieved great and promising results in terms of usability gaining the highest rating.

Recommendations – Though it has a Highly Efficient rating, maintenance is still recommended to ensure the successful implementation of this innovation. Future research may be performed to consider other aspects of the management system and/or different study locations, as the aforementioned system is new and still unknown in other areas.

Research Implications – Looking at the great significance of this system, this explicit focus can be manifested in how the administration should have a chance to upgrade the traditional system into this one dashboard that covers other systems.

Practical Implications – The latest trend in any workforce is the implementation of system innovations. Innovative systems facilitate commerce by organizing tasks, manageable environments, and systematizing procedures.

Keywords – IoT, CCTV, PA system, FDAS, centralized control, monitoring system, Raspberry Pi

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INTRODUCTION

The Internet of Things revolutionized the home automation mechanism and security system as it can control home appliances automatically based on climatic and security conditions available in the room. This mechanism helps the owner in case a burglar enters the house by sending a message that informs them to protect their home from burglars. The system also helps old people by controlling home appliances automatically as they do not need to go to the switchboard to turn the appliances ON or OFF (Reddy et al., 2019). IoT uses smart devices and the internet to provide innovative solutions to various challenges and issues related to various business, governmental, and public/private industries across the world. IoT is progressively becoming an important aspect of our lives that can be sensed everywhere around us (Kumar et al., 2019).

Historically, many lighting control systems used proprietary protocols. This might have protected the lighting systems market within client buildings, but it presented barriers to integration with other building systems that were not supplied by the lighting vendor. The IT world in general is moving towards open protocols, or at least open access to facilitate integration between hardware and control platforms from multiple vendors. The most straightforward way to enable integration is by defining open application programming interfaces (APIs) (Pandharipande & Newsham, 2018).

Despite evidence of increasingly widespread use of IT in monitoring initiatives around the world, there is less protocol available for policymakers and donor staff specifically targeted at countries considering using IT to encounter monitoring-related Development Goals. The system provides solutions to the problems encountered in power and safety management.

On the other hand, the advancement of science and technology has vastly contributed to the growth of computers and the internet which has immensely increased the use and need of a centralized monitoring and real-time control system. Schools, companies, organizations, and enterprises are seeking better ways to safeguard facilities and amenities. To achieve this, they develop and rely on online applications, which help them monitor, control, process, and disseminate information. This targeted managing and controlling facilities to be convenient and more efficient. It looks at improving the present traditional system of having separate systems, which are manually controlled.

LITERATURE REVIEW

Centralized Monitoring and Controlling System

The system uses presence technology to control turning ON/OFF lights; it deals with the design and implementation of a system, that aims to reduce power consumption and to take immediate action on faulty streetlights by knowing their location over the web. No need to modify the conventional streetlights for this system. Streetlights can be turned ON and OFF from the remote location through the web by using the collected information over the web, based on the signal from the load detecting circuit identifying the faulty streetlights, and updating the data over the web (Murthy et al., 2020). To obtain reduced power consumption and quality maintenance of the devices. The control host and combined with various environmental monitoring modules to achieve a fully controllable "on-demand lighting" operation mode, while centralized. The control device communicates with the control platform through a computer network to realize remote control and management of street lights. This centralized control system can improve the management level of urban intelligent street lighting systems, reduce management, operation, and maintenance costs, avoid the waste of lighting energy, save resources, and promote related lighting without reducing urban lighting design standards and affecting lighting equipment. The functional transformation and management innovation of the department creates favorable conditions for urban reform and development. (Qu et al., 2022)

The design and development of the smart home application, to control the lighting system is important, due to the efficiency of electricity consumption. Stating that the efficiency of electric consumption be minimized since it be controlled both manually and remotely via interface via sensors or both, using an automated system (Surriani et al., 2020).

This is a very good opportunity to educate everyone about maximizing the use of technology and applying it to our daily needs. It is a great advantage to those who are updated and knowledgeable in this field and fully grasp his/her skills. Those who can utilize it in daily routine, in work environments, in residential areas, in the community, and everywhere.

The phenomenal advancements of digital technologies and ubiquitous computing must become mandatory to train and educate people nowadays to make use of it in our daily activities; and utilize this technology in work environments, residential areas, and around the community (Pervez & Alandjani, 2018).

Database

A centralized database is maintained which stores all the information about all the activities in a specific area, in each module's details. This application helps the IT expert to select, confirm, and monitor all information in the database. It can easily troubleshoot errors and have preventive maintenance check-ups on the system using this application. It helps to locate specific information regarding the data received from the sensors, switches, and messages.

After the centralized database is confirmed from the triggered sensors or switches, an indicator is sent to the monitoring console or sub-console and the web interface, and a notification message to the mobile devices of each key personnel where their call number was encoded. It helps to study the status of the specific action or event that happened in a specific area. Data integrity always be maintained highly in this online process in the database.

Economic considerations are given to human productivity in the office environment and safety in factories and workplaces. As a result, home automation has interconnected sensors and devices that communicate to employ economic value. (Venkatraman & Overmars, 2021). Supported by another study home automation using a cloud-based system focuses on the design and implementation of a home gateway to collect data then send it to the data server and implement a monitoring task (Malik & Bodwade, 2017).

Energy Management and Automation System

A home automation system makes the operations of various home appliances more convenient, and easy to handle and also saves energy by switching off the electronic devices when not in use. Nowadays, by using the energy-saving concept, building automation makes life very simple and efficient. Through wireless communication, the automatic control of all electrical or electronic devices in houses can be done remotely. Centralized control of lighting equipment, air conditioning and heating, audio or video systems, security systems, kitchen appliances, and various other equipment used in home systems is possible with this system (Dahapute et al., 2019).

Security and Safety

Safety and security are inextricably linked, and it is impossible to create a security system without considering the safety of the person or thing being protected. The security feature of the study was based on where in the modern computing landscape, smart home devices are unique as they provide an often-imperceptible bridge between the digital and physical worlds by connecting physical objects to digital services via the Internet, allowing the user to conveniently automate their home. However, because many of these products are tied to the user's security or privacy (e.g., door locks, cameras), it is important to understand the attack surface of such devices and platforms, to build practical defenses without sacrificing utility (Kafle et al., 2020).

METHODOLOGY

Research Design

The study utilized both descriptive and developmental methods. The study started by identifying the current systems installed and used that need to be upgraded. This was done through observations, interviews, and experiences of the administrators and stakeholders. The system is envisioned to solve problems that the administrators and end-users encountered as well as their suggestions for the improvement of the current system. In addition, the study aimed to determine the level of acceptance and the level of quality of the system.

These were investigated through the descriptive method research and by using survey instruments and test cases. The study designed a new approach to centralized controlling and real-time monitoring systems for the institution. It developed a new model into an automated form, evaluated its quality, and tested its acceptance, as taken from the developmental method of research.
Monitoring and controlling electricity consumption state that many automation with IoT applications that are present today use microcontrollers like Arduino and Raspberry Pi. The

said microcontrollers are used alongside programming languages like Python and C++. (Medina, et al., 2018)

System Architecture

Different frameworks have been created in the past decade; the majority of these systems are implemented either with client-server architecture or are centralized server-based.

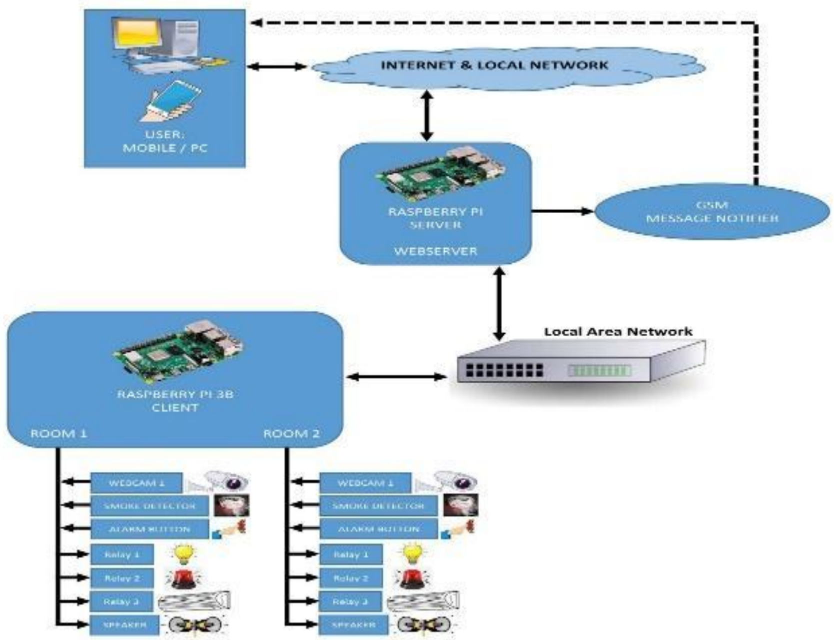

Figure 1. System Architecture of the Centralized Controlling System with Real-time Monitoring

Figure 1 shows the system architecture to be implemented. The use of a client-server architecture in which the organization integrates and maintains both data and device circuits. These device design challenges should be carefully considered early in the development process to minimize the downstream impact of poor architectural decisions.

Figure 2 shows the flow of the system for sending signals from the user commands to the web server console going to the relay. The user or key personnel who has the authorization to use this interface can manipulate such activity on the console by accessing his account clicking the button on the interface and activating the specified relay the person wishes to turn ON or OFF, or using other modules. Moreover, simultaneously monitored or shown in the console in real-time the status of the appliance. Blue for ON and Gray for OFF. This setup of the system can help to activate remotely any appliances in any part of the institution, so it lessens the time of waiting to turn ON or OFF any appliances, for example, an Aircon and the lights inside the classrooms, laboratories, or using another module by turning ON or OFF the speaker to give a piece of important information through a sound communication or Public Address system.

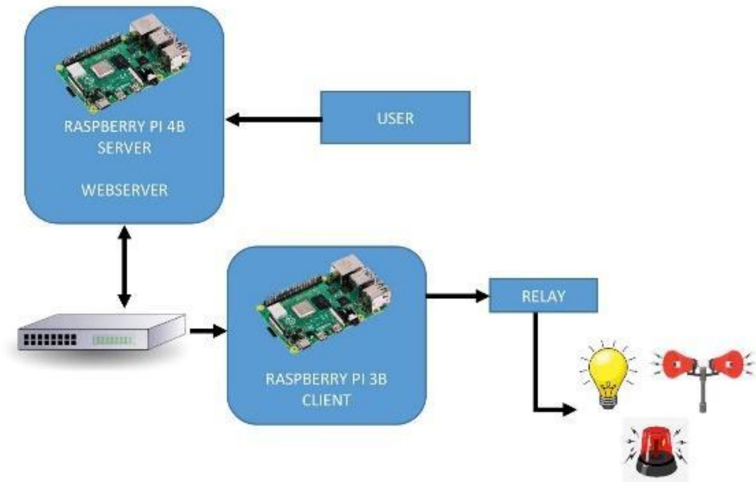

Figure 2. Block Diagram of the Centralized Controlling System with Real-time Monitoring: Sending of Commands from User to Actuators or Devices.

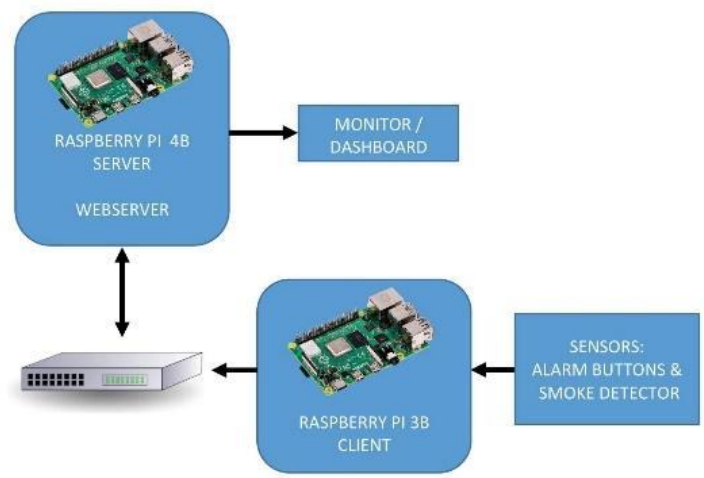

Figure 3. Block Diagram of the Centralized Controlling System with Real-time Monitoring: Sending of Commands from the Sensors to Server Monitor or Dashboard.

Figure 3 shows the flow of the system for sending signals from the sensors going to the relay and simultaneously to the webserver. This method activates the appliance and at the same time, a real-time status must be projected and monitored in the webserver.
This is also true for any sensors like the Smoke detector for the fire alarm system wherein if the sensor detects smoke within the area, it triggers the IR circuit inside the sensor and sends a signal to the local area circuit. It triggers the relay for the speaker horn to turn ON and sends a signal to the Raspberry Pi to determine what alarm sound to play and sends it

back to the speaker horn. In addition, transmits data to the webserver to project the status of that area.

Figure 4 shows the flow of the whole system for controlling and monitoring all four different systems: Fire Detection Alarm System (FDAS), Public Address System (PA), CCTV system, and Internet of Things system (IoT). In the Manual Control mode, two (2) systems are applicable, the Fire Detection Alarm System (FDAS) and light control (IOT). When the Alarm Push button is clicked, automatically all the Speaker Horn Siren activate, and a corresponding alarm sound can be audible to the whole perimeter. Moreover, it can be monitored where the exact location of the Alarm Push button was triggered. It can be only de-activated in the main controller or console of the system. The same method with the Lights Control, there is a push button to control the lights. It can be changed by a sensor to activate the relay and turn ON/OFF the lights.

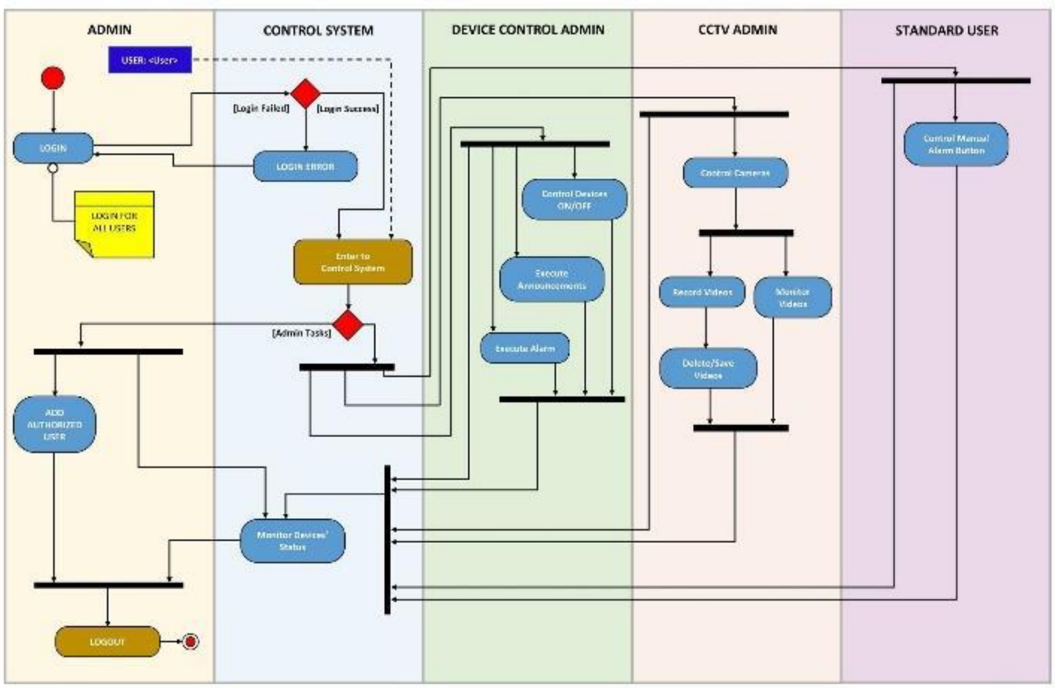

Figure 4. Activity Diagram with Swimlane of the Centralized Controlling System with Real-time Monitoring

In the Web Interface Control mode, both FDAS and IoT systems have their respective modules and controlled buttons. And can be triggered using the web buttons and simultaneously be monitored where it was clicked ON or turned OFF. On the other hand, the Public Address System has the same concept of controlling the Speaker Horn ON or OFF, however, only in the Web Interface Control mode can be manipulated in the system because of the text-to-speech technology and using microphone analog circuit. The user can select specific rooms for the speaker horn to turn ON or OFF.

For the CCTV system, there is no manual control or ON and OFF web buttons because it is continuously getting video data of the environment that is simultaneously transmitted to the Web Interface ready to be viewed. In the module, there is only a selection of which rooms to be viewed. The recording of videos is integrated into the system both in the web interface and in the physical hardware like the hard disk where the files are stored.

Hardware

Figure 5 Raspberry Pi is a low-cost, powerful computer that can offer a lot of capabilities at a reasonable cost. It is a useful computer that can integrate all 4 systems as a control and monitor system but also can send text notifications to the registered numbers of users and can be set up to save video clips of the CCTV. It can also broadcast audio files and signals to the RPI clients from the RPI server.

Figure 5. Raspberry Pi for Server and Client

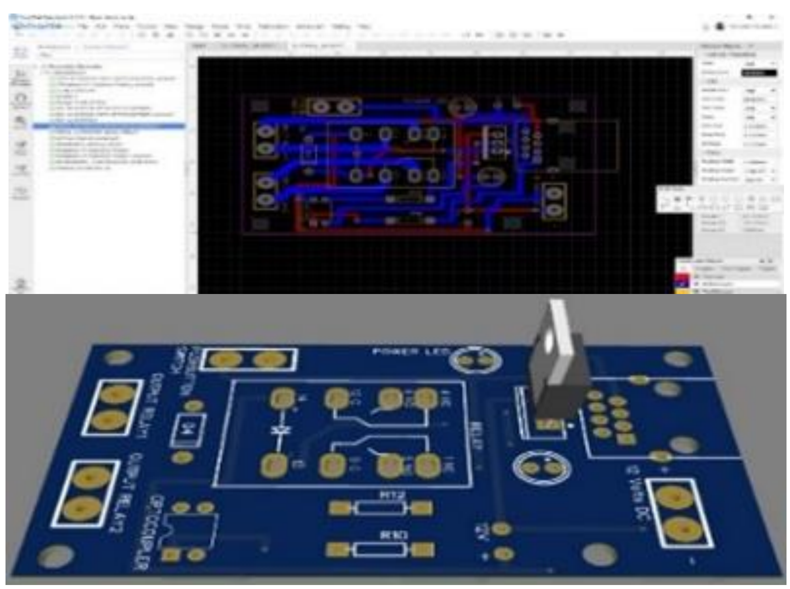

Figure 6. Relay Module Printed Circuit Board Layout and 3D view

In Figure 6, the Relay module was designed using the EasyEda application to ensure the accuracy of line connections and proper pad measurement that corresponds to each electronic component. In the circuit, the IO (Input/Output) LAN Terminal was used to have a better and perfect terminal connection from the main controller PCB.

In Figure 7, the Main Controller board was also designed in the EasyEda application. The circuit has an IO (Input/Output) LAN Terminal for each system – IOT and PA. There are pin header connectors for the FDAS sensors – smoke detectors and alarm switches. A 40-pin female header was used to connect to the 40-pin connector of the Raspberry Pi 4B Server for sending and receiving signals. The same PCB characteristics were also used in this board.

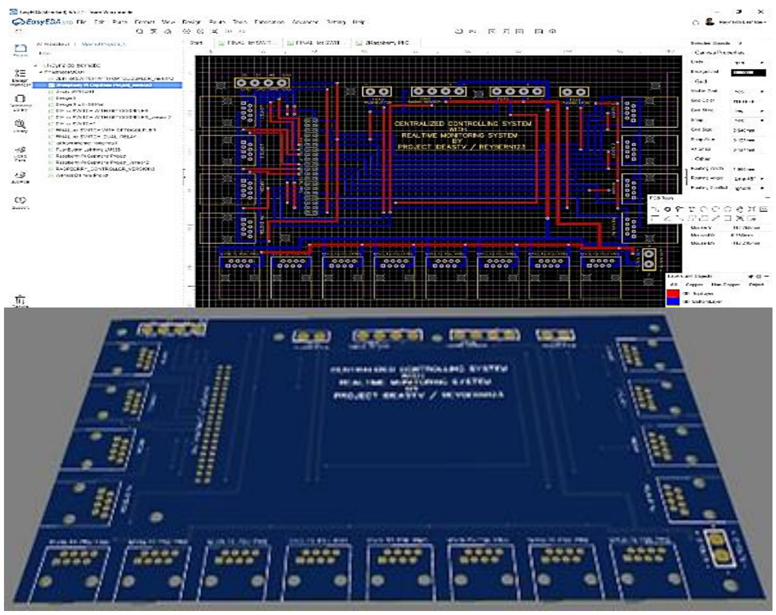

Figure 7. Main Controller Printed Circuit Board Layout and 3D view

Software

Lights Control System (IOT)

Figure 8 shows the Lights Control interface. The user can manipulate the buttons to turn ON/OFF the lights by clicking the icons. In this interface, the lights can be monitored whether they are turned ON or OFF. If the icon is colored Blue: it means the lights are ON. And if the icon is colored Gray: it means the lights are OFF.

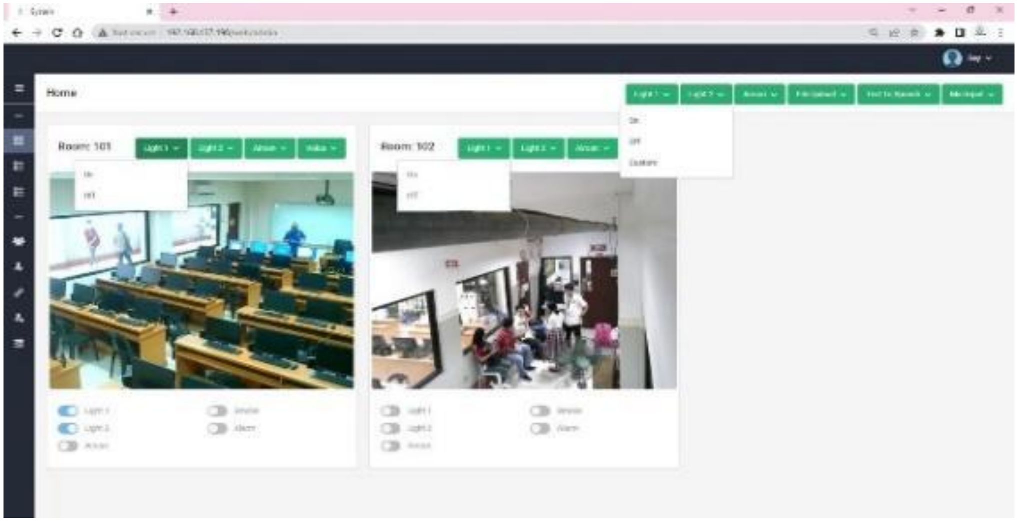

Figure 8. Lights Control Interface

Fire Detection and Alarm System (FDAS)

Figure 9 shows the Fire Detection and Alarm system (FDAS) interface. In this interface, the user can monitor the whole area in which the room is on fire based on the sensors triggered in a specific room.

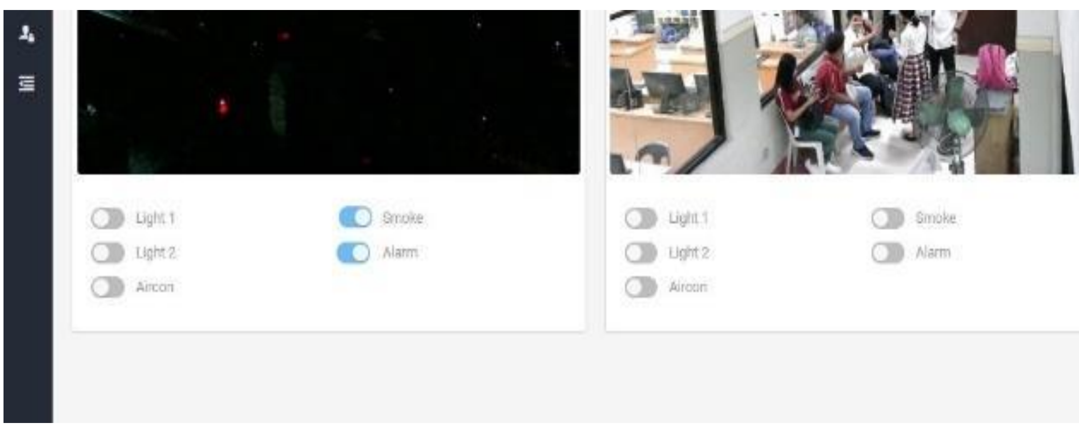

Figure 9. Fire Detection Alarm System (FDAS) Control Interface

Public Address System

Figure 10 shows the Public Address (PA) system interface. In this interface, the user can communicate with the whole area via live broadcast over the Local Area Network.

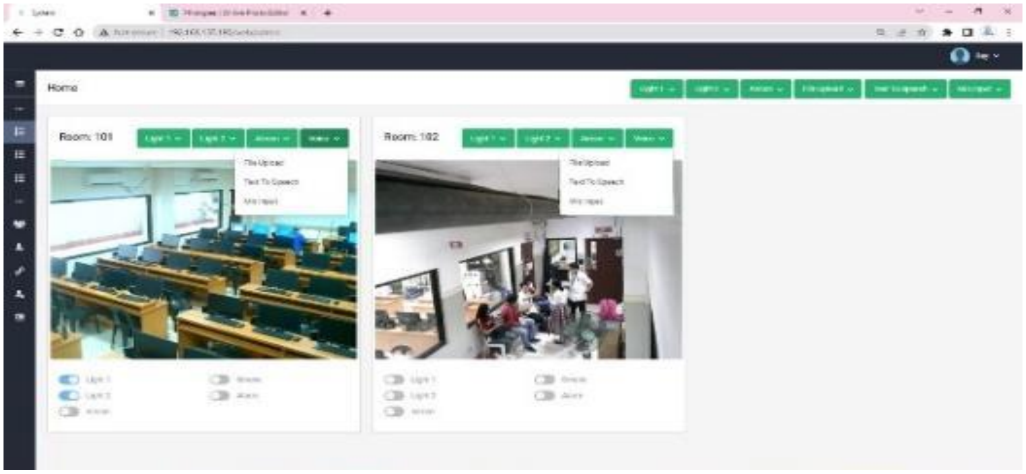

Figure 10. Public Address (PA) Control Interface

Figure 11 shows the Public Address (PA) system interface on the audio file. In this interface, the user can communicate with the whole area via live broadcast over the Local Area Network. The administrator can input an audio file on the given field and then submit the registration. The audio file then will be broadcast to all or selected rooms.

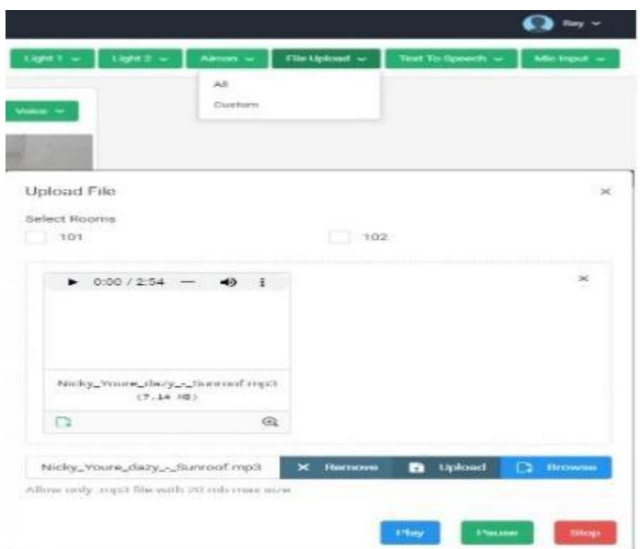

Figure 11. Public Address (PA) Control Interface – Audio File

Figure 12. Public Address (PA) Control Interface – Text to Speech

Figure 12 shows the Public Address (PA) system interface – Text to Speech. In this interface, the user can communicate with the whole area via live broadcast over the Local Area Network. The administrator can input the text on the given field and then submit the registration. The speech then will be broadcast to all or selected rooms.

Figure 13 shows the Public Address (PA) system interface – Mic Input. In this interface, the user can communicate with the whole area via live broadcast over the Local Area Network. The administrator can simply click the mic button to turn the microphone on and broadcast the input to all or selected rooms.

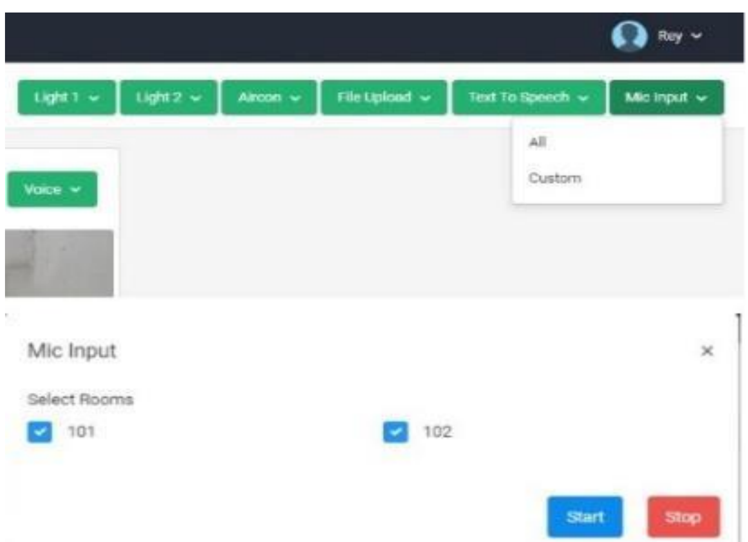

Figure 13. Public Address (PA) Control Interface – Mic Input

Closed-circuit television (CCTV)

Figure 14 shows the Close Circuit Television (CCTV) interface. The user can select the rooms to view the live camera inside the room which can be monitored in real-time. The camera used in this system is a USB Webcam 1080P resolution.

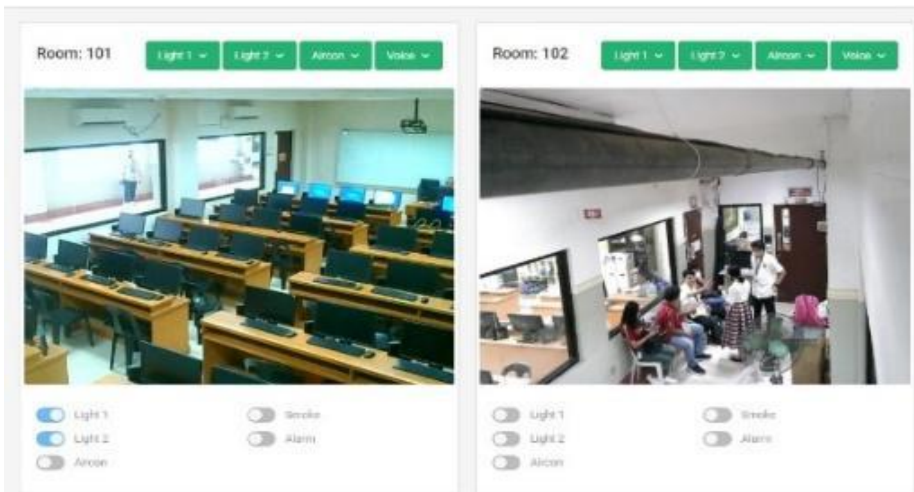

Figure 14. Closed Circuit Television (CCTV) Control Interface

System Evaluation

After the Prototype product was installed and tested. The researcher collected data using ISO/IEC 25010:2016 known as Systems and Software Engineering - Systems and Software Quality Requirements and Evaluation (SQuaRE) applies two software quality models. The respondents were twenty (20) end-users and five (5) IT experts of an institution where it was implemented. They were the key personnel related to the topic and work skills. A Quality in Use Model is composed of five characteristics (some of which are further subdivided into sub-characteristics) related to the outcome of interaction when a product is used in a particular context of use. This system model applies to the complete human-computer system, including both computer systems in use and software products in use. (Estdale et al., 2018)

RESULTS

Current System – IOT, FDAS, PA system, and CCTV

The institution is using traditional systems to cater to the safety and security of the facilities and they do not have a centralized command system for all of it. In the Lights/Aircon Controls, there are cases where they are left ON, creating chances for electricity wastage and possible risk of overheating. This is why personnel have to manually monitor and turn off them time to time.

Problem Encountered – IOT, FDAS, PA System, and CCTV

With the manual operations and non-existent interrelatedness of the circuits and systems in the Fire Detection and Alarm System (FDAS), Closed-circuit Television (CCTV), Internet of Things (IoT), and Public Address System (PA), problems were identified by the university personnel.

Software testing is a method to check whether the actual software product matches expected requirements and to ensure that the software product is defect-free. There are different stages at which testing is done to guarantee. The data is in line with the notion that the probability that a given maintenance action for an item under given usage conditions can be performed within a stated time interval when the maintenance is performed under stated conditions using stated procedures and resources (Phister & Olwell, 2022).

Table 1 shows the level of efficiency was measured using the 4-point Likert scale. The following numerical ratings, categorical responses, and verbal descriptions were used to identify the level of efficiency of the management information system of the respondents.

Table 2 presents the composite table relative to the level of efficiency of the system as rated by the end-users. It has an overall weighted mean of 3.64 with verbal interpretation "Highly Efficient". Five (5) out of the six (6) indicators were rated by the end-users as "Highly Efficient", namely: Usability; Functional Suitability; Performance Efficiency, Reliability, and Compatibility. The indicator Usability remarkably recorded a weighted mean of 3.81 as the highest or "Highly Efficient". However, one indicator was rated as "Moderately Efficient" namely, Security.

Table 1. The level of efficiency using the 4-point Likert Scale

Assigned Point	Numerical Ranges	Categorical Response	Verbal Interpretation
4	3.51 – 4.00	Very High	Highly Efficient
3	2.52 – 3.50	High	Moderately Efficient
2	1.51 – 2.50	Low	Slightly Efficient
1	1.00 – 1.50	Very Low	Inefficient

Table 2 Level of Efficiency as Rated by the End-Users

Indicators	Weighted Mean	Verbal Interpretation	Rank
Functional Suitability	3.78	Highly Efficient	2.5
Performance Efficiency	3.78	Highly Efficient	2.5
Compatibility	3.65	Highly Efficient	5
Usability	3.81	Highly Efficient	1
Reliability	3.69	Highly Efficient	4
Security	3.18	Moderately Efficient	6
OVERALL WEIGHTED MEAN	**3.64**	**Highly Efficient**	

Table 3. Level of Efficiency as Rated by the IT Experts

Indicators	Weighted Mean	Verbal Interpretation	Rank
Functional Suitability	3.87	Highly Efficient	1
Compatibility	3.20	Moderately Efficient	5.5
Reliability	3.70	Highly Efficient	2
Security	3.20	Moderately Efficient	5.5
Maintainability	3.24	Moderately Efficient	4
Portability	3.27	Moderately Efficient	3
Overall Weighted Mean	**3.41**	**Moderately Efficient**	

Table 3 presents the composite table relative to the level of efficiency of the system as rated by I.T. experts. It has an overall weighted mean of 3.41 with verbal interpretation "Moderately Efficient". Two (2) out of the six (6) indicators were rated by the I.T. Experts as "Highly Efficient", namely: Functional Suitability and Reliability. However, four (4) out of the six (6) indicators were rated as "Moderately Efficient" namely, Compatibility,

Maintainability, Security, and Portability

Reliability is noted as a fundamental attribute for the safe and profitable operation of any technological system. Reliability analysis aims at studying the failure mechanisms of a system (and of its protective barriers, for what concerns accident development) and at quantifying the associated likelihoods. The outcomes of the analysis serve to identify design solutions and maintenance actions for preventing the failures (hardware, software, human and organizational) from occurring, and protective barriers for mitigating the consequences of the failures. (Zio, 2019)

CONCLUSION AND RECOMMENDATIONS

Based on the salient findings of the study, it can be concluded that the current system of the institution is a manually operated system using an ON-OFF switch, FDAS circuitry, an obsolete Public Address system, and a common CCTV system. Another conclusion derived from this study entails that the current system needs improvement and innovation due to the existing problems encountered by the personnel and administrators. Similarly, a centralized controlling system with Real-Time Monitoring is created to resolve the information and communication technology needs on the day-to-day operations of the university personnel. Moreover, the system is efficient for end-users and I.T. experts. Therefore, utilization of the system may be recommended by the researcher to enhance its services.

In light of the findings and conclusions, it is recommended that Institutional Administrators acknowledge the current system of their facilities when it comes to FDAS, CCTV, IOT, and PA and may use this study to provide them knowledge on how Centralized Controlling System with Real-time Monitoring can be used to both control and monitor in real-time their facilities. They may also provide continuous and relevant training and/or seminars for their personnel regarding the further development and enhancements of their information system. This is so because the demands of technology are constantly changing so their skills should keep abreast of the trends and issues.

Institutional Personnel is also reminded to use and advocate the developed management information system to innovate the current manual system and avoid the problems brought by it. They can do this by regularly using the program. As part of the automation of information, streamlined processes have also been defined. Developers are exhorted to develop and improve the centralized control information system by investing in web hosting and domains for Institutional official use. Another recommendation involved the Information and Technology Department where it is advised to monitor, maintain, and troubleshoot time-to-time the use of a Centralized Controlling System with Real-Time Monitoring. Though the system obtained a Highly Efficient rating, maintaining it has still to be done to ensure smooth operation of the system.

Finally, future researchers may conduct another inquiry on the topic considering other features of the management information system and/or other study locale since the said program is new and still nonexistent in other places. They may also use a sampling technique that includes other campuses universities or companies since this study only covered one private institution.

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DECLARATIONS

Conflict of Interest

The researcher declares no conflict of interest in this study.

Informed Consent

The researcher declares an informed consent was provided for the participants while conducting this study.

Ethics Approval

The researcher declares an Ethical Approval was granted by the Review Board while conducting this study.

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Reynaldo Bernabe Jr. He is an IT Specialist and Electronics Professor and has been teaching college students since 2000 in his alma mater, Don Bosco College where he completed his Bachelor of Science in Industrial Education major in Electronics degree. Currently a Senior IT Network Infrastructure Support Specialist and an IT Professor at the University of Perpetual Help System Dalta, where he teaches Robotics, Automation, IOT programming, and managing the network infrastructures of the said institution. Consequently, he finished his Master's degree in Information Technology (MSIT) at the University of Perpetual Help System Laguna. Through this, he had opportunities to manage IT projects, Network Infrastructures, IOT Controlling Systems, Firewalls, and Cybersecurity. From then on, he has been attending research conferences and workshops to hone his skills in the Internet of Things and Automation, Robotics, image processing, and computer vision.

Oliver Junio As the Dean and IT Director of the University of Perpetual Help System Laguna, Oliver Junio leads with a passion for innovation and academic excellence. With over two decades of experience in higher education administration and information technology, he has spearheaded numerous initiatives to enhance student learning experiences and streamline campus operations. Under his leadership, UPHSL has embraced cutting-edge technologies to modernize its infrastructure and support the evolving needs of students and faculty. Oliver's strategic vision and collaborative approach have earned him recognition for fostering a culture of continuous improvement and digital transformation within the university community. With a commitment to student success and technological advancement, Oliver Junio continues to drive UPHSL toward greater heights of academic excellence and technological innovation.