IOT BASED SMART FAN CONTROLLER AND FIRE PREVENTION IN COMPUTER LABORATORY

Kevin Iriho

A Project Report Submitted in Partial Fulfillment of the Requirements of the Award the Degree of Master of Science in Embedded and Mobile Systems of the Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

July, 2022

ABSTRACT

Computer laboratory plays the role of key elements with high interest for different categories of populations. Event of fire, smoke, heat and water leakage when occurs could cause a big loss for business continuity. Their equipment is very expensive and its usage is more profitable to the population who used it. Many computer laboratories in the East Africa community region are equipped with equipment for protection against fire, smoke, and heat such as fire extinguishers, fans, and smoke detectors. However, when equipped with that equipment of protection, a system for monitoring and controlling the computer laboratory environment and warning the users in real-time is not yet implemented. This study aimed to develop an automated computer laboratory that would control and monitor the computer laboratory environment from the incident of fire, heat, smoke, and water leakage. The developed system is divided into three nodes which communicate separately with one database in common where the flame sensor is used to detect fire and allow the turning on automatically of a fire extinguisher in case of fire detection, DHT22 and ultrasonic sensor are used for management of fan controller, allowing to turn on automatically fan controller when there is high temperature and if there is a presence of a person, smoke and water sensors are used to detect the presence of smoke and water leakage. NodeMCU ESP8266, ESP32 WROOM-32D as a microcontroller, access point, and software are used to accomplish the development of that system. Different actions of warning users such as triggering buzzers and sending emails are done when fire, smoke, and water leakage are detected, email is sent to the users when there is a temperature more than 25℃. ThingSpeak cloud is used for the analysis of data from sensors, control of fire extinguisher and fan controller were done via mobile application and web applications. A prototyping methodology was used. The study aimed at interviewing 80 individuals based on their cluster. However, 64 individuals accepted to respond to our questionnaires. Results showed that 57.81% of females were interested in the interview compared to 42.19% of males. From the results which come of testing the prototype, it shows that the variation of temperature varies between 23℃ and 27.60℃, 11 times of fire detection, and 33 times of smoke detection. The developed system for IoT-based smart fan controllers and fire prevention in computer labs with its supported equipment will contribute to securing and protecting the computer laboratory against fire, smoldering, heating, and water leakage.

DECLARATION

I, Kevin Iriho, do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this project report is my original work and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

Kevin Iriho		11.07.2022
Name of Candidate	**Signature**	**Date**

The above declaration is confirmed by:

Dr. Neema Mduma	Mduma	18-07-2022
Name of Supervisor 1	**Signature**	**Date**

Dr. Dina Machuve		20-7-2022
Name of Supervisor 2	**Signature**	**Date**

COPYRIGHT

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by The Nelson Mandela African Institution of Science and Technology, a project report titled **"IoT Based Smart Fan Controller and Fire Prevention in Computer Laboratory"** in partial fulfillment of the requirements for the degree of Master of Science in Embedded and Mobile Systems, Embedded Systems specialty of the Nelson Mandela African Institution of Science and Technology.

Dr. Neema Mduma	Mduma	18-07-2022
Name of Supervisor 1	**Signature**	**Date**

Dr. Dina Machuve		20-7-2022
Name of Supervisor 2	**Signature**	**Date**

Dr. Dina Machuve

Name of Supervisor 2	**Signature**	**Date**

ACKNOWLEDGMENTS

First and foremost, praises and thanks to God to grant me an opportunity to join the Master's programme at Nelson Mandela African Institution of Science and Technology. I would like also to thank the almighty, for his showers of blessings throughout my research work to complete the research successfully.

I would like to express my deep and sincere gratitude to the Centre of Excellence for ICT in East Africa (CENIT@EA) for the scholarship and financial support granted to me in pursuit of my study during my master's study at NM-AIST.

I would like also to express my deepest gratitude to my supervisors Dr. Neema Mduma and Dr. Dina Machuve for allowing me to do research and providing me invaluable guidance throughout this research. It was a great privilege and honor to work under their guidance. I am grateful for what they have offered me.

I address my thanks to Dr. KAMUGISHA Kazaura Director of the Department of Infrastructure at the EAC secretariat, for his motivation and encouragement to accomplish this work.

I am extremely grateful to my parents, for their love, prayers, and sacrifices in educating and preparing me for my future. I also express my thanks to my brother, my sisters, and my brother-in-law for their support and valuable prayers. I am very much thankful to my colleagues, lecturers, and classmates for their good collaboration during my study at NM-AIST. They were of importance to me. Finally, I would like to address my special thanks to the family of Liberat MFUMUKEKO for their support and advice.

Thank you.

DEDICATION

This project report is dedicated to my esteemed parents Mr. Jean RWABUGIRI and Mrs. Christine MANIRAMBONA.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

API	Application For Programming Interface
App	Application
CSS	Cascading Style Sheet
DB	Database
DHT	Digital Temperature and Humidity
EAC	East Africa Community
GND	Ground
GPIO	General Purpose Input/Output
GPS	Global Positioning System
GPU	Graphics Processing Units
h1	heading one
h6	heading six
HE	High education
HTML	HyperText Markup Language
HTTP	Hypertext Transfer Protocol
I2C	Inter-Integrated Circuit
IA-32	Intel Architecture 32 bit
ICT	Information and Communications Technology
IDE	Integrated Development Environment
IoT	Internet of Things
IR	Infrared
IT	Information Technology
LPG	Liquefied Petroleum Gas

OS	Operating System
PCB	Printed Circuit Board
PHP	Hypertext Processor
PIC	Pin Configuration
PIR	Passive Infrared
ppm	Part per million
PWM	Pulse Width Modulation
RAM	Random Access Memory
RFID	Radio Frequency Identification
SD	Secure Digital
SPI	Serial Peripheral Interface
SQL	Structured Query Language
TV	Television
UART	Universal Asynchronous Receiver Transmitter
VDD	Voltage Drain Drain
WGBT	Wet Bulb Globe Temperature
Wi-Fi	Wireless Fidelity

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

A computer laboratory is defined as a place that can be used to provide services to a certain category of the population. It can be used by libraries to the public, by an academic institution to the student who attends the institution, or by the institution to their employees.

When a fire occurs in a computer laboratory, it could generate a big loss for many businesses. Then, there is not only the risk of personal injuries or loss of life during a fire incident but there is also the loss of data and equipment which can affect the failure of the business.

House fires are critical issues, aside from of loss life when it is busted, mass property destruction, and loss of information can occur. When operating a computer laboratory or server room, their data and information may be irreplaceable in the event of a fire emergency.

In computer laboratory, sometimes computers are switched on for a long time, which generates heat even if it comes with a complete built-in fan. The temperature allowed in the computer laboratory should not fall below 10 degrees or go above 27 degrees Celsius. The temperature should range between 18-21 degrees Celsius.

According to Norwegian HE (Document, 2013), the installation of a ventilation system must be so far from another ventilation system to avoid the spreading of smoke and fumes in the ICT room when a fire has occurred. The regulation of air humidity must be done following the requirement of the equipment used in the computer laboratory. The ventilation fan with smart features, which uses a microcontroller to create an automation function is the best solution for the ventilation system. The ventilation fan operates automatically according to the temperatures, which are set by the users. Users initially set the temperature to ON the fan together with the overheat temperature to ON the buzzer (Dzulkefli *et al.*, 2017). There are different functions used to control the fan, according to the realization done by Dioses (2020), voice recognition using the Filipino language was used to automatically control the electric fan speed from speed no.1 to speed no. 4. The user makes use of voice commands to perform certain actions. In the testing conducted on fan speeds, speeds no 1 and 2 obtained 50% accuracy, and speeds no.3 and 4 both obtained 100% accuracy.

According to Norwegian HE (Jensen & Nygaard, 2013), it is important for ICT room to be equipped with smoke detectors and also with an early facility based on high sensitivity aspiration detectors and an installation of a fire alarm system that is based on early detection employed in procedures and instructions to help reduces the risk of fires. For this inconvenience, fire protection is a basic safety issue for all categories of buildings. The criteria for effective fire suppression and the characteristics of extinguishing systems in insulated areas depend on the combination of factors (Kuznetsov *et al.*, 2022). For Jain *et al.* (2021) Water and chemical-based methods are the traditional fire extinguishing techniques and there is an urgent need to develop an extinguisher that can overcome the problem of residues and wastage of water. The best solution and Alternative to these traditional methods are sound waves. It is the cleanest method of extinguishing flames.

In the last decades, the automation system was limited to industries since it is required significant investments and now this technology became available to everyone, which contributes to IoT becoming a new advanced technology with devices controlled by the users at any place using the internet, wireless devices, sensors, microcontroller and actuators (Gomathi, 2018). A system for detecting fire and ventilation in a computer laboratory is considered home automation or smart house, this system starts to emerge with the technology used in IoT which makes the environment more comfortable, convenient, flexible, and secure for users (Gomathi, 2018). This led automation to become the key interest technology to many people who want to use automated devices in their daily activities due to several reasons such as ranging from safety to easy handling (Ekstsabi, 2018).

In this project, an IoT-based system for laboratory automation to control fire, temperature, water, and smoke was developed. In case the fire is detected, the alarm will be triggered, an email will be sent to subscribers to the system, and the fire extinguisher will be also turned off automatically. In the case of high temperature, the smart fan will be turned on automatically if there is a person in the room.

Detecting fire, water, temperature, and smoke, which can occur in the computer laboratory, will contribute to the prevention of incident in the computer laboratory and also to energy-saving which deal with minimization of energy wastage.

1.2 Statement of the Problem

Detection and prevention of fire is a detrimental work that can bring risks of loss of lives when extinguishment is done by an extinguisher person (Rashid *et al.,* 2017). Then, the computer lab is equipped with Electronic Equipment that possesses the risk of overheating when used continuously. Event of fire, smoke, heat and water leakage when occurs could cause a big loss for business continuity. Their equipment is very expensive and its usage is more profitable to the population who used it. Indeed, IT equipment and others materials used for data recording or storage can be damaged when they are exposed to sustained elevated temperatures. The degree of such damage depends upon the exposure of materials for data recording and storage (Hamidovic, 2014). However, all incidents which occur in computer facilities can cause significant damage and high consequential losses even where the fire is quite small (Johnson, 2010).

Many computer laboratories in the East Africa community region are equipped with equipment for protection against fire, smoke, and heat such as fire extinguishers, fans, and smoke detectors. However, when equipped with that equipment of protection, a system for monitoring and controlling the computer laboratory environment and warning the users in real-time is not yet implemented.

To overcome these above challenges in laboratory automation, a project of IoT-based smart fan controller and fire prevention was developed to extinguish the fire and reduce temperature. In case a fire is detected, a smart fire extinguisher will be opened automatically and start extinguishment

1.3 Rationale of the Study

Computer laboratory plays the role of key elements with high interest for different categories of populations. Event of fire, smoke, heat and water leakage when occurs could cause a big loss for business continuity. Detection and prevention of fire is a detrimental work that can bring risks of loss of lives when extinguishment is done by an extinguisher person (Rashid *et al.,* 2017). Then, the computer lab is equipped with Electronic Equipment that possesses the risk of overheating when used continuously. Their equipment is very expensive and its usage is more profitable to the population who used it. Many computer laboratories in the East Africa community region are equipped with equipment for protection against fire, smoke, and heat such as fire extinguishers, fans, and smoke detectors. However, when equipped with that

equipment of protection, a system for monitoring and controlling the computer laboratory environment and warning the users in real-time is not yet implemented. This study aimed to develop an automated computer laboratory that would control and monitor the computer laboratory environment from the incident of fire, heat, smoke, and water leakage.

1.4 Objectives

1.4.1 Main Objective

To develop an IoT based smart fan controller and fire prevention in computer laboratory.

1.4.2 Specific Objectives

(i) To identify requirements for developing a smart fan controller, for detecting fire, smoke, and water;
(ii) To develop a system for IoT based smart fan controller and fire prevention in computer laboratory;
(iii) To validate the developed system.

1.5 Research Questions

(i) What are the requirements for developing a smart fan controller for detecting fire, smoke, and water?
(ii) How to develop an IoT based smart fan controller and fire prevention in computer laboratory?
(iii) How to validate the developed system?

1.6 Significance of the Study

Computer labs are built with expensive money and are defined as a valuable area of any business. If something damages the equipment in the computer laboratory, there's a big loss to the owner which brings suffering of a serious loss in the business continuity. An automatic fan controller with temperature changes reduces the power consumption and monitors changes in the environment, then it assists people who are disabled to switch on and off the fan and prevent waste of energy when it is not hot enough for a fan to be needed. This study contributes to the improvement of IoT projects based on laboratory automation by incorporating the new task of security which will help to reduce the loss of lives, and equipment, and avoid heating in the

computer laboratory. This study will also help to motivate users of that system to the innovation in new fields of IoT including other IoT projects such as smart doors, RFID, and smart light.

1.7 Delineation of the Study

Nowadays, automation has been the key interest one of the key interests of modern-day technology. Everybody wants to use it in his or her daily activities due to several reasons. In the last decades, the automation system was limited to industries since it required significant investments and now this technology became available to everyone. This study aimed to develop an automated computer laboratory that would control and monitor the computer laboratory environment from the incident of fire, heat, smoke, and water leakage. The developed system is divided into three nodes which communicate separately with one database in common where the flame sensor is used to detect fire and allow the turning on automatically of a fire extinguisher in case of fire detection, DHT22 and ultrasonic sensor are used for management of fan controller, allowing to turn on automatically fan controller when there is high temperature and if there is a presence of a person, smoke and water sensors are used to detect the presence of smoke and water leakage.

CHAPTER TWO

LITTERATURE REVIEW

2.1 Overview of IoT based on Home Automation

Internet of Things is described as a system of objects connected to them that can exchange and transfer data over the network without human intervention (McClelland, 2021). Then, IoT is composed of sensors, software, and other technologies to connect and exchange data with other devices over the internet. Internet of Things is used in different technologies such as home automation, and smart cars.

The main purpose of home automation, it aims to bring control of our everyday home life (Ivanova *et al.*, 2016). It also aims to control our system security; it can control all devices of our smart home through internet protocol address and cloud.

Internet of Things based home automation is composed of servers and sensors. These servers are remote control located on the internet which helps us to manage and process the data without human intervention (Stolojescu-Crisan, 2021). There are different applications of IoT-based home automation which consists of smart devices such as applications for lighting, security, and home entertainment. Three protocols of wireless communication are widely used in home automation such as ZigBee, Wi-Fi, and z-wave (Danbatta, 2019).

The IoT in home automation is done in many different technologies which make it possible to access and control identifiable devices uniquely in our environments such as sensors, and actuators.

Cloud computing provides us the potential easy access to our home automation data via the internet. The users are not required to be in a specific place to access data, they are allowed to work remotely anywhere they are.

Home automation allows the users to use high technology functionality that wasn’t able possible in the past years (Al-Kuwari, 2018). As new technology continues to expand in the world, home automation makes the possibilities for its users for an easy life and more enjoyable. Different cases make home automation more beneficial such as:

(i) Managing all home devices from anywhere you are. The users can keep and control all devices connected to the internet through the user interface.

(ii) Flexibility for new devices and appliances. For these advantages, the users can integrate new devices.

(iii) Maximizing home security when we incorporate security and surveillance features in home automation.

2.2 Performance of Projects using Fan Controller

Dzulkefli *et al.* (2018) have created an innovative electric fan prototype with smart features. This electric fan has an automated capability using a microcontroller. It also contains two fans, such as using two fans, two Light Emitting Diodes (LEDs), and two sensors, which have all unique double feature designs. The goal of the project was to make the cooling process more efficient and effective, particularly for vast space applications and in hot weather owing to global warming. Then, using Arduino, temperature, and humidity sensors, Onibonoje *et al.* (2019) created a project that aims to manage the fan speed automatically. Fan speed must be manually modified every time, but with this concept, the fan's speed will be automatically adjusted based on the surrounding environment. The projectis based on the Internet of Things concept. Wid and Pramudita (2018) realize a project Automatic Lamp and Fan Control. The automatic lamp system required sensors to detect the light of the LDR (Light Dependent Resistor) sensor, which was based on a microcontroller. The automatic fan system, on the other hand, requires sensors to detect the DHT11 sensor's temperature. Lamps and fans have been found to work adequately in tests. To control the fan speed, Singh *et al.* (2017) proposes a project of an automatic control system. To control the fan speed, the components are developed and constructed to automatically control the fan speed. The temperature and fan speed are displayed on an LCD as an added function.

2.3 Advantages and Utilities of Computer Laboratory

Every commercial or public institution needs a computer lab to improve its users' scientific and technological research and invention capabilities. It offers computer services to a certain group of people.

Judi *et al.* (2011) stated in a study about a case of computer laboratory layout modeling and analysis that a computer laboratory is a facility where students have access to the hardware and

software needed to complete course requirements. Students are also trained and exposed to computer programming simulations in computer laboratories. The typical strategy for teaching introductory computer programming courses is to include a lecture component in the classroom and a supervised laboratory module where students write simple programs that match the subject covered in the lecture (Azemi, 1995). Computers, on the other hand, have been used in higher education for more than thirty years as both a subject and as tools to aid in the learning process in other disciplines, and computer laboratory classes have played a significant role in the teaching of computing subjects (Newby & Fisher, 1997).

Indeed, the usage of computer laboratories is something that most university computing courses, both expert and non-specialist, have in common (Yap & Ng, 2018). The importance of computer laboratories in such courses is understandable, given that using a computer, particularly for programming, is seen as a skill that cannot be learned simply by reading a book and requires practice to master (Azemi, 1995). An internet-based computer laboratory for ASP courses, where students are given exercises in the form of web pages and Java programs to help them solve difficulties and visualize topics. This computer lab allows students to complete exercises anywhere there is internet access (Clausen & Spanias, 1998). In ICT courses, computer lab activities are quite important. These activities not only help students understand what they are learning, but they also provide them with the problem-solving skills and experiences they need to apply their knowledge in a real-world setting (Kabiri & Wannous, 2017).

Finally, a computer laboratory can be used as a management system for improving teaching and learning methods, provided that the proposed system is designed as a computerized system with only one machine.

The lab's /pc serves as a server, while the others function as clients. The goal of implementing this management system is for keeping track of each student during practical and asking questions regarding practical to the teacher (Farag, 2018).

2.4 Effect of other Systems related to IoT

Nowadays many applications including IoT based home automation have been made to render the home smart.

Firstly, a smart light system with a PIR sensor, light, and other sensors, actuators to open the light and diming light with remote control using a network that can be programmed and designed using a microcontroller (Khoa *et al.*, 2020). Different sensors, actuators, microcontrollers, hardware, and software are used to perform this task:

Arduino Uno, Ethernet shield, motion sensor, with relay, light sensor, diodes, capacitors, buzzer, and TP-LINK.

Secondly, IoT based Secured Smart Door Access is used to provide smart monitoring and control of the visitors, the thieves, and the homeowner. This system is for monitoring the appliances for smart permission. For that method of monitoring and controlling smart permission, the users in this system have to use authentication to access the user interface allowing permission inside the house (Sail, 2019).

Thirdly IoT based home appliances control is applied in the control of electrical devices such as refrigerators, lights, and fans connected to the internet. This model performs the automation and reporting system where users can control all the automation systems (Dhobi & Tevar, 2018). The information is provided by the internet and the users of these electrical devices are allowed to control them and receive the data from these objects connected.

2.5 The Aspect of Fire Fighting's Policies

The key goal in detecting fire is to do so with as few false alarms as possible, concentrating on the time a fire is forming and where it is located (Kaiser, 2000). When a fireman enters a smoky room and knows where the source of the fire is, extinguishing action is taken swiftly.

Then, Feng and Liu (2021) discussed several areas of computer fire prevention, such as decision making, intelligent dispatching host systems, and fire alarms. The image monitoring system, processing system, digital recording system, fire geographic system, and GPS precise positioning These factors can be used to create a system that aids in fire prevention while also saving time and providing more ease for firefighting and rescue operations. Nonetheless, one of the greatest ways to avoid a fire is to prevent it from starting in the first place (Benson, 2019). The fire triangle is made up of three elements: fuel, oxygen, and environmental conditions. Fire cannot start without these three elements of the fire triangle.

Imteaj (2017) developed a system that offers confirmation for fire suspects, allowing them to

trigger an alarm when a fire is suspected while avoiding false alarms. When a fire is detected in this system, an alert is triggered. The system will allow you to send a message that includes an image and the name of the allocation. If a fire alarm is triggered, the system will quickly raise an alarm and send an automatic message to the nearest fire department. A wireless sensor network, on the other hand, was created to detect house fires using several sensors (Saeed, 2018). Each sensor in this system detects growing heat and smoke, looks about the house, and sends an alert to its network's head nodes. The presence of flames is collected and identified by the head nodes. Then, this IoT system will be more beneficial if it meets all of the security and automation requirements. Create a fire alarm system that utilizes a cloud-based system with sensors to detect fire and inform users via the internet using a single device. The app is built on a Raspberry Pi with Python programming and uses Google API for location recognition (Sassani, 2020). This study, on the other hand, is intended to provide a second check in terms of alerting individuals to the possibility of a fire on the premises. When smoke or fire is detected, it sends a text message to the users' phones, alerting them to the possibility of a fire or smoke.

2.6 Related Works

Hadi (2015) completed a project in his study that involved an automatic smart kitchen that was controlled by a microcontroller. The system was designed to discharge heat and smoke in the kitchen while controlling the speed of the air blower. PWM (Pulse Width Modulation) waves generated by a PIC 16F877, a microcontroller-based on a temperature sensor were used to drive the air blower system. The goal of this project is to ensure household safety by installing a fire alarm with a warning alert to prevent a fire accident. The system, on the other hand, tends to secure the home, but a fire in the kitchen is similar to a fire in a computer lab, design, or implementation. The optimum solution for home automation is a system that can automatically activate a preventative response if a fire or high temperature is detected on time. Finally, if he had employed alternative components or sensors of detection, such as a camera sensor, and other recognition modules to eliminate false detection, this system would have been secure.

Hsu (2019) developed a smart kitchen fire prevention system to protect cooks using gas stoves, which includes the following devices and functions. Above the stove, sensors are mounted. They engage the gas shutoff device to switch off the gas supply as soon as they detect a flame, high temperature, or gas leak. This development in how to turn off the gas supply has prompted me to consider how I can secure a computer lab with a fire extinguisher that is activated in the

event of a fire. However, while this system has an automatic prevention system, it lacks a data storage system that can save information on fires, temperatures, and gas leaks. To ensure the system's safety and security to safeguard our system, we created a mobile and web-based app that can display data from sensors to all system subscribers.

In this study, Bind (2020), a digital smart fan module is used to modulate fan speed based on room temperature. The presence of a human causes a fan speed based on room temperature to switch on or off. This project is being undertaken to reduce energy consumption.

The system was created for this investigation to reduce energy consumption, but no conditions were set for the automation of the fan controller laboratory.

P (2020) created a system that stated that power is an unavoidable part of our daily lives. To address this issue, he created a smart fan controller system because fans run on electricity. His smart fan system features a wirelessly enabled ultrasonic sensor. It is a technology that detects human presence and activates or deactivates the on/off operation. Due to two major constraints, the main goal is to reduce energy consumption. The first is due to a limited amount of electricity production, and the second is related to the overuse of electricity simply by failing to turn off devices when they are not in use.

In his study, Hariveena (2020) stated that fire detection in the home is critical to preventing property damage due to both natural and provoked fire events. The ability to recognize a fire will be useful. It's crucial because the difference between life and death could be as small as a hair's breadth. Fire can strike at any time and in any place, but the presence of a fire alarm will keep your family safe. In addition to this project, a preventive solution is introduced by installing sprinklers to spray water when a fire is detected, however electronic components in the computer lab are not permitted to use water to extinguish fire extinguishers in the event of a fire.

House combustion is the main issue for builders, designers, and property residents (Alqourabah, 2021). This research aims to develop a fire detection system that could detect fire using an integrated sensor and alert property owners and emergency services. The key features of this system were to reduce false alarms, resulting in a more dependable system.

Adam and Alzubaidi (2014) created a system that deals with the design and implementation of a Microcontroller-based firefighting system. The system uses GSM networks to connect with

its owners and implements an early fire detection method. His system dictates that temperature sensors are used by the Wireless Firefighting System to monitor its surroundings and warn the system owner if it detects smoke or fire, or if the temperature has gone outside of normal boundaries.

Dhumatkar *et al.* (2015) developed an Automatic Fire Fighting Robot that uses electrical thermostat technology to regulate the fire 24 hours a day. The system is cost-efficient, has a broad application, and may produce good and effective results when implemented. The system can be purposefully employed in industrial, commercial, and home applications where automatic control is required. It is stated in this system that fuzzy logic gives an adequate answer to an otherwise complicated task of building a precise model non-linear control system upon which conventional control techniques might be employed.

Dzulkefli *et al.* (2018) developed an innovative electric fan prototype with smart features. This electric fan has an automated capability thanks to a microcontroller. It also contains two fans, two Light Emitting Diodes (LEDs), and two sensors, which are all unique double-feature designs.

Onibonoje *et al.* (2019) complete a project that uses Arduino, temperature, and humidity sensors to adjust the fan speed automatically. Fan speed must be manually modified every time, but with this concept, the fan's speed will be automatically adjusted based on the surrounding environment.

In conclusion, all of the studies described above face the same challenge; even if they have systems that can be turned automatically, the condition to make an automation decision is missing, which our project aims to resolve by bringing the capability of performing complex sensing and recognition tasks to support human-machine interaction.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

A computer laboratory is defined as a space that provides services to a certain category of populations such as academic institutions to students who attend the institution, or by other institutions to their employees. When a fire occurs in the computer laboratory, there are risks of personal injuries, loss of lives, and loss of data and equipment which can affect the failure of the business. Then, the material and equipment used in IT to record and store data can incur damage in the event of a sustained elevated temperature. Safety of the equipment is needed for good management of the computer laboratory. Therefore, in several computer laboratories in East Africa region, an automation system that detects fire and temperature in real-time is not yet implemented. This study tends to develop a system that can help to secure the computer laboratory against fire, and sustained temperature and warn the users of the computer laboratory in case smoke is detected or water reaches the power supply. This study will help to support the student in acquiring the knowledge of new technology and in the realization of IoT projects which can contribute to the development of their countries. This study will help the researcher to improve or innovate their IoT projects.

Quantitative research relied on descriptive research has been selected and used to conduct this study to accomplish the developed system. These types of research were used to find the pertinent and precise information concerning this study.

3.2 Target Population

According to Majid (2018), the population of interest is the study of the target population that was intended to be studied, to investigate as a sample from the population that is included in the study. Then the sample is defined as the process of selecting a statically representative sample of individuals from the population of the study. Eligibility criteria are used to determine whether or not an individual is qualified to be a participant in the research study.

Aside from the advantages of the quantitative method and their abilities to use a small group of people, it is very important to define the degree to which the results will need to be generalized because it is one of the factors that determine the rigor of the study.

The population of this study included the Director of the Department of Infrastructure at EAC with which I was affiliated as an Intern, the ICT manager of EAC, the computer lab manager of two secondary schools in the northern capital of Bujumbura, and the students.

3.3 System Development Approach

Prototypes are used in many disciplines, engineers start developing prototypes before the manufacturing of a product (Carter *et al.,* 2001). Industries like to adopt the system of prototyping as models of simulations or as a partial implementation of the system to test the feasibility of certain technical aspects of the system to determine user requirements. Then, it consists of providing a version of the early system in the software lifecycle (Ince & Hekmatpour, 1987).

Evolutionary prototyping was selected because it focuses on gathering a consistent set of requirements. The main objective of this approach is to develop a system gradually, allowing it to adapt to inevitable changes for an organization using that system.

In conclusion, this approach was selected following this stepwise which explain how to design a software prototype including basic requirement which involve the understanding the very basic product requirement as presented in Fig.1.

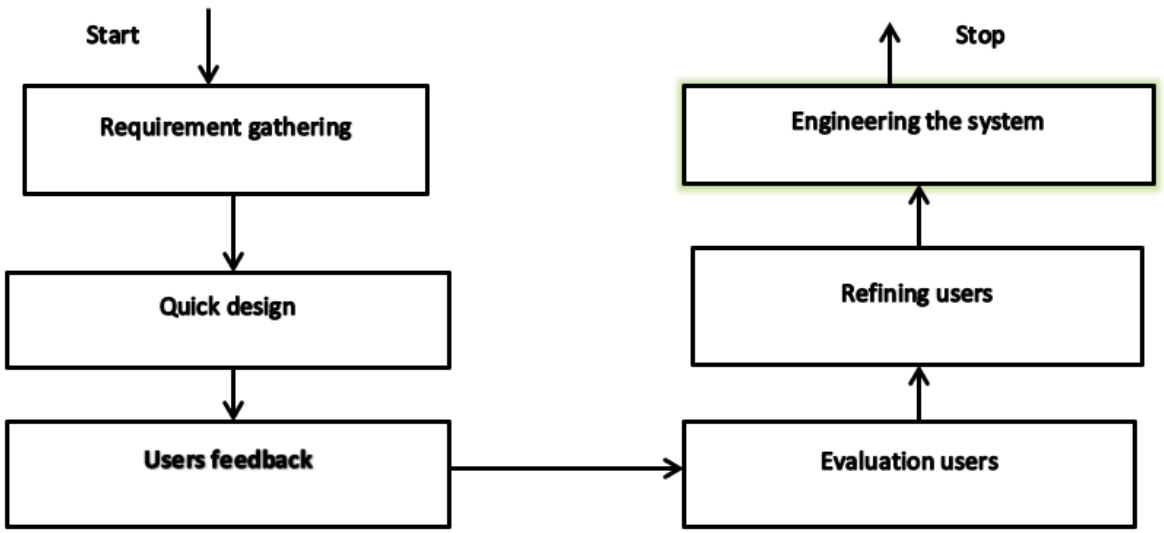


Figure 1: Prototyping model

3.4 Study Area and Scope of the Study

The study was conducted in the East African community region, particularly in ICT rooms of the East African community secretariat at Arusha city where I conducted my internship, and in computer laboratories of two secondary schools in the northern capital of Bujumbura to develop an automation system which can detect a fire and turn on automatically a fire extinguisher, turn on a fan in case of high temperature, warn users of the system where smoke is detected or water reach the power suppliers. The East African Community (EAC) is a regional intergovernmental organization of 6 partner states the Republics of Burundi, Kenya, Rwanda, South Sudan, the United Republic of Tanzania, and the Republic of Uganda, with its headquarters in Arusha Tanzania as shown in Fig.2.

Figure 2: East African Community Headquarters Arusha

View of Technical Lycée of Saint Luc computer laboratory as presented in Fig. 3

Figure 3: Technical Lycée of saint Luc Computer Laboratory

Secondary technical School of Carama Computer laboratory as presented in Fig. 4.

Figure 4: Secondary Technical School of Carama computer laboratory

3.5 Data Collection Methods

This method was carried out with aim of collecting data that is quantitative and descriptive. In this study interviews, observation, and documentation review were used.

(i) Interview

A structured interview which is a quantitative research method that uses a set of the prepared close-end question was conducted to understand the function of the computer laboratory and which system of protection was used.

(ii) Observation

The observation was done during the visit in two places of ICT room in East African Community headquarters at Arusha city and the computer laboratories of two secondary schools in the northern capital of Bujumbura. These visits have conducted me to understand the challenges of the manual setting of protection and how can be resolved with an automated system.

(iii) Documentation Review

Different works related to different studies such as book, documentary, and article was used to get more information regarding this study. The aim was to review existing documents related to the project was done to gather background information, to understand the operation of the existing system of protection against fire and high temperatures, and how implementation can be performed to innovate the existing systems.

3.6 Software Requirement and Architecture Design

(i) Software Requirements

During the development of the system, the windows10 operating system was used. Windows 10 is among the new version of OS that has a long-standing. It can be used as the bridge between tablet and desktop experience, it delivers one comprehensive app platform, one security, one deployment, and a management approach to create a universal experience across devices.

(ii) Web-based App and Mobile App

The developed system was based on web applications and mobile applications. It was designed to be used by different types of users such as computer lab managers, staff, administration officers, employees, and students. An administrator of the system can perform the administrative activity. The system keeps all information available for users regarding value recorded from the sensors. Furthermore, to access the system, there are restrictions added. All users must be registered and log in to see the value recorded from sensors and perform certain tasks of the automation system. Administrators can retrieve or add to the users the permissions to perform certain tasks. Figure 5 and Fig. 6 show how user authentication and user registration are presented in the system.

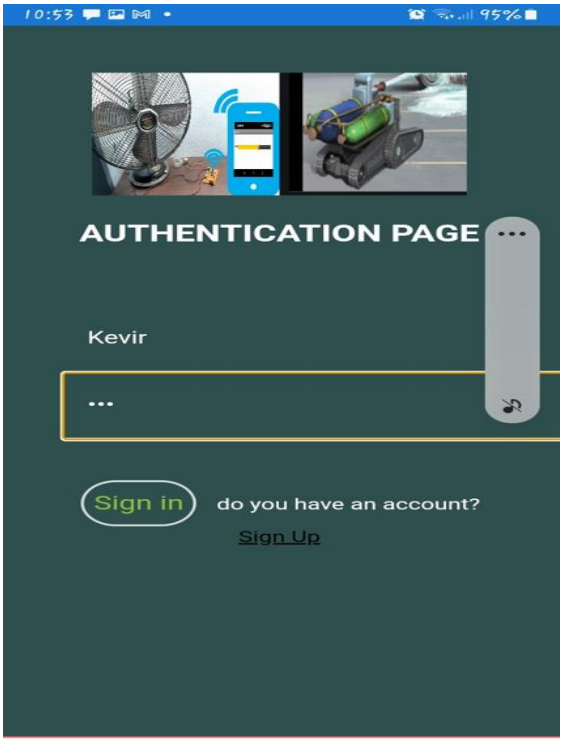


Figure 6: Interface for users' authentication

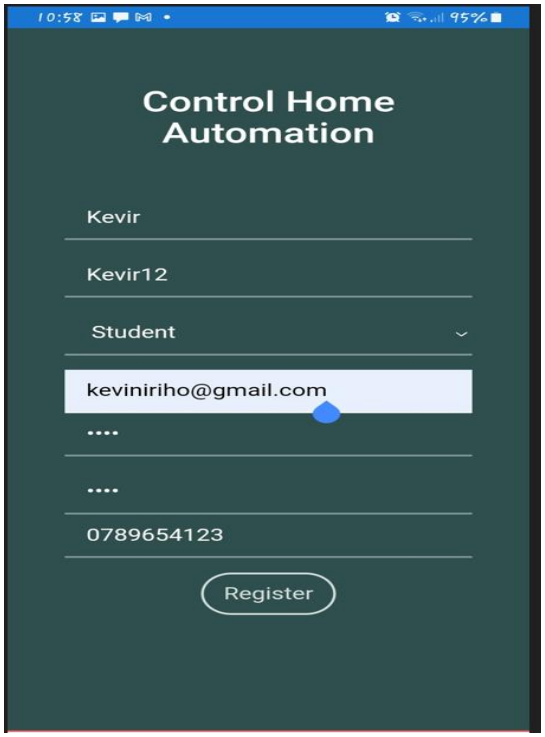


Figure 5: Interface for users' registration

(iii) Context diagram

A context diagram is defined as the level 0 data flow diagram which establishes the relationship between the systems with the external entities. The context diagram consists of the highest level of the data flow diagram.

A context diagram is an excellent tool to facilitate brainstorming between design and analysis. It also makes a skeleton, simply and straightforwardly of the project's scope. The context diagram presented in Fig.7 shows the functionality of the developed system.

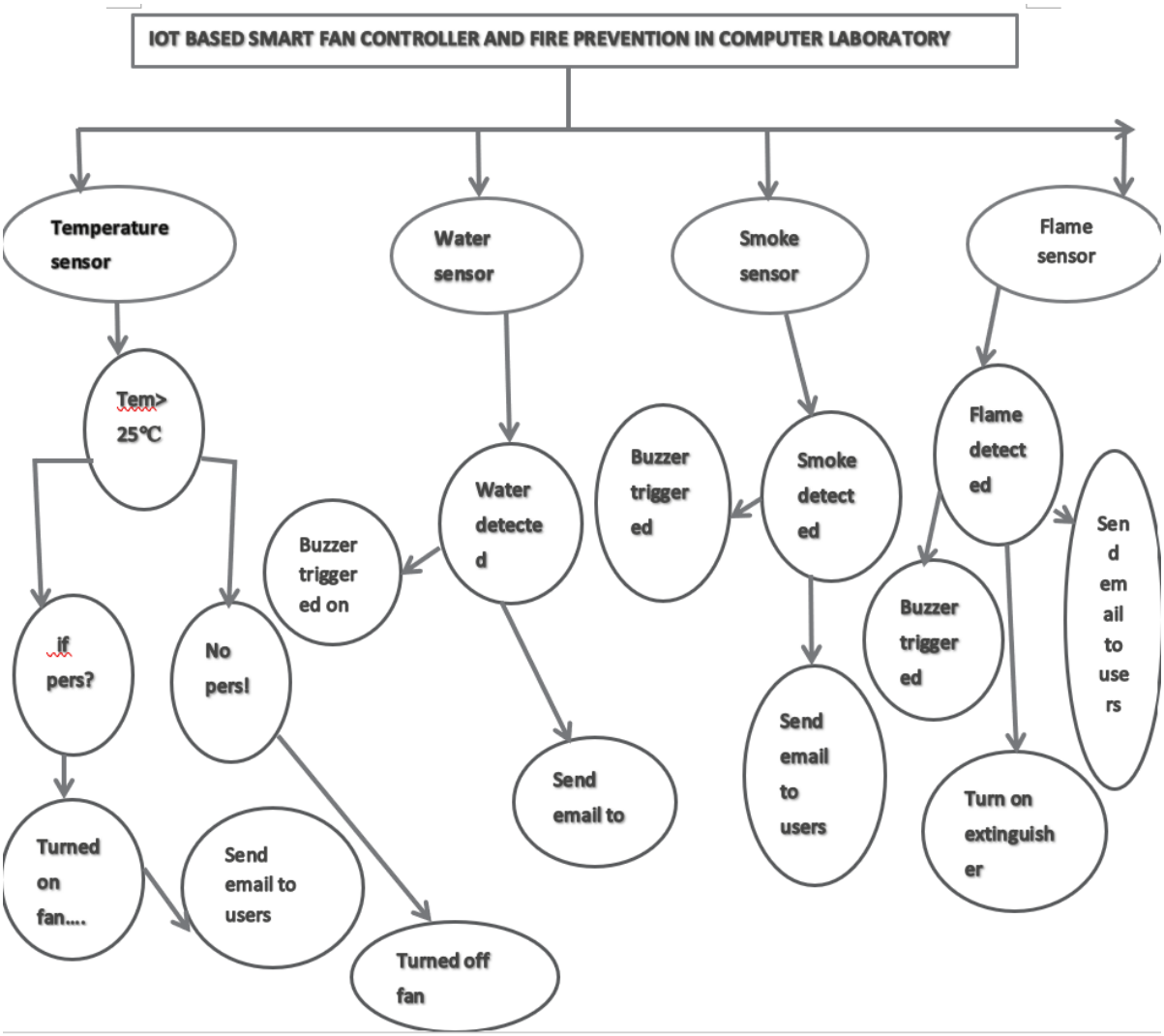


Figure 7: Flow chart diagram

(i) Database design

Database design consists of the collection of the data process and how was organized into a database model. A designed database provides the access to updated and accurate information.

A good database designer starts with a list of data that he wants to include in his database and what he wants to be able to do with the database later. Database designer provides the way or how data are going to be stored in the database for the overall performance of any application.

Finally, the designer should follow the constraints and decide how the element correlate and what kind of data must be stored.

3.7 Software Development Tools and Programming Languages

This part relates different tools and programming languages used to accomplish the development of this system. Software development tools perform the same task as an application or program. It can be used by developers when they want to create, maintain, test, build, debug, fix and support a software application or product. Users use it when they want to streamline and automate different software development tasks. In this project, different software tools have been used. They have used among other things following his performance, analysis, testing, verification debugging, and building application (Dhlamini & Nhamu, 2009).

Programming language as a command instruction and other syntax was used to create a software program. This language allows programmers to write high-level code that can be compiled into the low-level language which is recognized by computer software.

(i) Sublime Text Editor

The sublime text editor is defined as a text editor which is widely used by developers to create programs or applications. It contains several features which allow them to have a syntax highlight auto-indentation, file recognition, sidebar, plugin, and package that make it easy for working with the code base.

Sublime text support many file types that can reach more than seventy, multiple sections, multiple windows, and split windows. With a sublime text editor, we can customize the color scheme, text font, global key bindings, the tab stop, the file-specific, snippets, and even the syntax highlighting rule.

Sublime Text can be downloaded from the official website. Now, the latest version of the sublime text is version four (sublimetext4) compatible with OSX, windows, windows 64, and Linux.

Sublime was used during the coding of the developed system regarding user interface, data insertion, data displays from the database, and communication between sensors and database.

(ii) PyCharm

PyCharm is defined as a python environment integrated to provide a wide range of essential tools used by python developers when they want to create a convenient environment for

productive python, web, and data science development. It is compatible with Windows, Linux, and Mac OS versions. It was used during data analysis of data gathered during data correction.

(iii) XAMPP

XAMPP is a free and open-source cross-platform web server that is used by different servers and languages such as Apache HTTP server, MariaDB, and script languages like PHP and PERL. It is available on Windows, macOS, and Linux systems. XAMPP can be downloaded and run with zipping, tar, and exe file. Microsoft visual C++2017 redistributable is required to install when you are using windows OS. There are different modules included in XAMPP such as OpenSSL, phpMyAdmin, Mediawiki, Joomla, WordPress, etc.

XAMPP allows the developers to create and test their program on a local webserver. It is available in 11 languages and supported by different platforms such as IA 32 packages of windows and X64 packages of macOS and Linux. Xampp was used for the storage of data in data phpMyAdmin.

(iv) PHP

PHP is a popular language for server-side scripts applications. It allows developers to build a web application that can be run in a web browser. PHP contains several extensions that allow it to interact with the database and extract data to be displayed on the web page and store information in the database. For its characteristics, PHP is recognized for safety performance, multiplatform incapability, and high operating efficiency and is free. PHP was used for making a web-based application or mobile application dynamic. It allows inserting data in the database, displays data stored in the database, allows to receive data posted on the webserver to be inserted in the database, and allows performance action of sending email via PHP mail file.

(v) HTML

HTML is a language for displaying data in a web browser. HTML is the language used to develop websites. HTML files are ended by.htm or .html extension, HTML element is also consisting of a set of tags and attributes. A tag shows to the browser when the elements begin or end. We distinguish three main parts of an element.

- Open tag is used to show where the tag start
- Context used to contain output element to be displayed

- Closing tag to end the tag

There are many tags used in Html such as tag for heading which starts by h1 to h6, the output to be displayed with this contained between the tag, their size increases from h1 to h6 tag for a paragraph which is used to put the element in the paragraph, he starts by …. output element to be displayed …. .

We find many HTML tags used to follow the design you want to build in the block of HTML pages. Html was used to build the interface of users that interact with the system. HTML offers simple structures of size which are greater and improved by other languages like CSS, JavaScript is used mainly for design and styles. In this system, HTML was used because it is easy and can be incorporated into other languages. During the development of the developed system, HTML was used to design graphics, tables, and user interfaces such as user registration and user registration, and user authentication.

(vi) Python

Python is a scripting language that is more popular in data science. It is used to harvest insights from their data and gain a competitive edge. Python is a high-level programming language that is easy to read and implement. It is open-source which means it's free to use even for commercial applications. Python can be run on Mac OS, Windows, and Linux systems. It is used for building software, talking to embedded electronic web scraping, websites, data sciences, and artificial intelligence.

Python is also an interpreted object-oriented, high-level programming language with dynamic semantics. It is high-level built-in data structures, combined with dynamic typing and dynamic binding, make it very attractive for rapid application development as well as for use as a scripting language to connect existing components. There are different versions of python until now; we are on 3.9.7 as the latest version.

Python can be executed in the command line with for example:

C:\Windows\system32>python

Python 3.9.5 (tags/v3.9.5:0a7dcbd, May 3 2021, 17:27:52) [MSC v.1928 64 bit (AMD64)] on win32

Type "help", "copyright", "credits" or "license" for more information.

>>> print (" hello world")

hello world

Python can be connected to the different databases we use, for example for Postgresql, we need to install the pyscopg library to be connected and create a database and store the data.

Example of installation of pyscopg packages

pip -m install psycopg2>=2.8.0

To connect to the database created, we have to import pyscopg in python file code. His syntax is:

```
Import                                                    psycopg

connection          =          psycopg.connect          (host="localhost",
                           database="database                        name",
                           user="postgres", password="none")
```

Python as a scripting language was used to analyze data gathered during data correction via his library matplotlib.

(vii) CSS

CSS is the language for making styles to the web pages, including color, layout, and fonts to make our web pages presentable. It is independent of HTML and can be used with XML-based markup language.

CSS is used to define the style for webpages and the styles definitions are normally saved in external pages using link **<link rel=" stylesheet" href=" file name.css**"> CSS files with an external stylesheet are used to change the look of the entire website by changing just HTML file.CSS was used to make form designed by HTML tag.

(viii) Bootstrap

Bootstrap is a free and open-source CSS framework that makes it responsive for mobile-first front-end web development. It contains CSS and JavaScript based on templates for topology for button navigation and other interface components.

Bootstrap has HTML, CSS, and JavaScript as a library that focused on simplifying the development of informative web pages. The main purpose of adding it to a web project is to apply bootstrap choices of color, size, font, and layout to that project. The bootstrap framework was used to make user interface fix and to allow the developed system to be viewed via mobile and web-based applications with a fixed interface.

(ix) MySQL

MySQL is a tool used to create a database for storage, manipulation, and definition of each table. It has been known as the best tool for relational database management and is based on structured query language. It enables users to request information by using SQL statements.

3.8 Hardware Tools

(i) DHT22

DHT22 is calibrated with a final signal. It is used for humidity sensing and temperature sensing technology assuring its reliability and stability. DHT22 has different features such as small size, low consumption, and long transmission distance(20m). It has also 4 pins (1 for VDD, 2 for data, 3 is null,4 for GND) as shown in Fig.8. DHT22 was used to control fan-based room temperature.

Figure 8: DHT22

(ii) Ultrasonic Sensor

The ultrasonic sensor is an electronic device that measures a target object by emitting ultrasonic sound waves and converting the reflected sound into an electrical signal. The measurement range is up 11m. It is used as a primary proximity sensor. Figure 9 shows the interface of the

ultrasonic sensor. An ultrasonic sensor was used for human presence detection based on distance measurement.

Figure 9: Ultrasonic Sensor

(iii) Fire extinguisher

The fire extinguisher is a device that is used to extinguish fire or control fire in case of an emergency. It was used to push gas for extinguishment in case of fire detection. Figure10 shows devices used as fire extinguishers.

Figure 10: Fire extinguisher

(iv) Fan

A fan is a device machine that is used to create air. It is used for circulating air in rooms and buildings. It was used to act as a fan controller base on room temperature and the presence of the person. Figure 11 shows the interface of the pedestal fan.

Figure 11: Fan

(v) Solenoid Valve

A solenoid valve is an electrically controlled valve. It converts electric energy into mechanical energy. In this developed system his objective is to regulate the movement of gas or liquid and eradicate the need for an engineer to manually control the valve. Figure 12 shows the electrical solenoid valve.

Figure 12: Solenoid valve

(vi) Water Sensor

Water sensors detect the presence of water when it is placed in a location where water should not present a leak. It can be used to detect the water level, the volume, and the absence of the water. Water has three terminals as shown in Fig.13.

Figure 13: Water sensor

(vii) Relay Switch

Relay switches open and close circuits electronically. It controls one circuit by opening and closing contacts in other circuits. It controls a set of terminals for single or multiple signals. It was used as a switch to perform an act of opening or closing automatically a fan following

whether of environment room with the presence of the person and also to open a fire extinguisher in case of fire detection. Figure14 shows the interface of the switch relay.

Figure 14: Switch relay

(viii) IR Flame Sensor

The flame sensor is an electronic device that is used to detect a fire in the place where is placed. Figure 15 shows the interface of the flame sensor. It was used to detect the presence of fire and allow triggering prevention activities such as sending of email, triggering of buzzer and fire extinguisher.

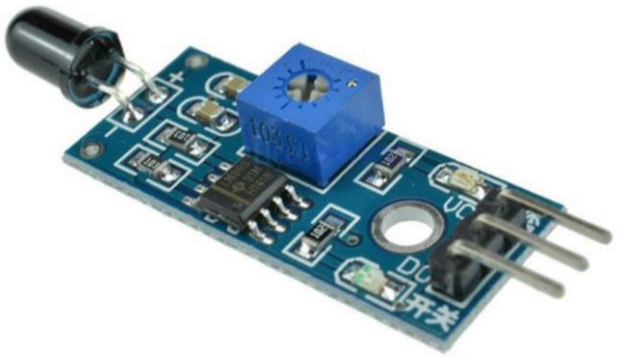


Figure 15: Flame sensor

(ix) MQ2 Sensor

MQ2 sensor is used to detect gas or smoke places where is placed. It can be used also for sensing the concentration of gases such as propane, methane, LPG, and hydrogen. It works in a concentration range between 200 and 10 000 ppm. Figure 16 shows the interface of the MQ-

2 sensor. It was used to detect the presence of smoke and warn the users by the action of sending an email and triggering a buzzer in case of smoke detection.

Figure 16: MQ2 sensor

(x) Buzzer

The buzzer is an actuator used to push a sound in a place where is placed to send the alarm. It was used for triggering a sound to warn the users in case of smoke, water, and fire detection. Figure 17 shows the interface of the buzzer.

Figure 17: Buzzer

(xi) ESP32-WROOM-32D

ESP32-WROOM-32D is a low-cost system-on-chip microcontroller. It is used to program IoT projects. It is integrated with WIFI and it can be programmed with the different environments such as:

- Arduino IDE
- Platform IDE
- LUA

- Micropython
- Espressif IDF
- JavaScript

Figure 18 represents ESP32-WROOM-32G. It was used to post data uploaded by sensors to a database hosted on the web server and it allows to control the action of warning users when fire, smoke, heat, and water leakage are detected or open automatically fan or fire extinguisher in case of any threat such as temperature more than 25℃ or fire is detected.

Figure 18: ESP32-WROOM-32D

(xii) NodeMCU ESP8266

NodeMCU ESP8266 is open-source firmware, it is integrated with WiFi from the Espressif system, and the hardware is based on the ESP-12 module. It was used to post data uploaded by sensors to a database hosted on the web server and it allows to control the action of warning users when fire, smoke, heat, and water leakage are detected or open automatically fan or fire extinguisher in case of any threat such as temperature more than 25℃ or fire is detected. Figure 19 below shows the interface of NodeMCU ESP8266 (ESP-12F)

Figure 19: NodeMCU ESP8266 (ESP-12F)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Assessment of Findings

4.1.1 Demographic Information

This study aimed at interviewing 80 individuals based on their cluster. However, 64 individuals accepted to respond to our questionnaires. Results showed that 57.81% of females were interested in the interview compared to 42.19% of males. This gender balance was important as far as the sample was concerned.

To meet the gender balance, this study was challenged by several females who showed interest in using a computer laboratory. This study shows that 57.81% of female students used a computer laboratory that 42.19% of male students.

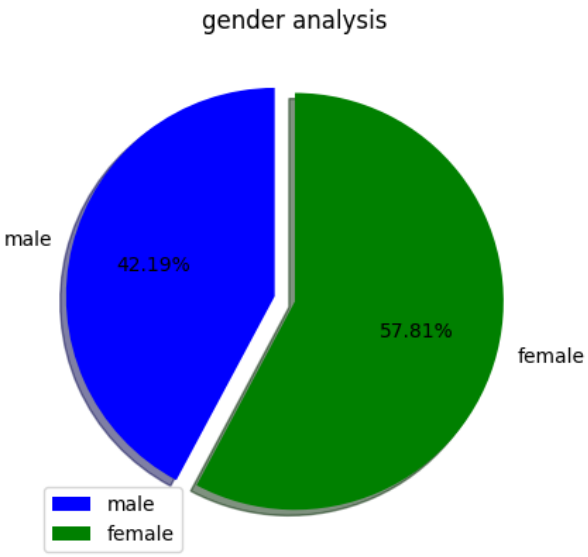


Figure 20: Gender information

The study sampled the respondents based on their age group. Among 64 individual respondents in this study, 40 respondents were aged between 16 and 18, 12 were aged between 19 and 24, 10 were aged between 25 and 35, and 2 were aged above 35.

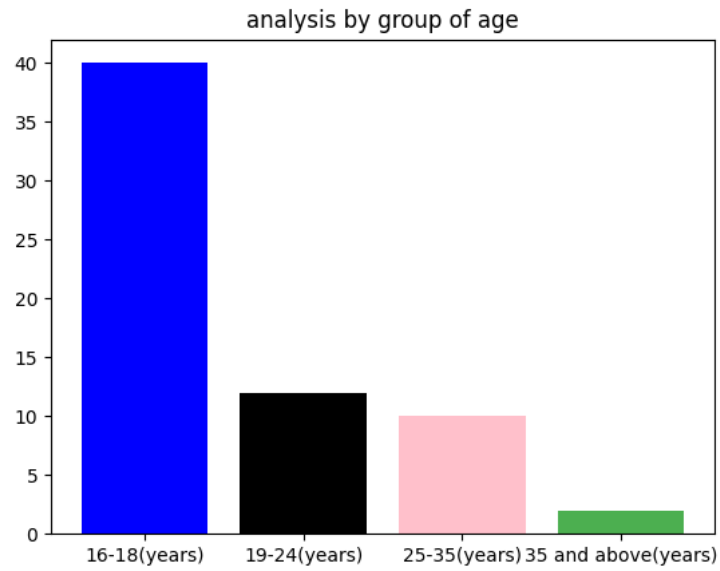


Figure 21: Analysis of respondents by age

According to the respondents who participated in this study, the majority (50) of the respondents were secondary school students, 12 were holding bachelor's degrees, and 2 were postgraduates.

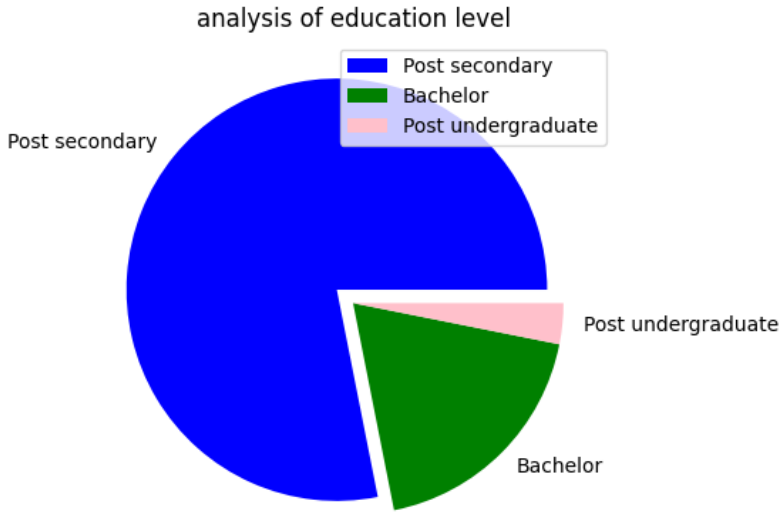


Figure 22: Analysis of respondents by the level of study

4.1.2 Main Source of House fire

The study aimed to understand the main cause of fire in the house, out of 52 respondents 16 said electrical appliances due to overloading which damages the cable and generates short circuits, and 3 said that the cause could be the heating system when you put cooking devices

near the heating system. Fifteen said the candles, 8 said smoking, and 10 said old and inadequate wire could be also the cause of fire in a house.

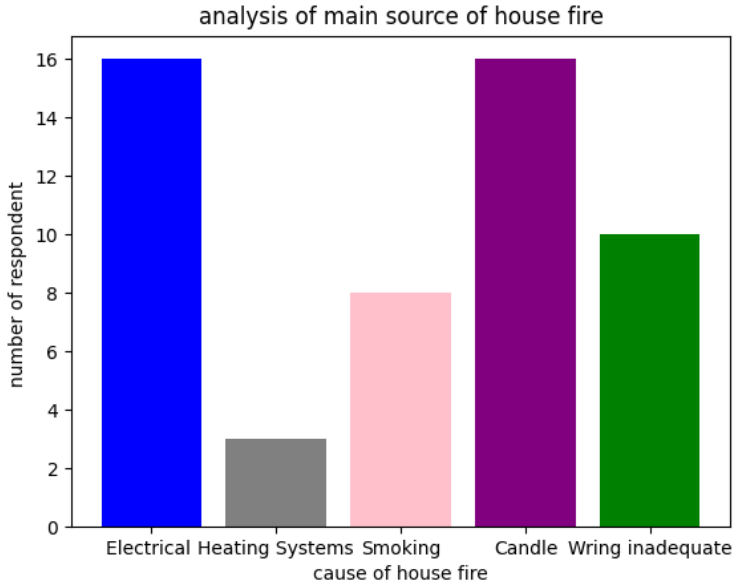


Figure 23: Source of fire

4.1.3 Computer Equipment in East African Laboratories

According to the documentation surveyed during the development of this study, it showed that 80% of computer laboratories are equipped with desktops and 20% are equipped with laptop computers. Several computer laboratories are equipped with either laptop computers or desktop computers. To monitor these devices, there is a need for an IoT Based Smart Fan Controller and Fire Prevention in Computer Lab which is not yet implemented.

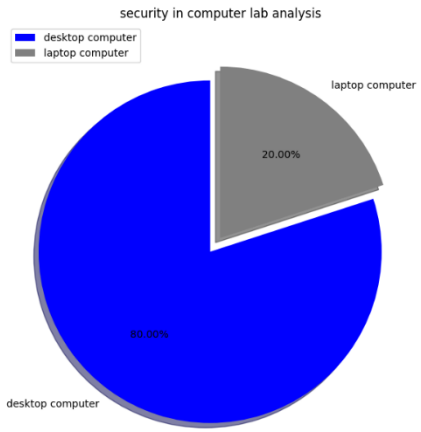


Figure 24: Security in Computer Lab Analysis

4.1.4 Internet access and devices connected

Internet of Thing Based Smart Fan Controller and Fire Prevention in Computer Lab use the internet to access data and automation of devices. Among the respondents who participated in the survey, 40 have a connection to the internet through their smartphones and 24 have no access to the internet. Following this, it was concluded that the majority of the respondents have an internet connection which allows this study to have a good impact on society.

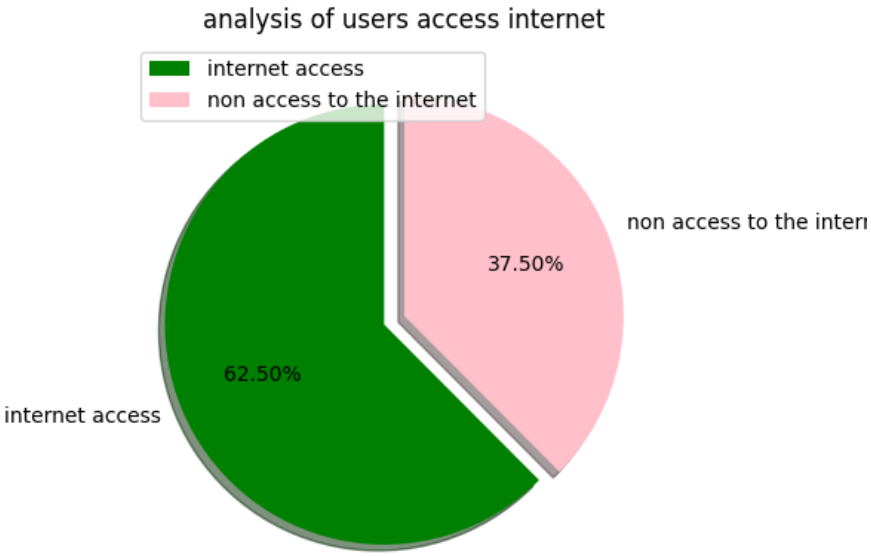


Figure 25: Analysis of user's access to the internet

4.2 Result and Discussion for the Developed System

In this section, we present data from the study's findings, as well as the methodology that was used to develop this Internet of Thing-Based Smart Fan and Fire Prevention in Computer Laboratory System.

4.2.1 Description of the system design

(i) The design of this developed system is composed of three nodes that communicate separately. The first node is composed of two sensors, one microcontroller (NodeMCU ESP8266), one actuator (buzzer), one fan, one switch relay, one PCB, and different wires. The sensors which composed this node are temperature sensors (DHT22) and ultrasonic sensors. They have been used to allow turning on the fan automatically in case there is a high temperature and also when there is a person inside the computer laboratory. The data from these two sensors were recorded and inserted into a database

hosted on a web server. The fan is controlled via smartphone android, mobile app, and web-based apps are designed to perform the task. Also, data were visualized via mobile and web-based applications.

(ii) The second node was composed of two sensors, and one microcontroller (ESP32-WROOM-32D). The sensors used are smoke sensor (MQ2) and water sensor. The functionality of those two sensors was to detect smoke and water leakage in the computer laboratory.

(iii) The third node was composed of one sensor, one solenoid valve, one fire extinguisher, one microcontroller, one switch relay, one actuator, and different wires. The sensor used is a flame sensor. It has been used to detect the presence of fire. In case a fire is detected, a buzzer triggers a sound to alert the users to warn them of the presence of fire.

(a) Smart Fan Controller and System Performed

Internet of Thing based smart fan controller module was developed for monitoring and controlling fans based on room temperature of more than 25°C and also with the presence of a human. The values obtained from the two sensors used in the developed system are sent to the database and the ThingSpeak cloud. In this study, IoT based smart fan controller system was developed for monitoring and controlling fans based on room temperature and also in the presence of a human. The values obtained from the two sensors used in the developed system are used to record and sent to the database and ThingSpeak cloud. Figure 26 steps demonstrate how a smart fan controller is performed from the prototype implemented on PCB to the graph of ThingSpeak.

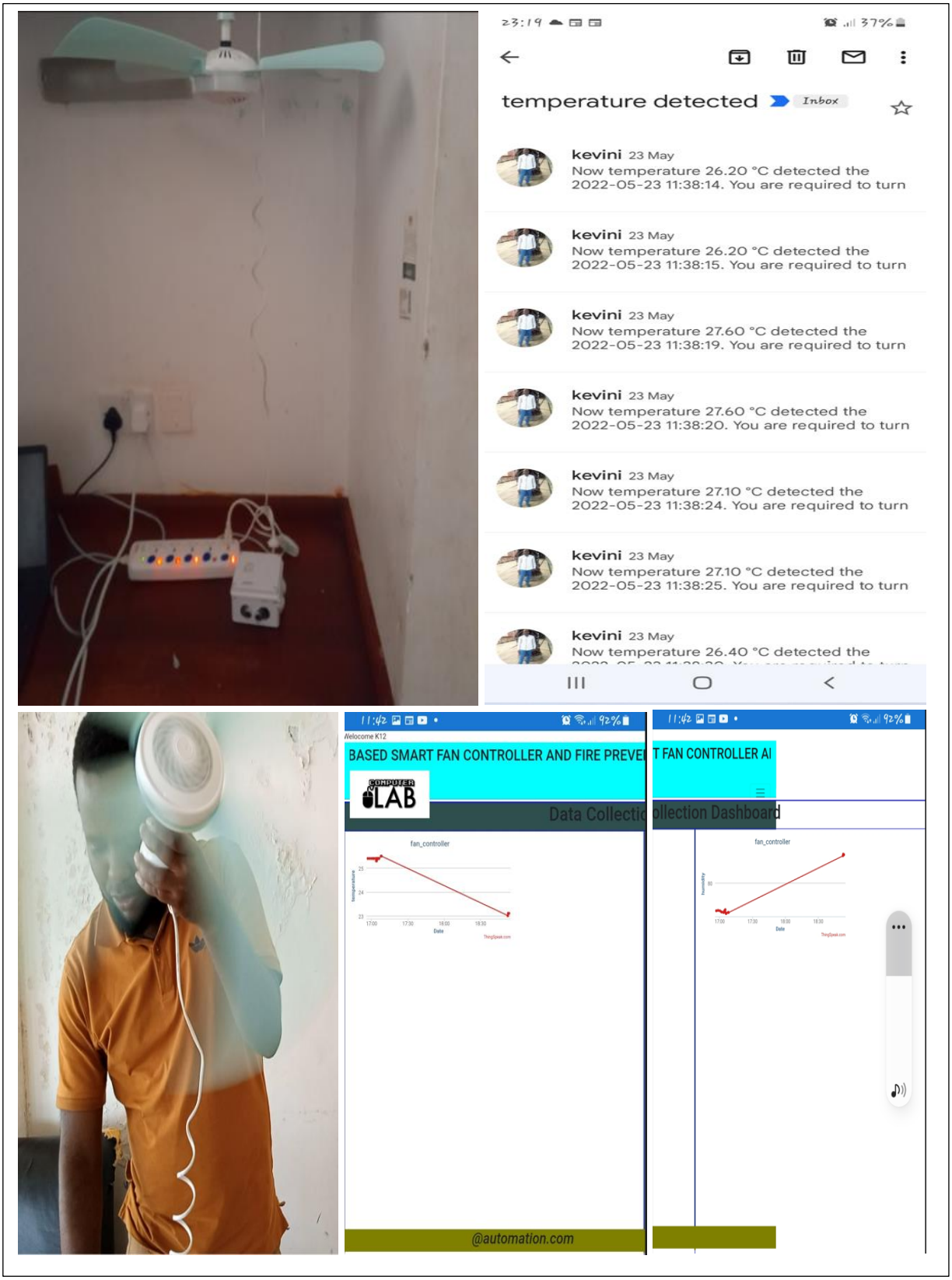


Figure 26: Fan module context performance

(b) Smoke detection and water leakage

Smoke detectors are important for the safety of the buildings. Smoke detectors detect and warn the owners and the users of the building automatically in case there is the presence of smoke. Indeed, smoke leads to disease and harms nearly every organ of the body. Smoke can cause different diseases such as cancer, heart disease, stroke, and lung.

As it is important to use smoke detection for the safety of the house, it is also important to use a water detector because it can detect water leakage in the house which is the cause of short circuits and can cause loss of lives and equipment or property.

The developed IoT based for smoke detection and water leakage was developed to control and monitor water leakage and smoke spreading in the computer laboratories. Two sensors were used to accomplish this task an MQ-2 sensor and a water sensor. The value from those sensors is recorded and inserted into the database. The value from those sensors will allow detecting smoke and watering leakage and warn the users of the computer laboratory. The action of sending emails to the users in case there is the detection of smoke or water leakage will be based on data inserted in the database.

Finally, this system is developed to warn the users when there is the detection of smoke or water leakage, buzzer will trigger a sound once there is the detection of either smoke or water leakage. Figure 27 steps of operation designs of smoke detection and water leakage using the smoke sensor.

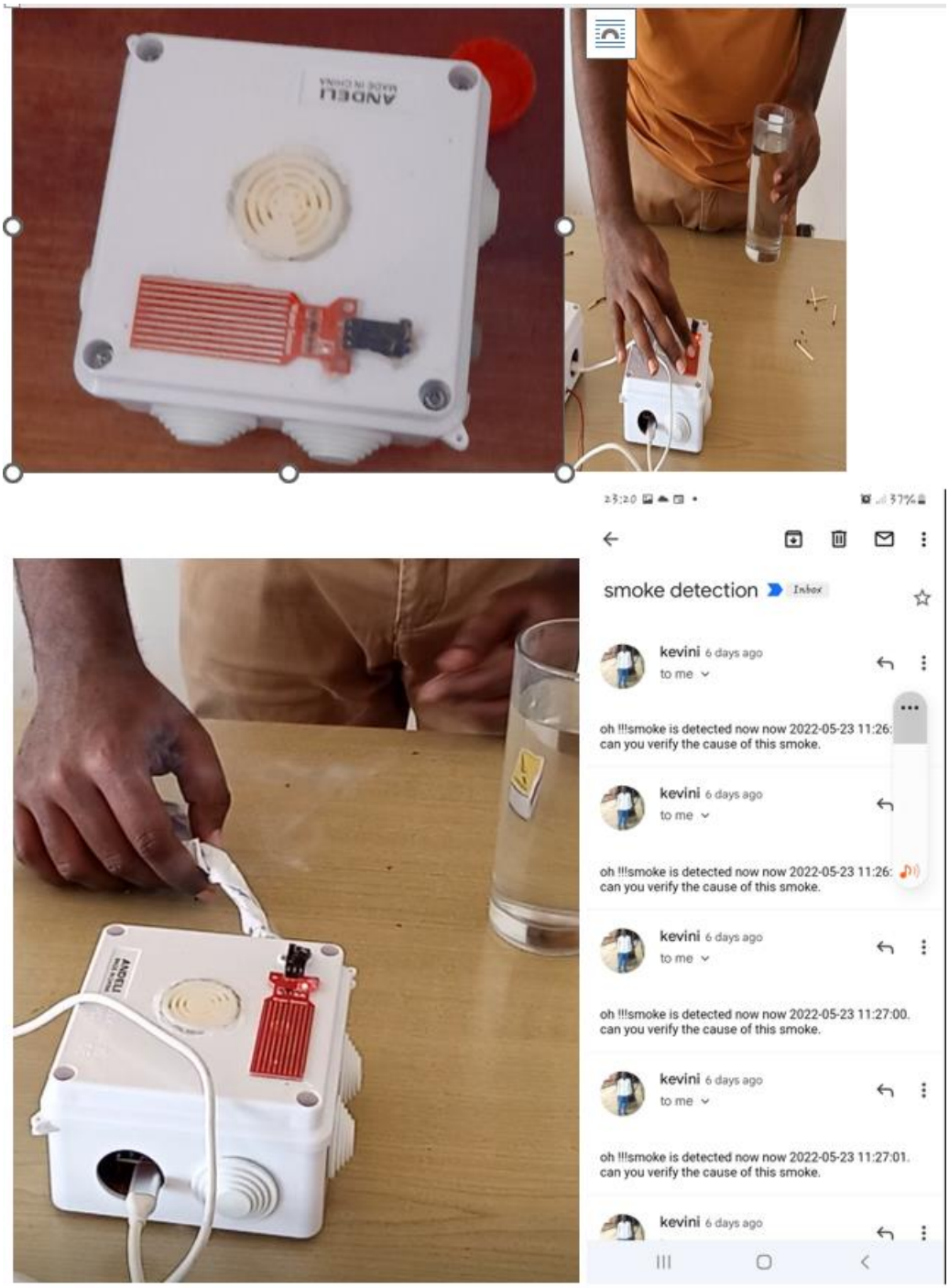


Figure 27: Smoke and water detection context

(c) Fire prevention in the computer laboratory

When a fire occurs in a computer laboratory, there is a lot of loss to business continuity, either as a result of equipment loss, data loss, and loss of lives. The IoT-Based Fire Prevention in Computer Laboratory system was developed to detect the presence of fire in the computer laboratory and perform necessary steps. To make this system effective, the flame sensor was

used to detect fire in the computer laboratory and an actuator (buzzer) was used to trigger an alarm each time fire is detected.

Then, once the fire is detected, a message is sent which shows that fire is detected, the information is sent to the database and an email is sent to the users. The email sent to the users comes from the data stored in the database and the action of triggering the fire extinguisher is automatically taken in real-time as at the same information is stored in the database. Figure 28 steps which shows fire detection design.

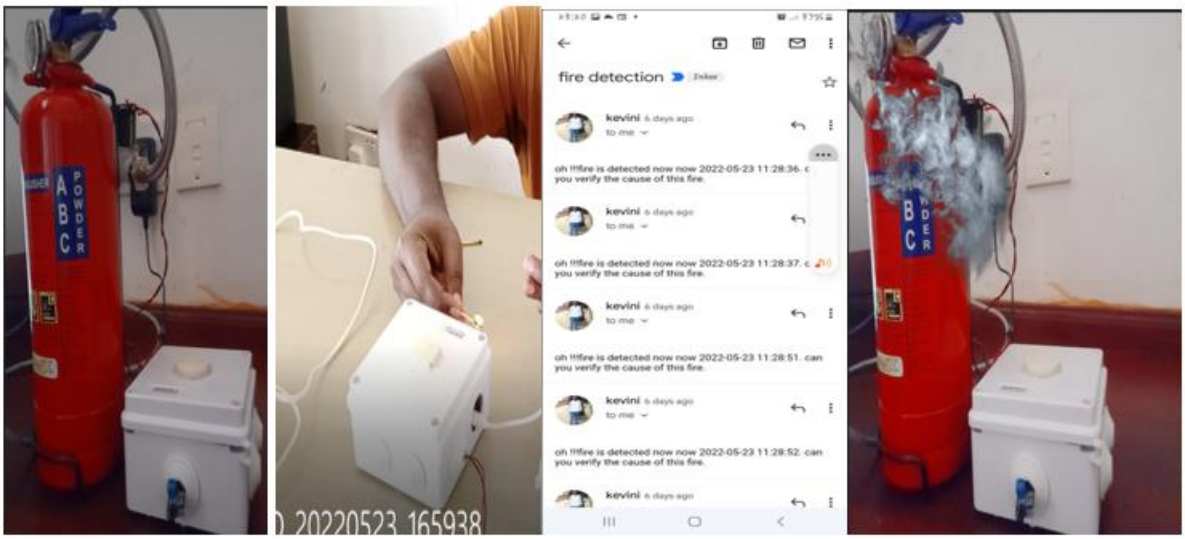


Figure 28: Context prototype of fire prevention

4.2.2 Description of the developed system

The developed system allows the users to register and access different values or data recorded from sensors via mobile applications and web-based applications.

(i) Mobile application and Web-based application

Mobile applications and web-based applications have been developed to allow the user of the system to access the data recorded from the sensors from anywhere they are via their smartphone, their laptop computer, or desktop computer. To access those data, the application and database are hosted on the web server and data are accessed when there is the internet. The developed system includes different functionalities such as user registration and user authentication which allow the users to redirect to other pages.

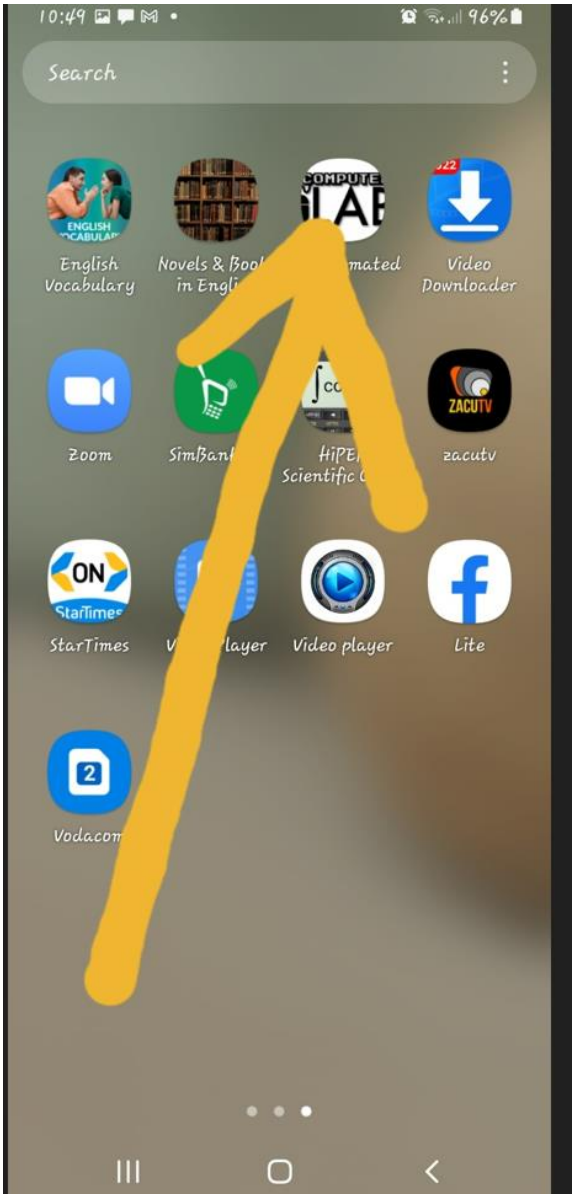


Figure 29: Lab automated mobile App

(ii) User Registration

User registration allows the users to be registered to a website, program or application, or other systems which need the user's credentials for their subscription to get some services. In this developed system, user registration was integrated into the system. Users are differentiated according to their rights to access different pages once they are authenticated. After registration, the users are redirected to the authentication page. The user must remember their username and password for authentication.

Finally, the credentials of the users registered in the database are stored also in the database hosted on the web server. The credentials for users include name, username, identifier, email, password, and telephone number.

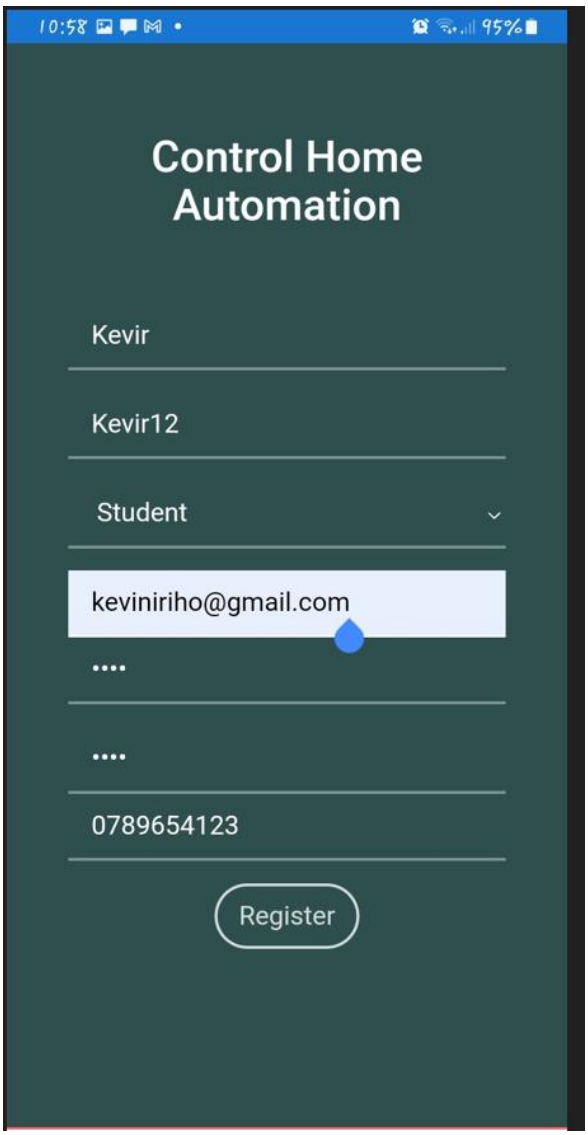


Figure 30: Lab automated user registration

(iii) User Authentication

The user authentication interface allows users subscribed to the system to access different functionalities of the system. The developed system allows the users registered on IoT based smart fan controllers and fire prevention in the computer lab system to access all available data recorded from sensors and the last 10 entries are displayed from those sensors. To authenticate, the users must be registered and must remember their credentials such as the username and password used for the authentication.

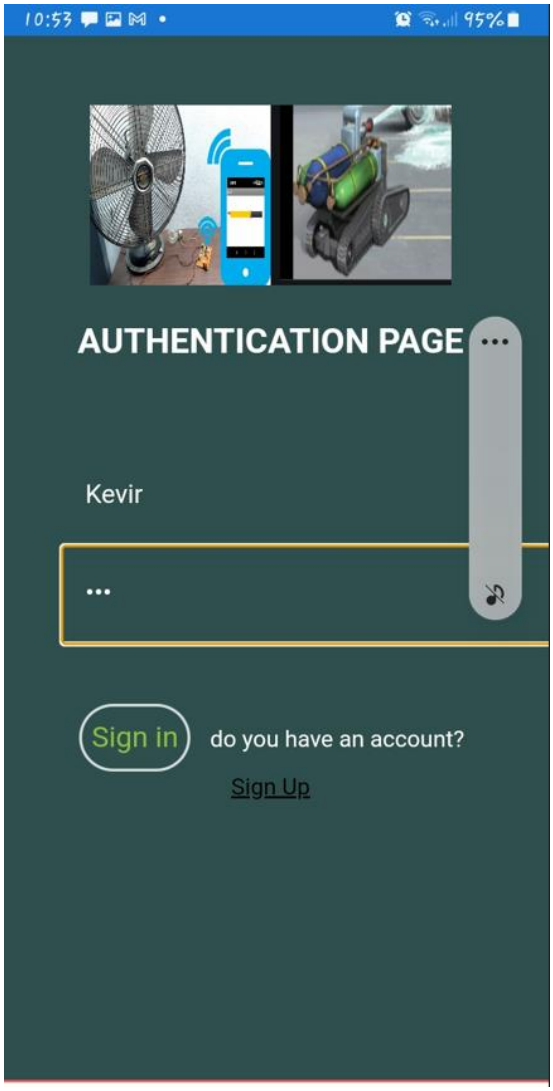


Figure 31: Lab automated user authentication

(iv) User Admin

The developed system IoT based smart fan controller and fire prevention in computer lab admin function has been created to perform the different tasks on users registered such as deleting and editing. The admin can delete or update the information of the users.

Figure 32: Lab automated user admin

(v) Management of the System

The management of the developed system allows the attribute of some functionality to access different pages and tasks. For example, if a user is registered as a student, it allows for him or her only to see data recorded from sensors but lab managers or staff, are allowed to perform other functions beyond only seeing data recorded from sensors.

4.2.3 System Validation of the Developed System

System validation is a set of actions needed for the development of a system. Different actions were taken to achieve the user requirements and functional requirements to avoid risk. In this developed system, different steps were taken to validate and realize the system in terms of software and hardware requirements, unit testing, integration testing, system testing, and acceptance testing of the developed system.

(i) Analysis of Hardware and Software Requirements

Software and Hardware are key elements used for the development of IoT system-based smart fan controllers and fire prevention in the computer laboratory. To realize this system, the software has been used for programming the sensors using programming languages. The sensors and microcontrollers used were compatible with the internet which allows the system to be IoT based. Programming languages used were able to design, record, display, edit, and delete, either the information or data regarding the users and sensors. Hardware used was able

to set the information of temperature, smoke, water leakage, and fire and trigger action of fan controller or fire extinguishing following the detection of either fire or high temperature.

(ii) Unit Testing

Unit testing focused on verifying different parts of the system to check if they are all working as expected. These parts were tested separately. For the developed system, the units that were tested are User login, User registration, data insertion to the database from sensors, restriction on access to different pages, control of the fan, control of fire extinguisher, and also, the action of sending email to lab Managers in case of high temperature or presence of fire.

(iii) Integration Testing

Integration Testing follows unit testing, it focused on verifying different parts of the system to check if they can work together properly. The main purpose is to test or verify if there is consistency between software and hardware requirements, and verify if different functionalities can work properly. For example, you cannot log in if you are not registered. First, you have to register then you are redirected to the login page. After authentication, the user is redirected to other pages according to their user rights.

(iv) System Testing

System testing follows the integration testing, it was conducted to test if the developed system meets the specified requirements of the end-users. It is the final step for verifying if different types of testing such as unit testing and integrating testing meet the specification of the developed system. Finally, the developed system is hosted on the web server and data from sensors or applications were stored in the database on the webserver for later retrieval.

(v) Acceptance Testing

Acceptance testing was conducted on both software and hardware are tested to see whether both are working properly intending to evaluate the system’s compliance with the business requirement. This test was performed by the end-user for verifying both software and hardware before the final implementation of the system in the production environment.

4.3 Discussions

The findings of this study show that the majority of females were more interested in computer laboratories than the male with a lot of desktops than a laptop. The study also shows that the source of the fire was an electrical appliance compared to the smoke, heating, and candle.

Regarding the results from testing the study shows that variation of temperature varies between 23℃ and 27.60℃, 11 times fire detection and 33 times smoke detection. It has been found from the results which are in the database. For the placement of all tools, the fan controller is controlled by DHT 22, and an ultrasonic sensor is placed near the entrance of the computer laboratory to detect if there is a person in the computer laboratory triggering the fan when the temperature is more than 25 ℃. Then smoke and water supply will be placed near the power supply of the computer laboratory to detect the presence of water which can cause a short circuit and also detect smoke which can come from of short circuit. In the case of fire, it will be placed at the center of the computer to the wall to push the gas in all computer laboratories when the fire is detected. Finally, the developed system will be online with a web-based application and mobile application.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The computer laboratory is built with a lot of money. It is used to provide services to certain categories of the population; it can be used by an academic institution for research by its students and commercial institutions for the public. When the incident of fire occurs in the computer laboratory, it could cause a big loss to the business continuity. Then in case of high temperature, the computer laboratory can be damaged due to overheating even though the lab is having fans, but when they are not used correctly overheating can still happen.

Therefore, this study presents the analysis and the results from the research carried out in the ICT room of East Africa Community Headquarters in Arusha City and two computer laboratories of two secondary schools north of Bujumbura in Burundi.

The developed IoT based smart fan controller and fire prevention in computer laboratories are to warn and trigger action of prevention for the user of the computer laboratory in case there is the detection of fire, smoke, water, and high temperature. The system has different modules such as user registration and user authentication. To access different functions of the system, the user must be registered first.

The developed system is made of three nodes that communicate separately but have the same database in common which senses and detects whether computer laboratory environment. The values recorded from the sensors are sent to the database and can be visualized via mobile app or web-based application. Those obtained values are also used to serve warnings to the users such as sending an email or triggering the buzzer in case fire, smoke, or water leakage is detected.

The results which come of testing the prototype show that temperature variation varies between 23℃ and 27.60℃, 11 times fire detection and 33 times smoke detection.

The developed system presents different actions of automatic prevention such as:

(i) When the fire is detected: the alarm is triggered automatically by a buzzer and an email is sent to all users and the fire extinguisher is turned on automatically to extinguish the fire.

(ii) When the water sensor senses water leakage reaching near the power supply, the alarm is triggered automatically and an email is sent to all users.

(iii) When smoke is detected, an alarm is triggered automatically and an email is sent to all users.

(iv) When there is a high temperature in the computer room, the fan is turned on automatically but only when there is the presence of a person.

Finally, the developed system is controlled and monitored via mobile and web-based applications.

5.2 Recommendations

When carrying out a project, the main purpose is not to fail. Investment in a building requires different means of protection against any hazard such as fire, smoke, water leakage, and high temperature. A computer laboratory is built with a lot of money, any damage to it as a result of fire, smoke, and temperature can cause great loss to the owner and the business itself.

However, it is always the best idea to be proactive in case a problem occurs, there is a solution for solving the problem. For that reason, the computer laboratory has to be equipped with protective equipment to protect the business by detecting any problem such as fire, smoke, water leakage, and high temperature in real-time and providing warning to the users in case any threat is detected.

Finally, the developed IoT would be an instrument for protecting against any of the mentioned incidents. The developed IoT based smart fan controller and fire prevention laboratory would be a good solution for protecting the building against fire and smoke in avoiding false recognition.

REFERENCES

Adam, M., & Alzubaidi, A.J. (2014). Microcontroller *04*, 64–68.

Al-Kuwari, Majid, Ramadan, A., Ismael, Y., Al-Sughair, L., Gastli,A., & Benammar, M. (2018). Smart-home automation using IoT based sensing and monitoring platform. *2018 IEEE 12th International Conference on Compatibility, Power Electronics and Power Engineering (CPE-POWERENG 2018)*, 2018, 1-6.

Alqourabah, H., Muneer, A., & Fati, S. M. (2021). A smart fire detection system using IoT technology with an automatic water sprinkler. *International Journal of Electrical and Computer Engineering*, *11*, 2994–3002.

Azemi, A. (1995). Teaching computer programming courses in a computer laboratory environment. *Proceedings Frontiers in Education 1995 25th Annual Conference. Engineering Education for the 21st Century*, *1*, 107-109.

Benson, G. (2020). Fire Prevention, Detection, and Response. *The Professional Protection Officer*, 157-164. Butterworth-Heinemann.

Bind, A., Ashtankar, K., & Chahare, P. M. (2020). An IoT-Based Smart Fan Module. *International Research Journal of Engineering and Technology*, *7*(4), 1281–1284.

Carter, R. A., Antón, A. I., Dagnino, A., & Williams, L. (2001). Evolving beyond requirements creep: a risk-based evolutionary prototyping model. *Proceedings Fifth IEEE International Symposium on Requirements Engineering*, 94-101, IEEE.

Clausen, A., & Spanias, A. (1998). An internet-based computer laboratory for DSP courses. *28th Annual Frontiers in Education Conference. Moving from 'Teacher-Centered to Learner-Centered Education. Conference Proceedings* (Cat. No. 98CH36214), *1*, 206-210.

Danbatta, S. J., & Varol, A. (2019). Comparison of Zigbee, Z-Wave, Wi-Fi, and Bluetooth wireless technologies used in home automation. *7th International Symposium on Digital Forensics and Security*, 1-5, IEEE.

Dhlamini, J., & Nhamu, I. (2009). Reactive Proactive. 33–40.

Dhobi, P. A., & Tevar, N. (2018). IoT-based home appliances control. *Proceedings of the*

International Conference on Computing Methodologies and Communication (ICCMC) 2018, 648–651.

Dioses, J. L. (2020). AndroiDuino-Fan: A Speech Recognition Fan-Speed Control System utilizing Filipino Voice Commands. *International Journal of Advanced Trends in Computer Science and Engineering*, 9(3), 3042-3047.

Dzulkefli, N. N. S. N., Abdullah, R., Jaafar, A. N., Shafie, R., Yassin, I. M., Rizman, Z. I., & Abidin, H. Z. (2017). Design an automatic temperature control system based on PIC controller for a smart ventilation fan. *Journal of Fundamental and Applied Sciences*, *9*(3S), 779-790.

Farag, S. G. (2018). Computer Laboratory Teaching Management System for Improving Teaching and Learning. *International Journal of Online Engineering*, *14*(9), 182-189.

Feng, X., & Liu, F. (2021). Research on Computer Realization of Building Fire Safety Assessment. *Journal of Physics: Conference Series*, *1992*(3), 032076.

Fjerdingen, O. T., & Nygaard, S. (2013). Ventilation and Cooling Requirements for ICT rooms.

Hadi, N. A. A., Hasan, M. H. C., Hashim, N. M. Z., Salleh, A., Salam, A. A., & Hasan, Z. (2015). Automatic Smart Kitchen System Using Microcontroller. *International Journal for Advance Research in Engineering and Technology*, *3*, 30-34.

Hamidovic, H., & CIA, I. I. (2014). Fire Protection of Computer Rooms-Legal Obligations and Best Practices. *Information Systems Audit and Control Association Journal*, 4, 1-3.

Hariveena, C., Anitha, K., & Ramesh, P. (2020). IoT-based Fire Detection and Prevention System. *IOP Conference Series: Materials Science and Engineering*, *981*(4), 042080.

Hsu, W. L., Jhuang, J. Y., Huang, C. S., Liang, C. K., & Shiau, Y. C. (2019). Application of Internet of Things in a kitchen fire prevention system. *Applied Sciences*, *9*(17), 3520.

Imteaj, A., Rahman, T., Hossain, M. K., Alam, M. S., & Rahat, S. A. (2017). An IoT based fire alarming and authentication system for workhouse using Raspberry Pi 3. *International Conference on Electrical, Computer and Communication Engineering*, 899-904.

Ince, D. C., & Hekmatpour, S. (1987). Software prototyping progress and prospects. *Information and Software Technology*, *29*(1), 8-14.

Ivanova, N., Gugleva, V., Dobreva, M., Pehlivanov, I., Stefanov, S., & Andonova, V. (2016). We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists. Intech, 13.

Jain, S., Ranjan, A., Fatima, M., & Siddharth. (2021). Performance Evaluation of Sonic Fire Fighting System. *7th International Conference on Advanced Computing and Communication Systems*. 1510-1514.

Jensen, G., & Nygaard, S. (2013). Fire Prevention Requirements for ICT rooms. *Best Practice Document. UNINETT Led Working Group on Physical Infrastructure.*

Johnson, P. F. (2010). Fire Detection in Computer Facilities: 25 Years On. Fire Technology, *46*(4), 803-820.

Judi, H. M., Cheng, Y. Z., Seong, T. B., Yuan, L. Z., Yen, H. H., & Voon, L. W. (2011). A case of computer laboratory layout modeling and analysis. *Proceedings of the 2011 International Conference on Electrical Engineering and Informatics*, 1-4.

Kabiri, M. N., & Wannous, M. (2017). An experimental evaluation of a cloud-based virtual computer laboratory using OpenStack. *2017 6th IIAI International Congress on Advanced Applied Informatics*, 667-672. IEEE.

Khoa, T. A., Nhu, L. M. B., Son, H. H., Trong, N. M., Phuc, C. H., Phuong, N. T. H., Dung, N. V., Nam, N. H., Chau, D. S. T., & Duc, D. N. M. (2020). Designing efficient smart home management with IoT smart lighting: a case study. *Wireless Communications and Mobile Computing*, 2020.

Kuznetsov, G., Kopylov, N., Sushkina, E., & Zhdanova, A. (2022). Adaptation of fire-fighting systems to localization of fires on the premises. *Energies*, *15*(2), 522.

Majid, U. (2018). Research fundamentals: Study design, population, and sample size. *Undergraduate Research in Natural and Clinical Science and Technology Journal*, 2, 1-7.

McClelland, C. (2021). What is the Internet of Things, or IoT? A Simple Explanation. IoT all.

Kaiser, T. (2000). Fire detection with temperature sensor arrays. *Proceedings IEEE 34th annual 2000 International Carnahan Conference on Security Technology (Cat. No. 00CH37083),* 262-268. IEEE.

Newby, M., & Fisher, D. (1997). An instrument for assessing the learning environment of a computer laboratory. *Journal of Educational Computing Research*, *16*(2), 179-190.

Onibonoje, M. O., Bokoro, P. N., Nwulu, N. I., & Gbadamosi, S. L. (2019). An IoT-Based Approach to Real-Time Conditioning and Control in a Server Room. *2019 International Artificial Intelligence and Data Processing Symposium*, 1-6. IEEE.

Gokul Dev. P., Arun, V. S., & Mani, S. (2020). IoT-based energy-conserving smart fan. *International Research Journal of Modernization in Engineering Technology and Science*, *2*(9), 1-8.

Rashid, H., Ahmed, I. U., Ullah, A., Newaz, M. F., Robin, M. S. R., & Reza, S. T. (2016). Multiple sensors-based fire extinguisher robots based on DTMF, Bluetooth, and GSM technology with multiple modes of operation. *International Workshop on Computational Intelligence*, 41-46, IEEE.

Saeed, F., Paul, A., Rehman, A., Hong, W. H., & Seo, H. (2018). IoT-based intelligent modeling of the smart home environment for fire prevention and safety. *Journal of Sensor and Actuator Networks*, *7*(1), 11.

Saif, E., Alharthy, A., Ali, S., Alwahaibi, S., & Al-malki, R.A.O. (2019). Secured Smart Door Access using IoT. *International Journal of Engineering Research and Technology*, *7*(4), 1–3.

Sassani, B. A., Jamil, N., Villapol, M., Abbas Malik, M., & Tirumala, S. S. (2020). FireNot-An IoT-based Fire Alerting System: Design and Implementation. *Journal of Ambient Intelligence and Smart Environments*, *12*(6), 475-489.

Singh, K. (2017). Automatic fan speed control system using Arduino. *International Journal of Novel Research and Development*, *2*(4), 75-77.

Stolojescu-Crisan, C., Crisan, C., & Butunoi, B. P. (2021). An IoT based smart home automation system. *Sensors*, *21*(11), 3784.

APPENDICES

Appendix 1: **An interview guide for developing IoT-Based Smart Fan Controller and Fire Prevention in Computer Laboratory**

A. Interview based on the function of computer Laboratory

1. What is a computer Laboratory?
2. What equipment can you find in your computer Laboratory?
3. How operations are performed on the laptop computer or desktop computer?
4. Why process need to be cooled?
5. Why it is important to put a cooler beyond the processor?
6. Why do computers have a built-in fan inside?
7. What is the effect of heat in the computer Laboratory?
8. What is the effect of fire in the computer Laboratory?
9. What is the effect of water leakage in a computer laboratory?
10. What is the effect of smoke in computer laboratories?
11. What is the cause of heat in the computer laboratory?
12. What is the cause of the fire in the computer laboratory?
13. What is the cause of smoke in the computer laboratory?
14. What is the cause of water leakage in the computer laboratory?
15. What do you understand when you hear the word IoT?
16. Which equipment do you have to protect your computer Laboratory against fire, smoke, heat, and water leakage?
17. What measures did you to protect your computer when a fire occurs?
18. Do you use a fan in the computer Laboratory? How action of turning on or off is managed? Who has permission to turn on or off the fan?
19. Did you see or use a system of protection that warn the user in case of detection of fire, smoke, or water leakage?
20. Did you use a system of fan controllers which can be turned on or off without human intervention?
21. How can you feel when you have a system of protection which could warn you in case of fire detection, smoke detection, or water leakage?
22. What do you about the developed system?

23. Suppose you want an IoT system that can protect your computer laboratory, what do you want to be included in your system?

B. Interview about Demographic information of respondents.

1. What is your gender?
2. How much time do you like to be in the computer laboratory?
3. Do you like to use a computer laboratory?
4. How old are you?
5. What is your function?
6. Which class are you in?
7. Which degree or diploma do you have?
8. What is the main source of a house fire?
9. What kind of computer do you have in your computer laboratory?
10. Do you have a smartphone?
11. How do you access the internet?
12. How many hours are you online?

Appendix 2: Internship Offer Letter

EAST AFRICAN COMMUNITY

P.O. Box 1096
ARUSHA, TANZANIA

Tel: +255 27 2162100
Mob: +255 752 899151
Fax: +255 27 2162190
E-mail: eac@eachq.org
Web: http://www.eac.int

OFFICE OF THE SECRETARY GENERAL

Ref: F&A/2/2/5
Date: **9th March 2021**

Kevin Iriho
Nelson Mandela African Institution of Science and Technology (NM-AIST)
Arusha, Tanzania
Tel: +255 684160162 / +25771577280
Email: keviniriho@gmail.com /kevini@nm-aist.ac.tz

Dear Mr. Iriho,

RE: APPLICATION FOR INTERNSHIP – INFRASTRUCTURE DEPARTMENT

We acknowledge receipt of your letter dated 22nd February 2021 on the above subject.

I am pleased to inform you that your request for internship has been accepted for a period of six (6) months at the Department of Communications from the date you report for internship under the Director of Infrastructure, Dr. Kamugisha Kazaura.

Kindly note that the EAC does not offer any form of financial assistance or allowance to interns. You will therefore, be fully responsible for your own upkeep during the period of internship.

Yours sincerely,

Amb. Liberat Mfumukeko
SECRETARY GENERAL

cc: DHRA; DT

Appendix 3: Codes used to develop system IoT based smart Fan controller and fire prevention in computer laboratory.

A. Code php for home page for Authentication (log.php)

The code bellow allow the users to authenticate to the developed system , it check if the users are registered ,if his credentials are in databases

```
<?php

session_start();

include"connection.php";

if(isset($_POST['login'])){

$ad=$_POST['name'];

$ade=$_POST['pass'];

if($ad == "kevir" && $ade == "irh1800!"){

header('Location:display.php');

}

else{

$ader=md5($ade);

$sql="SELECT function  FROM users WHERE users.function='Student' AND  username ='$ad'  AND password ='$ader'";

$sql1="SELECT function  FROM users WHERE users.function='Lab Manager' AND username ='$ad'  AND password ='$ader'";

$sql2="SELECT function  FROM users WHERE users.function='Staff' AND  username ='$ad' AND password ='$ader'";

$as=(mysqli_query($con,$sql));

$as1=(mysqli_query($con,$sql1));
```

```
$as2=(mysqli_query($con,$sql2));
  if (mysqli_num_rows($as) == 1) {
            $logged_in_user = mysqli_fetch_assoc($as);
            $_SESSION['name']=$ad;
            header('Location:home.php');
}
else if (mysqli_num_rows($as1) == 1) {
            $logged_in_user = mysqli_fetch_assoc($as1);
            $_SESSION['name']=$ad;
            header('Location:home1.php');
}
else if (mysqli_num_rows($as2) == 1) {
            $logged_in_user = mysqli_fetch_assoc($as2);
            $_SESSION['name']=$ad;
header('Location:home1.php')
}
else{
header('Location:index.php');
                        echo "Error: " .$sql. "". mysqli_error($con);} }
}?>
```

B. Code php for user registration and sending email to user registered on the system

```
<?php
use PHPMailer\PHPMailer\Exception;
use PHPMailer\PHPMailer\SMTP;
require $_SERVER['DOCUMENT_ROOT'] . '/mail/Exception.php';
require $_SERVER['DOCUMENT_ROOT'] . '/mail/PHPMailer.php';
require $_SERVER['DOCUMENT_ROOT'] . '/mail/SMTP.php';
include"connection.php";
include"connection.php";
if(isset($_POST['save'])){
        $name=$_POST['name'];
        $user=$_POST['username'];
        $funct=$_POST['function'];
        $passer1=$_POST['pass1'];
        $passer2=$_POST['pass2'];
        $em=$_POST['email'];
        $telephone=$_POST['telephone'];
if($passer1!==$passer2){
                ?>
   <script type="text/javascript">
 alert("password incorrect.");
 window.location = "register.php";
</script>';
```

```
<?php
}
        elseif(filter_var($em,FILTER_VALIDATE_EMAIL)==false){
                ?>
                <script type="text/javascript">
 alert("password incorrect.");
 window.location = "register.php";
</script>';
<?php
         }
        else{
        $passer=md5($passer1);
        $a="insert into users(name,username,email,password,telephone,function)
VALUES('$name','$user','$em','$passer','$telephone','$funct')";
$result =(mysqli_query($con,$a)) or die(mysqli_error($con))
        ?>
<script type="text/javascript">
 alert("inserted Successfull.");
 window.location = "index.php";
</script>
<?php
 require_once("class.phpmailer.php");
$mail = new PHPMailer();
```

```
$mail->isSMTP();

$mail->SMTPDebug = 2;

$mail->SMTPSecure = 'tls';

$mail->SMTPAuth = true;

$mail->Host = 'smtp.gmail.com';

$mail->Port = '587';

$mail->Username = 'kevini@nm-aist.ac.tz';

$mail->Password = 'irh1900!';

$mail->SetFrom("kevini@nm-aist.ac.tz","kevini");

$mail->addAddress($em);

$mail->AltBody = 'HTML messaging not supported';

$mail->Subject =' user registration notification';

$mail->Body ='Thank you' .'  '.$name.'  '.'to register to the developed System for IOT BASED SMART FAN CONTROLLER AND FIRE PREVENTION IN COMPUTER LABORATORY.';

$mail->SMTPOptions = array(

                'ssl' => array(

                    'verify_peer' => false,

                    'verify_peer_name' => false,

                    'allow_self_signed' => true

                )

            );

            if(!$mail->send()){
```

```
            echo "Mailer Error: " . $mail->ErrorInfo;
             }else{
            echo "Message sent!";
             }
}
}
mysqli_close($con);
?>
```

C. Code php to get data from fire detection and sending email to all users registered in the system

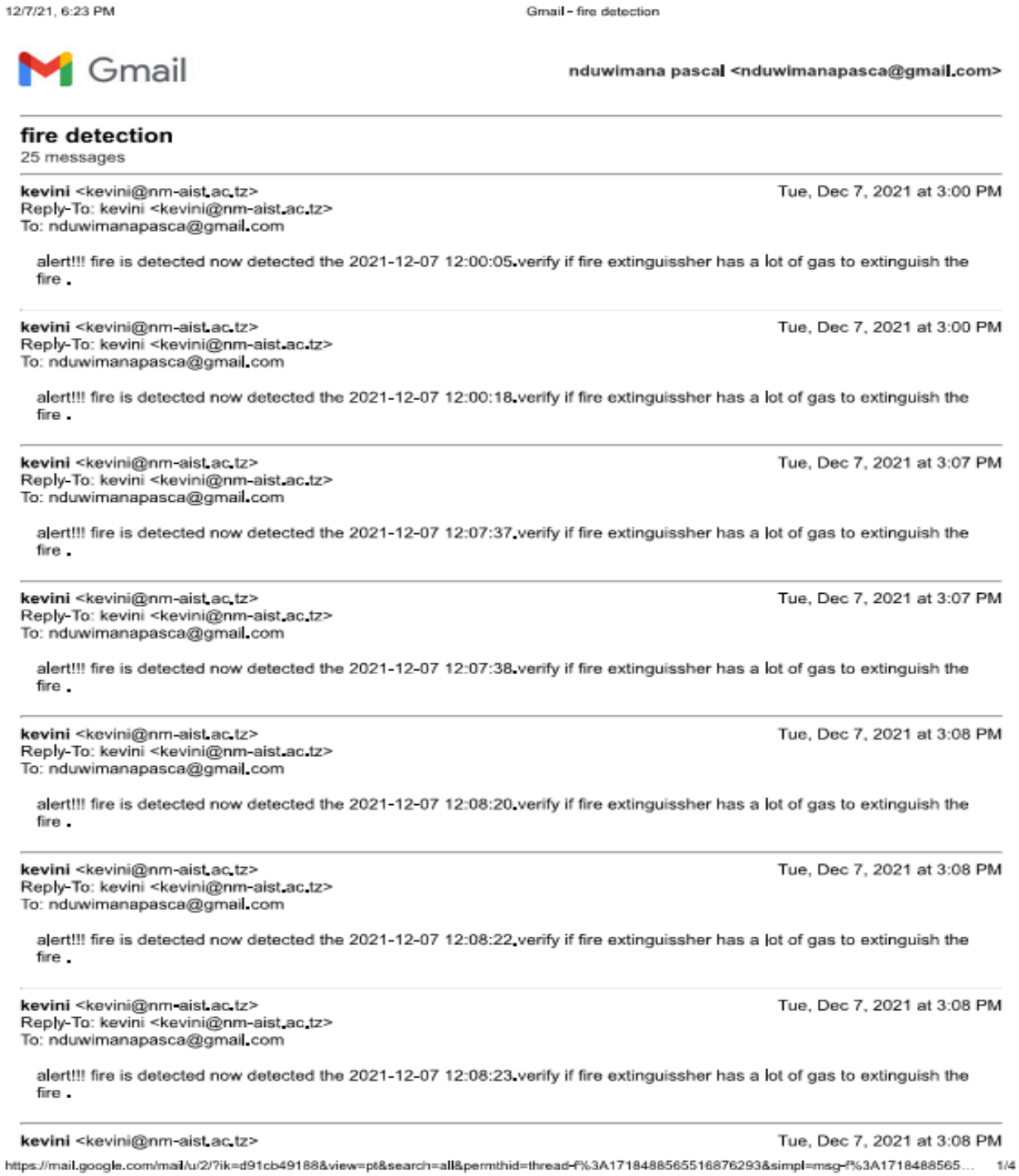
```
<?php
use PHPMailer\PHPMailer\Exception;
use PHPMailer\PHPMailer\SMTP;
require $_SERVER['DOCUMENT_ROOT'] . '/mail/Exception.php';
require $_SERVER['DOCUMENT_ROOT'] . '/mail/PHPMailer.php';
require $_SERVER['DOCUMENT_ROOT'] . '/mail/SMTP.php';
include"connection.php" ;
$enter=test_input($_POST['sensor']);
$enter1=test_input($_POST['detection']);
//$enter2=testinput($_POST['detectione']);
$d = date("Y-m-d");
$t = date("H:i:s");
```

```
$as="INSERT INTO fire(sensor,detection,date,time) VALUES('" . $enter . "','" .$enter1 . "','" . $d . "','".$t."')";

  $con->query($as) or die(mysql_error())

   if ($enter1='fire is detected now') {

 $sql2 = "SELECT * FROM users";

          $as=(mysqli_query($con,$sql2));

          while($row = mysqli_fetch_assoc($as)){

             $email = $row['email'];

             require_once("class.phpmailer.php");

             $mail = new PHPMailer();

             $mail->isSMTP();

             $mail->SMTPDebug = 2;

             $mail->SMTPSecure = 'tls';

             $mail->SMTPAuth = true;

             $mail->Host = 'smtp.gmail.com';

             $mail->Port = '587';

             $mail->Username = 'kevini@nm-aist.ac.tz';

             $mail->Password = 'irh1900!';

             $mail->SetFrom("kevini@nm-aist.ac.tz","kevini");

             $mail->addAddress($email)

             $mail->AltBody = 'HTML messaging not supported';

             $mail->Subject =' fire detection';
```

```
            $mail->Body ='alert!!! '.$enter1.'  detected the '.date("Y-m-d H:i:s").'.verify if fire extinguissher has a lot of gas to extinguish the fire .';
            $mail->SMTPOptions = array(
                'ssl' => array(
                    'verify_peer' => false,
                    'verify_peer_name' => false,
                    'allow_self_signed' => true
                )
            );
            if(!$mail->send()){
            echo "Mailer Error: " . $mail->ErrorInfo;
             }else{
            echo "Message sent!";
             }
          }
        }
   $con->close(); function test_input($data) {
 $data = trim($data);
   $data = stripslashes($data);
   $data = htmlspecialchars($data);
   return $data;
}
?>
```

Appendix 4: Output from Testing Different Nodes

OUTPUT1: EMAILS SENT TO USERS AFTER FIRE DETECTION



12/7/21, 6:23 PM Gmail - fire detection

Gmail nduwimana pascal <nduwimanapasca@gmail.com>

fire detection
25 messages

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:00 PM
Reply-To: kevini <kevini@nm-aist.ac.tz>
To: nduwimanapasca@gmail.com

alert!!! fire is detected now detected the 2021-12-07 12:00:05.verify if fire extinguissher has a lot of gas to extinguish the fire .

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:00 PM
Reply-To: kevini <kevini@nm-aist.ac.tz>
To: nduwimanapasca@gmail.com

alert!!! fire is detected now detected the 2021-12-07 12:00:18.verify if fire extinguissher has a lot of gas to extinguish the fire .

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:07 PM
Reply-To: kevini <kevini@nm-aist.ac.tz>
To: nduwimanapasca@gmail.com

alert!!! fire is detected now detected the 2021-12-07 12:07:37.verify if fire extinguissher has a lot of gas to extinguish the fire .

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:07 PM
Reply-To: kevini <kevini@nm-aist.ac.tz>
To: nduwimanapasca@gmail.com

alert!!! fire is detected now detected the 2021-12-07 12:07:38.verify if fire extinguissher has a lot of gas to extinguish the fire .

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:08 PM
Reply-To: kevini <kevini@nm-aist.ac.tz>
To: nduwimanapasca@gmail.com

alert!!! fire is detected now detected the 2021-12-07 12:08:20.verify if fire extinguissher has a lot of gas to extinguish the fire .

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:08 PM
Reply-To: kevini <kevini@nm-aist.ac.tz>
To: nduwimanapasca@gmail.com

alert!!! fire is detected now detected the 2021-12-07 12:08:22.verify if fire extinguissher has a lot of gas to extinguish the fire .

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:08 PM
Reply-To: kevini <kevini@nm-aist.ac.tz>
To: nduwimanapasca@gmail.com

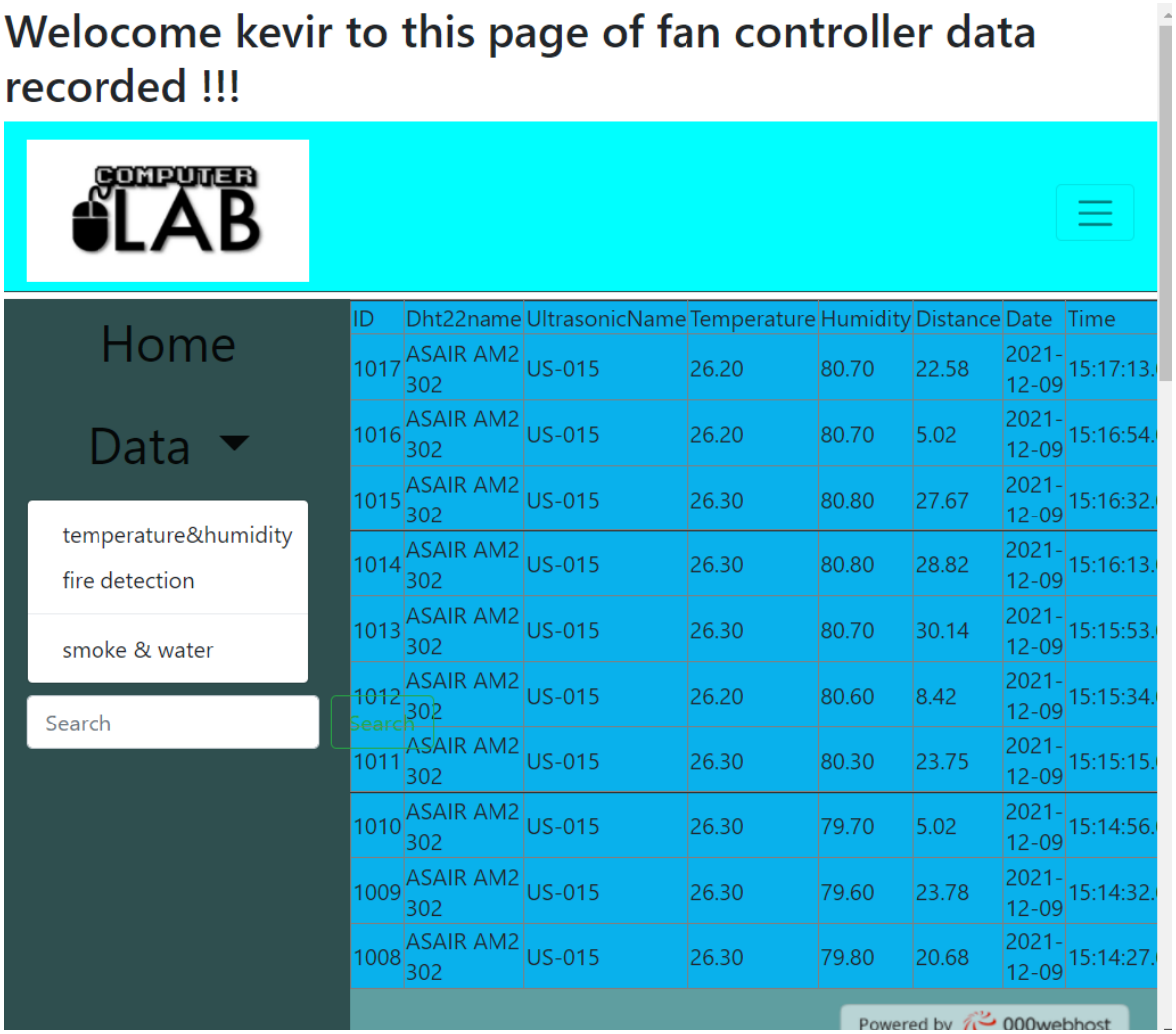
alert!!! fire is detected now detected the 2021-12-07 12:08:23.verify if fire extinguissher has a lot of gas to extinguish the fire .

kevini <kevini@nm-aist.ac.tz> Tue, Dec 7, 2021 at 3:08 PM

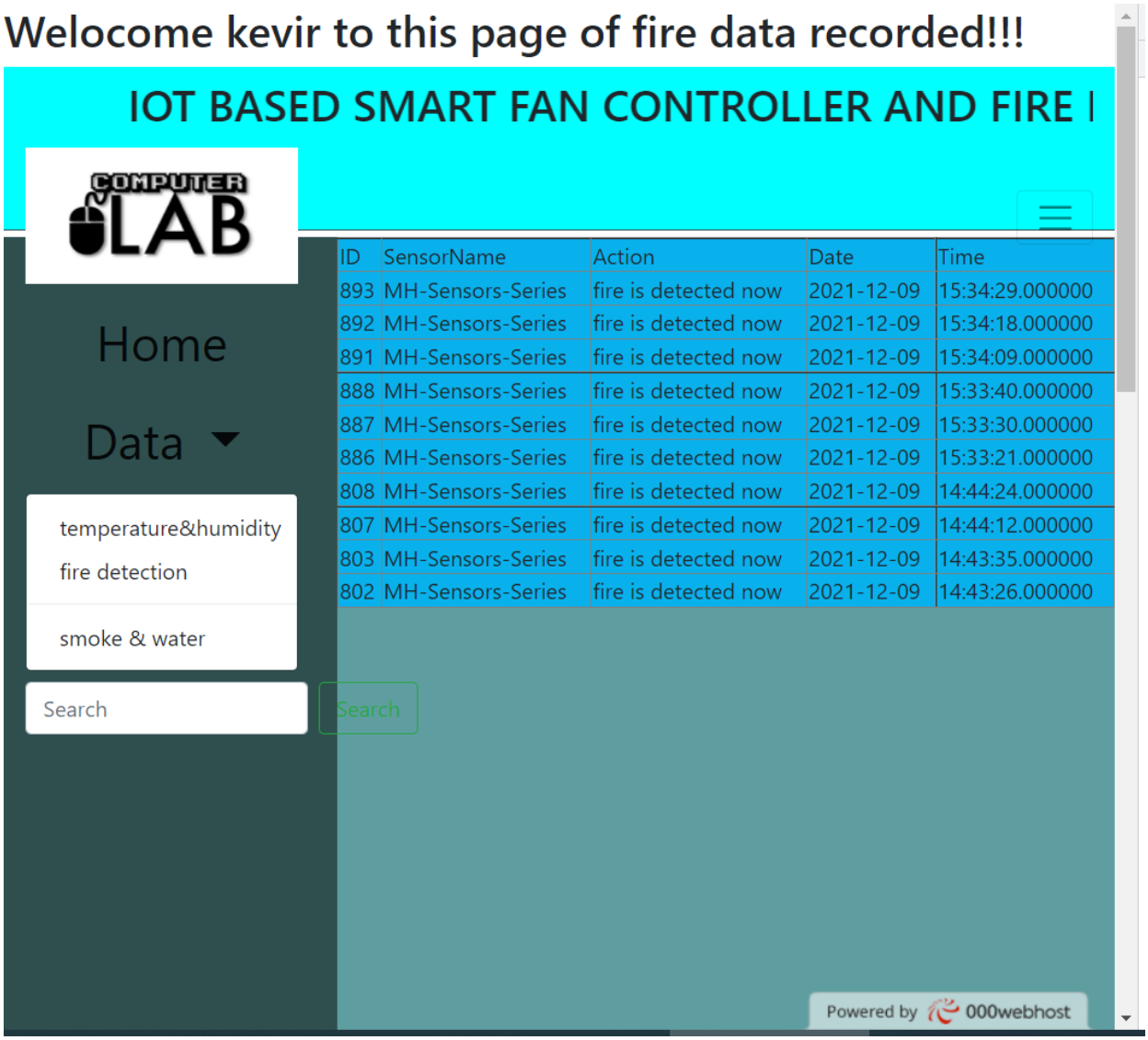
https://mail.google.com/mail/u/2/?ik=d91cb49188&view=pt&search=all&permthid=thread-f%3A1718488565516876293&simpl=msg-f%3A1718488565... 1/4

OUTPUT 2: DATA RECORDED FROM TEMPERATURE SENSORS

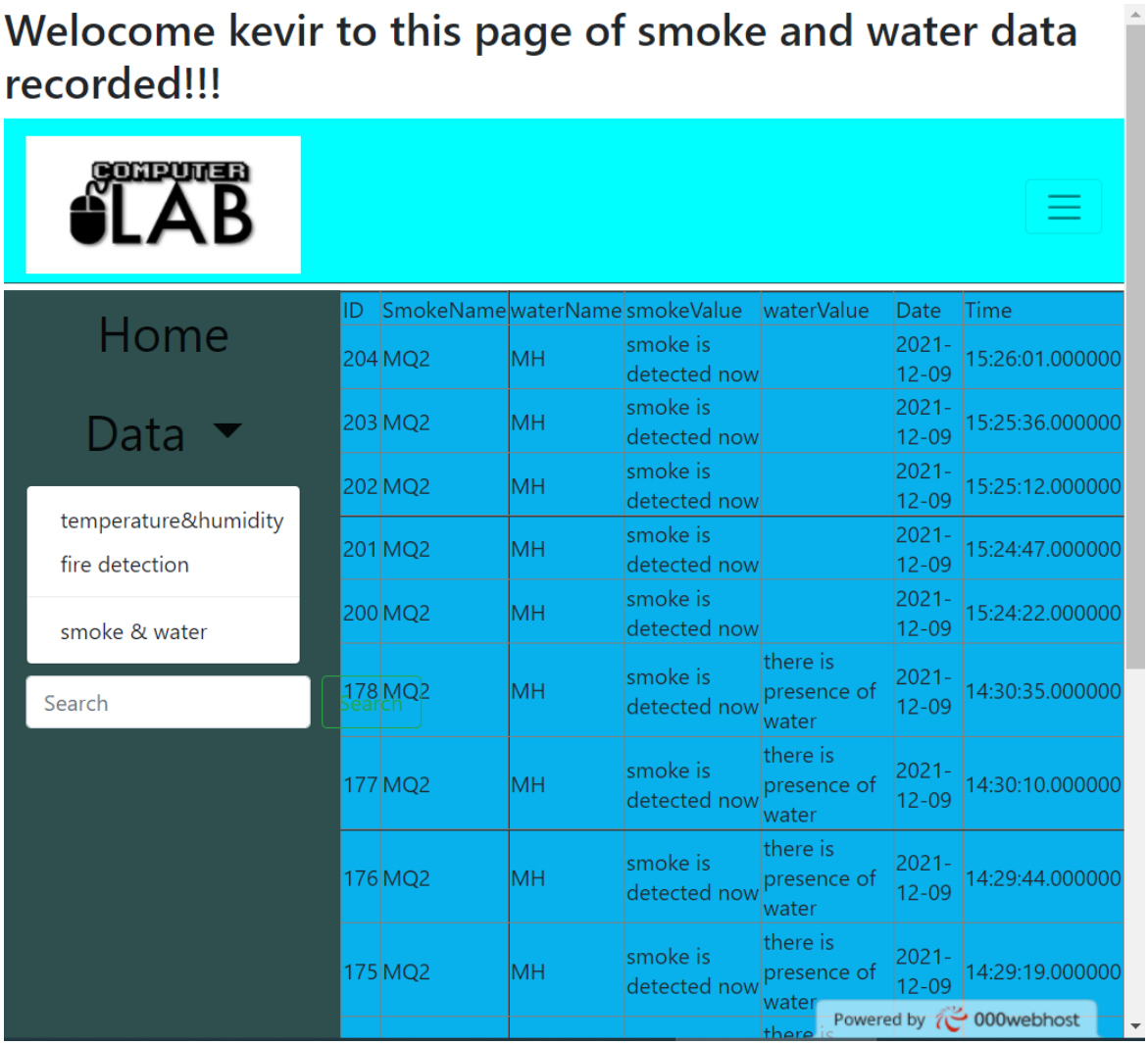
A. Temperature sensors (10 last entries)



B. Fire detection values (10 last entries)



C. Smoke and water detection(10 last entries)



Appendix 5: Prototypes developped

A. Fan Module controller Prototype

B. Fire extinguisher Module

C. Smoke and Water detections Module

Appendix 6: Poster Presentation

IoT based smart fan controller and fire prevention in computer laboratory. Case Study: East African Region

Dissertation made By Kevin IRIHO (Reg n0:M079/BI19)

Introduction

This study aims to develop automated computer laboratory that would control and monitor computer laboratory environment from incident of fire, heat, smoke and water leakage. The developed system is divided in three nodes which communicate separately with one database in common where flame sensor is used to detect fire and allowing turning on automatically of fire extinguisher in case of fire detection, DHT22 and ultrasonic sensor are used for management of fan controller ,they allow to turn on automatically fan controller when there is high temperature and if there is presence of person, smoke and water sensors are used to detect presence of smoke and

Problem Statement

Detection and prevention of fire is a detrimental work which can bring risks of loss of lives when extinguishment is done by extinguisher person. Then, IT equipment and others materials used for data recording or storage can be damaged when they are exposed to sustained elevated

Tools used in nodes construction

- ESP8266,
- ESP32 WROOM-32D,
- Sensors, fire extinguisher,
- laptop, fan, wire, pipes

Result obtained

The developed system allows the users to register and to access different values or data recorded from sensors via mobile application and web-based

Conclusion

The developed IoT Based Smart Fan Controller and Fire Prevention in computer laboratory is to warn and triggering action of prevention for the user of the computer laboratory in case there is detection of fire, smoke, water and high temperature