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IoT Based Gate for Covid-19 Prevention Measures

Case study of Churches in Kigabiro Sector, Rwamagana District

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Award of Masters of science degree in Internet of Things/ Wireless Intelligent Sensor Networking.

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January 2022

DECLARATION

I, Jean d'Amour MIREMBE declare that this Dissertation entitled "**IoT based gate for covid-19 prevention measures: Case study of churches in Rwamagana District, Kigabiro Sector**" is my original work. I also declare that as required by rules, I have fully cited and referenced all materials and results that are not original to this work.

Jean d'Amour MIREMBE (220014205)

January 2022

CERTIFICATE

This is to certify that the project work entitled **"IoT based gate for covid-19 prevention measures: Case study of churches in Rwamagana District, Kigabiro Sector"** is a record of original work done by **Jean d'Amour MIREMBE** (**220014205)** as a partial fulfillment of the requirement for the award Masters of Science in the Internet of Things in the College of Science and Technology, the University of Rwanda during the academic year 2020-2021. This work has been done under the guidance of Dr. Enan MUHIRE NYESHEJA and Dr. Emmanuel MASABO

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ABSTRACT

The whole world is facing Covid-19 pandemic caused by a coronavirus which is affecting negatively various spheres of life and requires to take strict preventions measures. Some of the measures taken are implemented by people themselves placed at the entrance of specific public places to help screen body temperature and record people address related details. In many public entry points, manual methods involving the use of books and handheld thermometer to screen their body temperature were adopted. The use of such methods is costly in term of time and numbers of workers deployed at entry points to ensure proper implementation of prevention measures. In addition, people may forget to get test through handheld thermometer and can be granted passing permission with suspect temperature or without being recorded. More time also is required to check in books records for contact tracing.

The current study is intended to demonstrate how IoT based gate for covid-19 prevention measures in public places with frequent users such as churches was prototyped with MLX90614 IR thermometer sensor can enable contactless body temperature scanning, RFID based automatic address details recording, computerized database to store recorded data and enable simplified contact tracing, and automatic notification system to concerned people in case of Covid-19 patient suspect for quick response.

Prototype was tested and the results shows that the IoT based gate for covid-19 prevention measures simplified implementation of the covid-19 preventions measures as it allow only customers recorded, with body temperature screened and with allowed temperature. The system reduces time taken to record address details of person by 90% and number of workers required by 66.6%. It provided a simplified reporting system as data are visualized online from computerized database. The system is used on gate of public places with regular users as it requires each user to possess RFID card and to be registered once. It is recommended, among other things, to the government to adopt the system, expand it and synchronized it with National Identity Agencies database to enable every user with National Identity card to use it in any every places without being registered.

Keywords: IoT, Covid-19, Gate, Temperature, Addresses

LIST OF ABBREVIATIONS AND ACRONYMS

GPRS:	General Packet Radio Service
IDE:	integrated Development Environment
I/O:	Input/Output
IoT:	Internet of Things
IR:	Infrared
LCD:	Liquid Crystal Display
LED:	Light Emitting Diode
MCU:	MicroController Unit
MQTT:	Message Queue Telemetry Transport
OLED:	Organic Light Emitting Diode
RFID:	Radio Frequency Identification
SMS:	Short Message Service
Wi-Fi:	Wireless Fidelity

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Chapter 1 : GENERAL INTRODUCTION

With the advancement of technology, people are finding an easy and efficient way of doing work without the intervention of human effort. Within this technology also Smart gates have been inverted to automatically operate gate doors during opening and closing[1]–[4]. For decades, these smart gates have been applied in different public places such as airports, banks, schools, churches, parking, and supermarket, and so on. These smart gates were primarily designed for security purpose where the authorized people were the only ones to pass through these gates [4]. Since the introduction of Covid-19, public places mostly in Rwanda have been identified as places contributing to the spread of coronavirus. Governments enforces the Covid-19 prevention measures to be followed in these public places including body temperature screening and recording address detail for easy future contact tracing and so on[5]–[7]. In the staring, these prevention measures have been implemented manually where people have to screen body temperature with a handheld contactless thermometer, and record address details. This manual system was also identified as the source of contamination [5]. Different research is being conducted to automate these Covid-19 prevention measures and integrate them into the existing smart gate primary used for security purposes to enable them to automate these Covid-19 prevention measures at the entry gate.

1.1. Background and motivation

The Covid-19 is one of the biggest pandemic the whole world is facing especially our country. Different prevention measures have been putted into places to minimize the spread of this pandemic but the pandemic is still problem. One of the resolution putted into place is to screen body temperature and to record address details of customers at entry point of different workplace and public places such as churches. A manual book recording system and a handheld thermometer system to screen temperature were adapted but has challenges of many people required to be at this entry point to implement these prevention measures, more time required, minimum social distance between prevention measures implementer and gate user, and allowing suspected people to pass by error of reading on thermometer screen. The prototyping an IoT-based gate for covid-19 prevention measures removed these challenges associated to manual and automate the

implementation of these prevention measures at the gate and notify people in charge of this gate through SMS in case there is suspect body temperature.

1.2. Problem statement

From the starting of 2020 up to date, the world is still struggling to deal covid-19 pandemic by controlling the unprecedented spread of the virus and developing a vaccine. To control the spread of the virus, different measures are enforced including recording people's addresses in public places, testing their temperature, and frequent sanitizing hands. The implementation of some of the above prevention measures is still done manually like recording people's address details and body temperature screening. The manual implementation of one or all of these preventive measures, firstly has been identified as the source of Covid-19 contamination. Secondly, it is difficult to trace contact as there is no computerized system provided to filter the recorded data. Thirdly, even for the places where the automated body temperature screening system, or Automatic address detail recording have been introduced, still, there is need of mapping the screened body temperature to the address details and notification system for any suspected covid-19 case to the response team for quick response to save life. The proposed IoT based gate for covid-19 prevention measures is a security purpose gate but intended to integrate and automate the main and important Covid-19 prevention measures like body temperature screening, daily address details recording and automatic SMS notification in case of suspected people trying to enter in place. Within this proposed system, passing security permission will be given to the people meeting all prevention measures at the gate. These prevention measures are automated where, firstly the address details will be recorded automatically with RFID technology and stored into the database. Secondly, the body temperature will be screened and displayed automatically without human effort and mapped to passing people's addresses details. Thirdly in case of suspected people, passing permission will be denied and automatic notification sent to the gate guard for emergency response.

1.3. Study objectives

1.3.1. Aim

To design an IoT- based gate where people's address details and body temperature recording and screening are done automatically and passing permission given to one with normal temperature and denied to one with abnormal temperature.

1.3.2. General objective

The main objective of this research is to integrate IoT solution in the implementation of Covid-19 prevention measures at the public entry point gates for automatic recording and storing of people's address details and body temperature screening and granting or denying the passing permission to people depending on their normal or abnormal body temperature.

1.3.3. Specific objectives

- Analyze people addresses data recording and temperature screening at the gate and how the recorded data are stored.
- Automate addresses data recording at the gate for future easy tracing.
- Automate body temperature screening at the entry point (gate) and map screened temperature to the people's address.
- Build automatic notification solution to the gate guard in case of temperature suspect for emergency response.

1.4. Hypothesis

IoT based gate for covid-19 prevention measures enforces the covid-19 prevention measures at entry point, decreases number of employees used at the gate, speeds up the process and simplify data records, and provides timely response through timely automatic notification in case of the covid-19 suspect case based on body temperature.

1.5. Study scope

The research focuses on designing system that is going to automate address details record that was recorded manually before, body temperature screening and mapped it to the recorded address details and provide passing permission if recorded temperature is normal or deny passing permission if temperature is abnormal but sent notification to the gate guard in place with regular user.

1.6. Significance of the study

The aim of this IoT based Gate for covid-19 prevention measures is to enforce and automate address data record and body temperature screening as covid-19 prevention measure at entry gate. This will decrease time was taken to records address data at entry point, decrease time was taken to screen body temperature and decrease number of peoples were in charge of this activity. It will also be easy to monitor all gate user and their temperature as the data will be sent to database and monitored online which will allow easily to plot all daily gate user, highest and lowest temperature, easy contact tracing. Lastly there is notification system in case of temperature suspect to the authority in charge (gate guard) for real time response to the case before the suspect enter in the place and the passing permission will be given to the people with recorded address with normal temperature.

1.7. Organisation of the study

Chapter one gives an introduction of the research which includes the background of the study and its motivation, study objectives, hypothesis of the study, the limitation of the study, the interest and the conclusion.

Chapter two discusses related works that were carried out before, the gaps founded in existing works and how this research is going to improve and fill the existing research gaps.

Chapter three is the research methodology. Discusses on summary of the research methods that will be used in this work and describe the requirements needed in this work.

Chapter four focuses on system analysis and design that includes all theories used in this research.

Chapter five deals with the presentation, analysis and interpretation of results using graphs and screen shoots.

Chapter six finalize the research with a conclusion and recommendation for the future work.

Chapter 2 : LITERATURE REVIEW

This chapter also revised the related work of this project and provides critical analysis of what other researchers have said on the subjects where my project fit in. This overview serves as the root that leads to the successful design and implementation of IoT based gate for covid-19 prevention measure

2.1. Review of related works

Currently the world is still struggling to deal covid-19 pandemic by controlling unprecedented spread of the virus. Different institutions are placing these controlling measures on their entering gates. On these place the automatic mechanism for controlling the suspect and recording the gate user is needed to ensure that the spread of the virus is being controlled at the entering point of each institution and the details of the gates user are being recorded. Different work have been conducted on smart gate.

K. P. Bhattarai, B. P. Gautam, and K. Sato, [8] proposed smart home security system by using local binary pattern histograms (LBPH) face detection algorithm when image is processed to lock and unlock gate or door for security purpose. If the people with image not stored in database comes on the gate system identify her/him as unauthorized intruder and system can inform the administrator about his/her presence on the gate and decision can be taken accordingly.

S. Oluwole et all [9] proposed automatic gate control using infrared remote with password protected features where users can open and close the gate with password using IR control. With this system the microcontroller obtains the infrared signal from the transmitter which remote control through IR sensor, interpret it and switch ON the relay that governor the DC motor which incorporate with gear that control the movement of the gate forward and backward. When the wrong password enters through IR remote control designed for the circuit and open button is press the gate will not open, the security alarm will sound for security purpose.

T. Emerick [10] designed smart gates security where employees have to scan their id card for entering or leaving the company. The system uses RFID reader and RFID tags for access and cameras for recording the gate activities for father decision if needed. Only the card with the tag

embedded in the system would initiate the servo motor to open the gate. If visitors come to the company they have to register to the guard for getting access to the company.

S. P, V. Valsan, and P. C, [11] proposed IoT Based RFID Gate Automation System where the authorized gate users have RFID tag and once come near the gate the RFID tag is recognized by the reader and processed by a Raspberry pi, which sends a signal to the motor and the gate is automatically opened. With this system, if unauthorized gate user come, they have needs to inform the person they want to meet so that the person inside can login to the website and click the OPEN button to open the gate.

D. D. Putra, M. Febriyanto, etc all [12] have Designed Smart-Gate Based on Artificial Intelligence Possibly for COVID-19 Early Prevention at Public Area based on artificial intelligence is designed to be integrated with the INCEPS website. This smart gate aimed to check whether people are wearing face mask or not and notify in case people are wearing the face mask.

Hugo Martín [10] Also write article about airport places equipped with full-body scanners, metal detectors and face-recognition technology to identify potential terrorists are starting to make room for devices to target the latest global threat where testing thermal cameras are integrating to scan body temperature.

T. Abuzairi, N. Imaniati Sumantri,etc have devigned non-contact infrared thermometer mounted on the wall on the wall which do not require operator [13]

2.2. Critical review

All the above proposed system are for the security purpose either for the company or the employees inside the company and for better management of employees other are for temperature screening. Even for considering the current situation in the world where Covid-19 is a problem, other proposed systems are for body temperature Scanning, other are for checking whether people are wearing face mask or not. Based on the above solutions there still gap of integrating automatic address details recording, automatic body temperature screening mapped to the recorded address details, and automatic notification to the concerned people in case of body temperature suspected to have Covid-19. The proposed IoT based Gate for covid-19 prevention measures is integrating all above preventive measures and automate them at the gate.

Chapter 3 : METHODOLOGY

This chapter summarizes the tools and techniques used to investigate the research issues deemed relevant to the current topic. The methodologies used depended on the pursued objective. The methodology applied to achieve the first objective focuses on the research design, sampling aspects, population, sources of data, methods for data collection, data analysis tools and ethical consideration. The methodology applied to achieve the second, third and fourth objective involved experimental research method that was undertaken through implementation of a prototype.

The main objective was to integrate IoT solution at the gate to automate covid-19 prevention measures like to automate data recording and storage at the gate, automate body temperature screening, open gate based on the screened temperature and notify gate guard for any body temperature suspect. To achieve this objective, different materials and technologies was adopted and implemented. RFID reader and RFID card using near field communication technology was used for automatic gate user's addresses details data recording[14]–[16]. MongoDB database as database management system for internet and web-based application was used to store and manage the recorded data at the gate[17]. The MLX90614, numerical contactless Infrared (IR) temperature sensor able to measure the temperature of a specific object fluctuating from -70° C to 382.2°C was installed in right position to detect hand temperature automatically[18], [19]. Twilio as a messaging cloud platform using API to send and receive SMS globally was used to notify gate guard[20]. For gate user with abnormal temperature the guard was notified through twilio platform. Lastly To be able to visualize temperature value online adafruit.io cloud platform as the open source MQTT server working on internet using TCP/IP connections was used[18]. An open-source software and hardware development environment (microcontroller) NodeMCU ESP8266 was used to collected data from RFID reader and MLX90614, processed and send them into database and adafruit IO, online platform be visualized[21]–[24].

3.2. Analyze addresses data recording and temperature screening at the gate and how the data are stored.

3.2.1. Research design

The research design used is a combination of cross-sectional, survey and experimental designs. In order to achieve the first objective of analyzing people addresses, data recording and temperature screening at the gate and how the recorded data are stored, the researcher followed both cross-sectional and survey designs.

A cross-sectional study is, according to Kate, A., L. (2014), " a study carried out at one time point or over a short-period" while a survey is defined as "a flexible research approach used to investigate a wide range of topics". Considering both cross-sectional and survey, Linda, K., O. (2002), put it that a cross-sectional survey design is "the collection of data at one point in time or over a short period of time from a sample selected to represent a larger population". In end, a cross-sectional survey design was applied on the case of churches operating in KIGABIRO Sector located in RWAMAGANA District.

3.2.2. Data sources

To achieve the first objective of the study, the current study relied on both primary and secondary data. Primary data is one which is collected for the first time by the researcher for getting the identified problem solved while secondary data is the data already collected or produced by others[25], [26]. To obtain primary data, self-administered research questionnaires were made available to the identified respondents for them to provide responses about the pinpointed aspects under investigation. The use of different textbooks, websites, internet, registries containing records kept by churches about Covid-19 prevention measures, journals, enabled to obtain secondary data and helped the researcher to gain deeper understanding of what has been found out by other researchers.

3.2.3. Population of the study

All the individuals or units of interest is taken as population[27]. The population of the current study included all churches that were established in KIGABIRO Sector. Yet, the study focused on a target population of 15 churches that were authorized to operate since they were the only ones meeting Covid-19 related restrictions imposed by the Government.

3.2.4. Sampling

3.2.4.1 Sample size determination

A sample is, a subset of the individuals in a population [28], [29]. The size of the sample can be determined using Sloven's formula stated as $n=\frac{N}{1+N(e)^2}$

Under this formula, n represents the sample size, N stands for the population, while (e) represents the level margin of error estimated at 5% since the confidence level is considered to be 95%. Applying the formula enables to note that

$$n=\frac{15}{1+15(0.05)^2}=14.45783.$$

Since respondents cannot be split into decimals, the sample size was rounded to 15 leading to the consideration of the entire target population.

3.2.4.2. Sampling procedure

The selection of the respondents, from each church, to be included in the sample was done using purposive and simple random sampling procedures. Ghauri, P. & Gronhaug, K., (2005), put it that simple random sampling "means that every case of the population has an equal probability of inclusion in sample[28]–[32]".

Since there were different church employees carrying out different responsibilities, the researcher deemed it compelling to identify employees that were thought to be in a position to provide relevant responses. Consequently, gate guards were found to be in a position to provide the required information and were given questionnaires through which they provided their responses. As there were more than one gate guards at all churches and only one guard was needed, since they were thought to provide the same responses due to the nature of the questions set, simple random sampling procedure was used to select one guard as the respondent as it gave equal chance to all guards to be selected.

3.2.5 Data collection techniques

Both the observation and the questionnaire were used to collect primary data. Mathers, N., (2007) considers the combination of both techniques to be appropriate techniques for the collection of both qualitative and quantitative data under cross-sectional survey design. The observation technique was use by the researcher being present when the church members were attending various church services and being. The questionnaire contained closed ended questions providing limited options of responses. For the collection of secondary data, documentation based on the registries held at the churches gates.

3.2.6 Administration of the questionnaire

The questionnaires were self-administered. As the number of respondents was relatively small, the researcher administered the questionnaire to the respondents. This enabled the research to clarify any aspect about which the respondents needed clarification and to retrieve the questionnaire immediately after all responses were given. All the questionnaires were retrieved.

3.2.7 Data processing and editing

Excel software was used for processing data collected through the questionnaire. Data were entered into the computer and meaningful information stored in the tables was produced after being processed.

3.2.8 Data analysis

Responses collected through the questionnaire were analysed using statistical analysis especially using descriptive statistics. Descriptive statistics generated in the form of frequencies and percentages were contained in a consolidated table and helped to organise and summarize the observations made.

3.2.9. Ethical consideration

The researcher was bound to seek for the authorization from the church leaders and to obtain the consent of the respondents before starting to collect the data. Moreover, the research was bound to keep the respondents' identity confidential. Integrity and respect were exercised towards the respondents all along the research process.

Chapter 4 : SYSTEM ANALYSIS AND PROTOTYPING

4.1. Experimental approach to achieve the second, third and fourth objectives

4.1.1. Automate addresses data recording at the gate

To be able to automate the addresses details data recording in this research, the RFID reader and RFID cards was used to automate the gate user's addresses details recording. MongoDB, the general database was to store the gate user's addresses details and the daily recorded data with RFID reader.

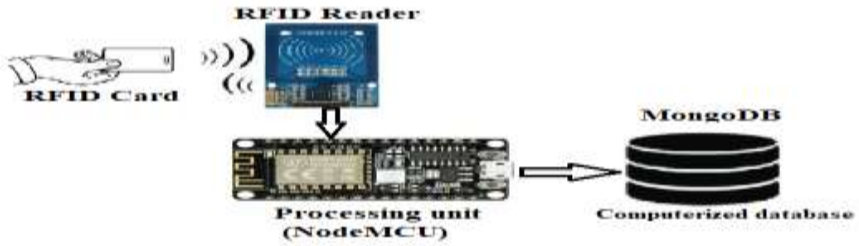

Figure 4.1: Automation of addresses data recording at the gate

Source: Primary data, 2021 (own designed)

The figure 3.2 shows system to automate addresses details recording. The RFID card was used as unique identification of user[14]. Once user come, he/she swipe his/her RFID card on the RFID reader, the Addresses mapped to this card are retrieved from the registered user's table and then stored in the daily gate attending table automatically. A beeping device called buzzer was used to generate an audio signal for signaling the gate user that his/her addresses details was recorded[24].

4.1.2. Automate body temperature screening at gate and mapped to addresses details

MLX90614 non-contact IR temperature sensor was used to enable automatic body temperature screening. During swiping RFID card on the RFID reader, the MLX90614 temperature sensor installed in right position to detect hand temperature, it automatically screened the hand temperature and send it to be processed. OLED (organic light-emitting diode) which is a light-emitting diode (LED), in which respond to the electrical current by emitting light using organic molecules was used to display the screened body temperature [33], [34].

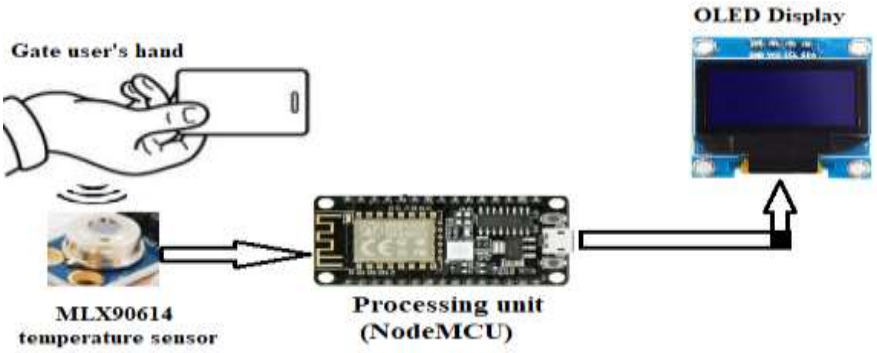

Figure 4.2: Automation of body temperature screening

Source: Primary data, 2021 (own designed)

4.1.3. Build automatic notification system and opening/closing the gate

The other objective of the research was to provide and deny the passing permission based on the screened temperature. Servo motor was used to open and close electronic gate. For the user with normal temperature, servo motor open gate for short time and close it automatically. For the user with abnormal temperature means temperature greater than the coded, the gate remain closed and with the use of twilio cloud communication platform, SMS notification is sent to the gate guard informing the presence of suspected body temperature

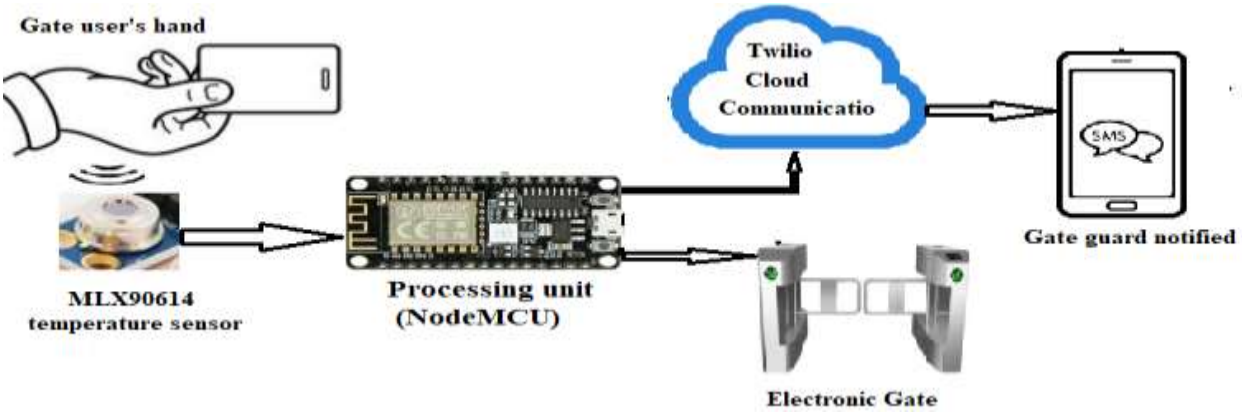

Figure 4.3: Automatic notification system and opening/closing the gate

Source: Primary data, 2021 (own designed)

4.2. Communication technology

4.2.1. RFID protocol

This is wireless technology called Radio frequency identification (RFID) uses electromagnetic fields to detect and identify nearest objects [35]. Within these technology, there is a tag stored information about the gate user and reader to interpret the information and send them into NodeMCU to be processed.

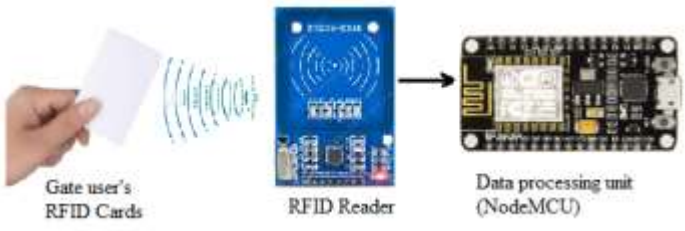

Figure 4.4: RFID Communication Protocol

Source: Primary data, 2021 (own designed)

4.2.2. Cellular and Hotspot Wi-Fi

One and most widely available options for IoT Applications is cellular communication protocol. Sometimes this is referred as satellite communications and this type of communication allows devices to send and receive data through a cell network [36]. Mare telecommunications companies are coming to provide this technology. Within this cellular communication protocol, cellular hotspot Wi-Fi technology was used as to connect NodeMCU to cellular network using hotspot access point to be able to send collected and processes data to the cloud database. The end user also use this cellular hotspot Wi-Fi technology to retrieve and monitor the collected data from sensors.

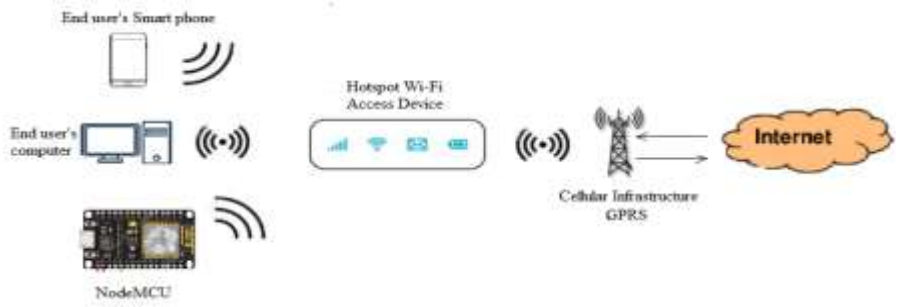

Figure 4.5: Cellular with Wi-Fi Communication Protocol

Source: Primary data, 2021 (own designed)

4.2.3. MQTT Communication protocol

Within this IoT based smart gate, we need to the collected data to be continuously shared and monitored remotely. These to be possible data need to be shared on cloud where they will be access continuously monitored. MQTT is the best protocol for this which is based on publish-subscribe protocol. This mean one end of the network publish data with a topic while the other end get data by subscribing to the some topic. This protocol is very short and therefore the time for communicating with the end user is reduced [37]. As shown in figure below, The NodeMCU microcontroller was used to collect and process the data collected from MLX90614 Non-Contact IR Temperature Sensor and therefore send the data to the broker (cloud as control elements).

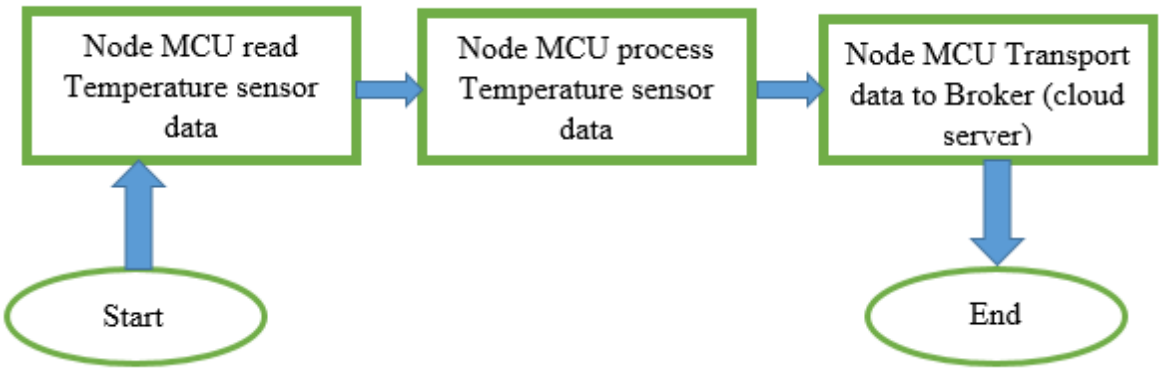

Figure 4.6: MQTT subscribing system architecture

Source: Primary data, 2021 (own designed)

4.3. System prototyping

4.3.1. System overview

Within this IoT based Gate for covid-19 prevention measures, each gate user possess a registered RFID Card with his/her addresses details for unique identification. The system on the gate has RFID reader to read RFID card and interpret information on it, Non-Contact MLX90614 IR temperature sensor to screen gate user's body temperature, NodeMCU microcontroller to receive data, process them and send them via Wi-Fi and MQTT communication protocol. There is also electronic gate to grant passing permission to the gate user. There is also a screen to inform the gate users about their body temperature status. Once the gate users come, firstly they have to swipe their cards on the RFID reader. During swiping card process, Non-Contact MLX90614 IR temperature sensor installed in right position to detect hand, it is automatically detect body temperature (hand temperature) and mapped to the addresses details of the gate user retrieved registered users table in database, and saved into attendance table in database. After the gate user's information have been recorded with normal body temperature, the electronic gate open itself automatically for short period giving passing permission to that user and closed itself after short period. If the suspect body temperature detected, the addresses details data with detected temperature are recorded but the system deny passing permission to that user, and SMS notification send to the gate guard informing about the presence of suspect gate user for timely decision making. There is a screen to inform the gate user about their temperature status and buzzer for signaling if data have been recorded.

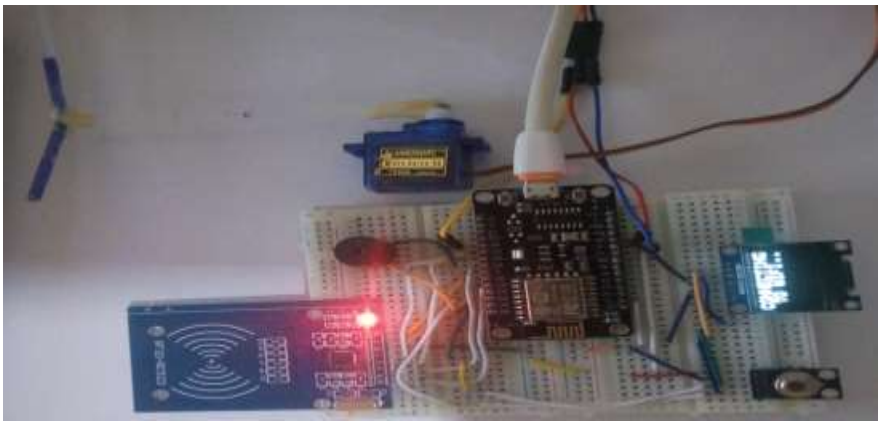

Figure 4.7: Physical components lab setup for the system prototype

Source: Primary data, 2021 (own designed)

4.3.2. System architecture

A system architecture is a conceptual model consist of system components and explain the construction structure of the system, behavior and other more views of the system [38]. The system architecture of IoT based Gate for covid-19 prevention measures is shown below with its components and the function of each component.

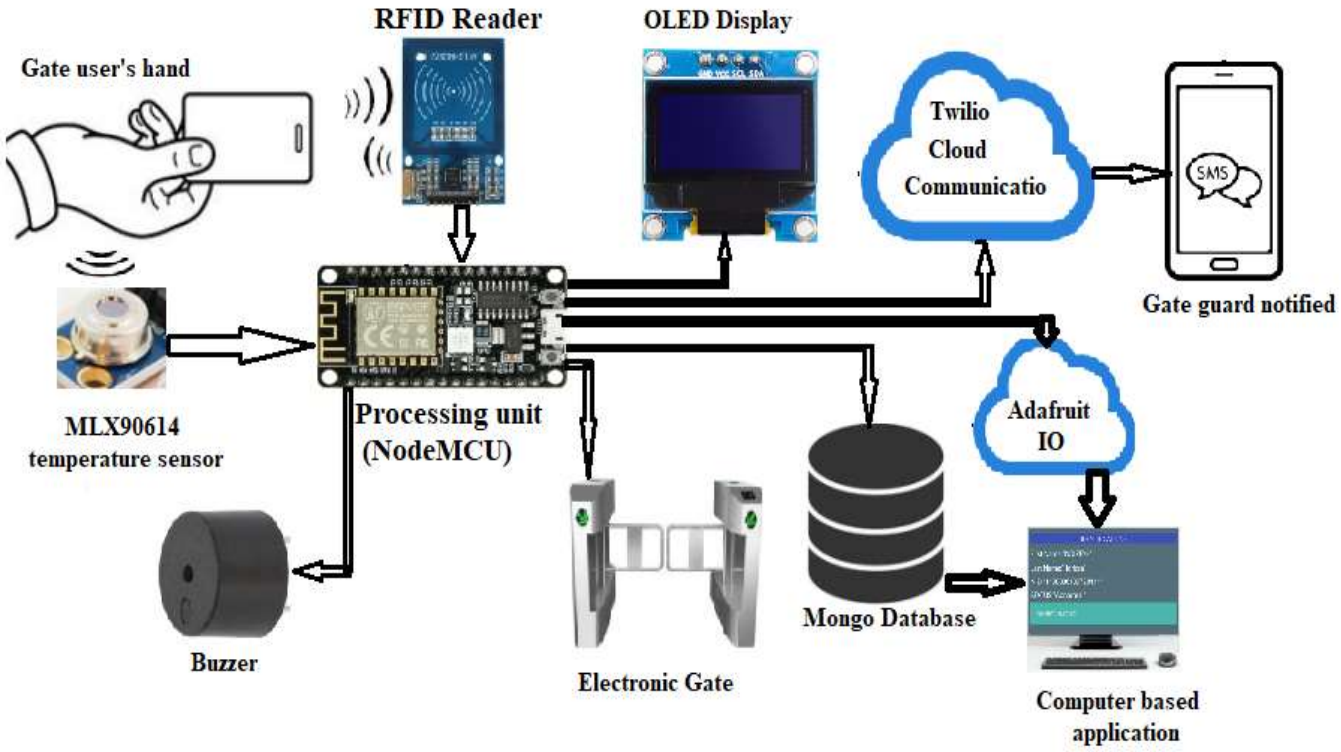

Figure 4.8: System architecture IoT based gate for covid-19 prevention measures

Source: Primary data, 2021 (own designed)

4.3.3. System flowchart

Flowchart is simply a way to represent how the data flows in the system from one activity to another activity and one or more decision are made in the system to monitor the system events[39]. The figure bellow shows how data flow in IoT based Gate for covid-19 prevention measures, from the action of swiping card up to the opening gate.

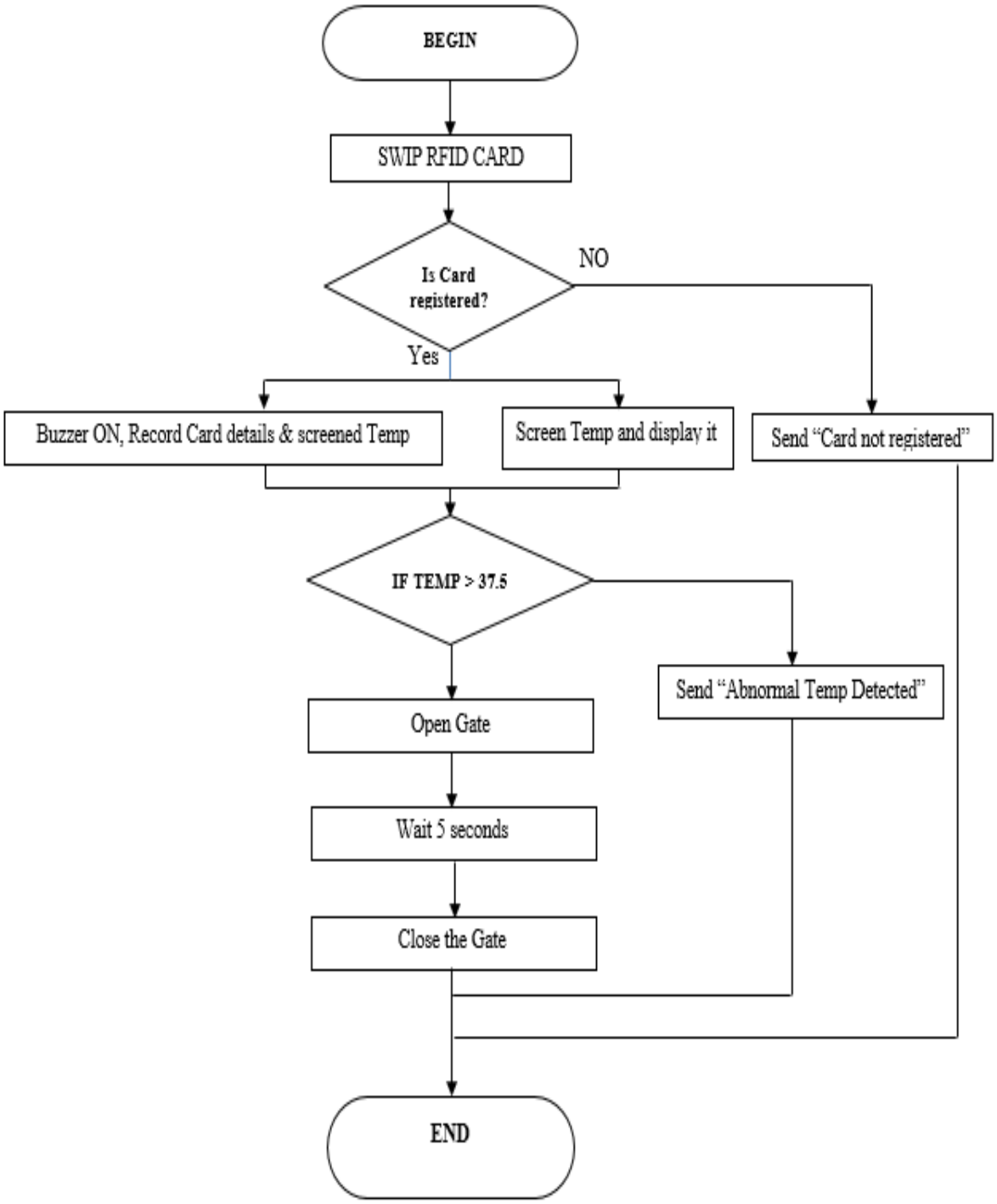

Figure 4.9: Flowchart for IoT based gate for covid-19 prevention measures

Source: Primary data, 2021 (own designed)

4.3.4. Block diagram

This is the physical representation of system using graphs or blocks to show the components of the system, how those components are connected together and the functional relationship between these components of the system. Block diagram on figure 13, show the main components of IoT based Gate for covid-19 prevention measures, how the components are connected together and functional relationship [38]. There is power supply to power processing unit, RFID sensor and Non-contact IR temperature sensor to collect data and send them in processing unit, NodeMCU as processing unit to process data and sent them in database, LCD to display gate user body temperature status, Buzzer to inform user that his/her address details have been recorded, servo motor to open and close gate door, Notification system to inform gate guard in case required timely response and data application which computer application to monitor the recorded data in system.

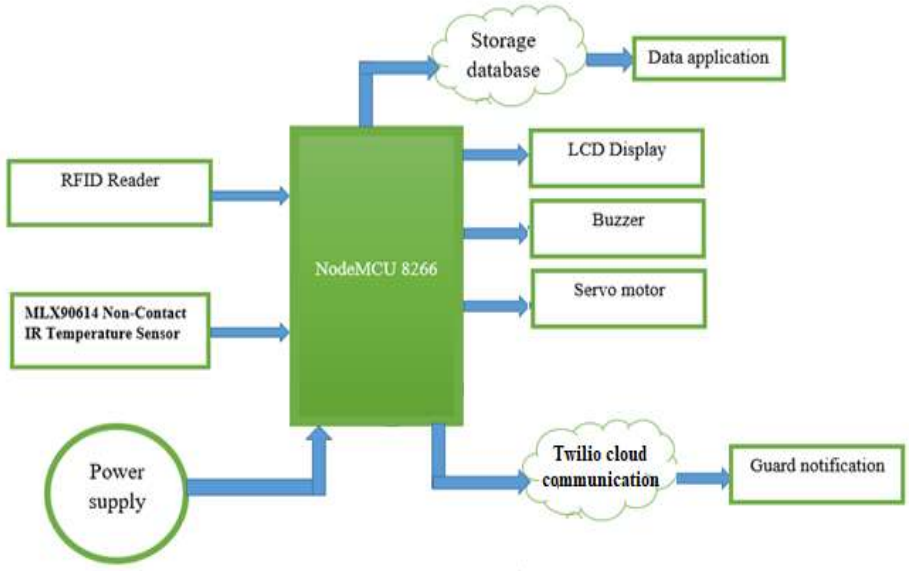

Figure 4.10: System block diagram

Source: Primary data, 2021 (own designed)

4.3.5. Schematic/ circuit diagram

This is the schematics/circuit diagram that shows electrical connection between different components of IoT Based gate for covid-19 prevention measures. Fritzing software was used to design these circuit diagram.

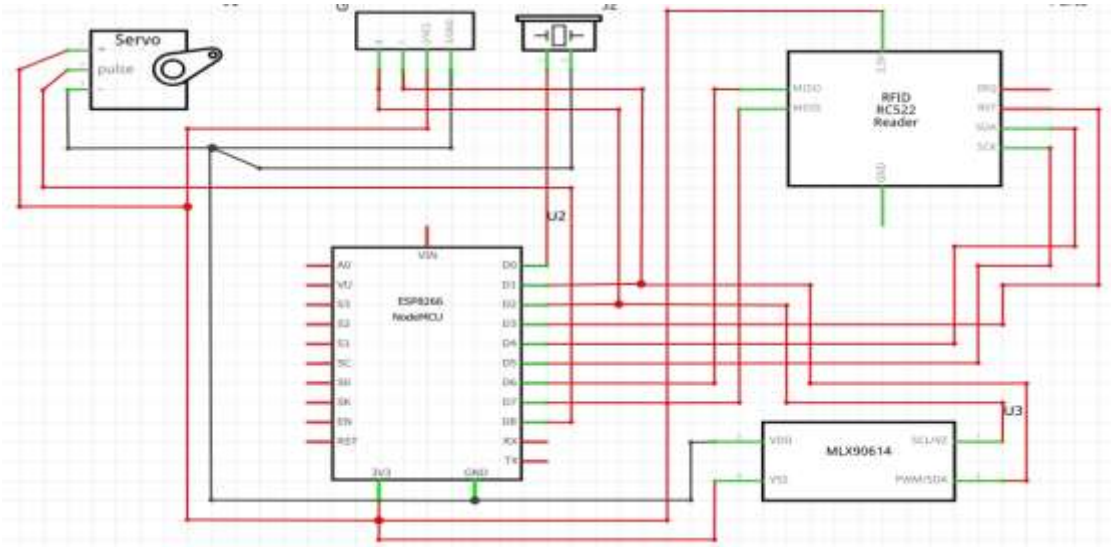

Figure 4.11: Schematic diagram of the system

Source: Primary data, 2021 (own designed)

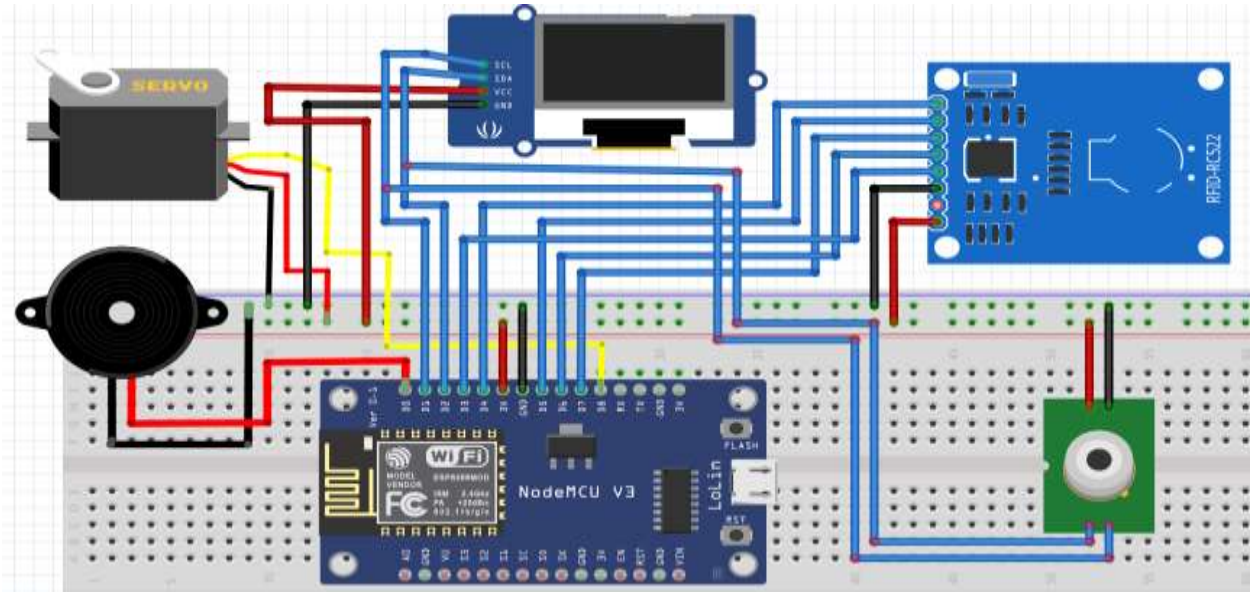

Figure 4.12: Breadboard diagram of the system

Source: Primary data, 2021 (own designed)

4.3.6. Database design

Database is a structured collection of inter-related information kept together in form of tables to be used in different application[40], [41]. In these systems, mongoDB was used to create database to store addresses details of the gate users and the daily data recorded at the gate. This database is computerized database and it simplified people tracing. Cloud database to store the temperature and visualizing the variation temperature value was created using was used to store and monitor screened body temperature and variation of the tested temperature

4.3.6.1. Database creation

These code bellow shows how database called PRAYERS was created and connected on it in mongoDB

```
//creation of PRAYERS DATABASE and connectPRAYERS DATABASE
mongoose.connect('mongodb://localhost:27017/PRAYERS',{ useUnifiedTopology: true, useNewUrlParser: true })
.then(()=>
console.log('connected to mongodb locally')
)
.catch((error) =>{
console.log("not connected to db");
console.error(error)
}
)
```

Figure 4.13: Mongo DB creation

Source: Primary data, 2021

4.3.6.1. Table creation

In this database, two tables was created. The first table is called “client” and was created to store the gate user’s addresses details. Each registered user, his/her data are saved into this table. The second table is called “transaction” and was created to store the daily data recorded at the gate. The bellow codes shows how each table was created in mongoDB and indicates the information stored in each table.

models > JS client.js > ...

```
1   const mongoose = require('mongoose');
2   const Schema = mongoose.Schema;
3
4   const userSchema = new Schema({
5    firstname: { type: String},
6     lastname: { type: String},
7     NID: { type: String},
8     District: { type: String},
9     Sector: { type: String},
10    Cell: { type: String},
11    Village: { type: String},
12    Phone: { type: String},
13    card: { type: String, required:true },
14  });
15
16  const client = mongoose.model('client',userSchema);
17
18  module.exports = client
```

Figure 4.14: mongo DB transaction table creation

Source: Primary data, 2021

models > JS transaction.js > ...

```
1   const mongoose = require('mongoose');
2   const Schema = mongoose.Schema;
3
4   const userSchema = new Schema({
5     firstname: { type: String},
6     lastname: { type: String},
7     NID: { type: String},
8     District: { type: String},
9     Sector: { type: String},
10    Cell: { type: String},
11    Village: { type: String},
12    Phone: { type: String},
13    card: { type: String, required:true },
14    temperature: { type: Number},
15    status: { type: String},
16    time: { type: String},
17  });
18
19  const transaction = mongoose.model('transaction',userSchema);
20
21  module.exports = transaction
```

Figure 4.15: mongo DB transaction table creation

Source: Primary data, 2021

Chapter 5 : RESULTS AND DISCUSSION

IoT based Gate for covid-19 prevention measures prototype was tested and this chapter highlights the results from prototype testing. During this test, it is shown that the gate user's address was recorded automatically when people swipe their cards on the designed gate device and their body temperatures were automatically screened and mapped to their address details. For the gate user with abnormal temperature, the data was recorded in database but the gate door was not opened to let this user pass, instead the system sent SMS notification to the gate guard informing the presence of suspect body temperature for timely response. For the user with normal temperature, the gate door was opened to allow the user to pass.

5.1. Analyzing addresses recording, temperature screening and data storage

The first objective of the current study was to analyze people addresses data recording and temperature screening at the gate and how the recorded data are stored. Both primary and secondary data were collected and analyzed to achieve this research objective. This was done to understand how existing systems are working and get the requirements of the proposed system. Data collected by different data collection methods was analyzed.

5.1.1. Analysis of data collected through documentation

Documentation is the existing evidence provided for information. In this research, documents from churches were used to understand the type of the data collected within the existing system, how these collected data are stored and analyzed for father people's contact tracing.

The figure below, shows that the book based manual data recording system is being used and the data for customer's addresses details needed to be recorded are names, district, sector, telephone number and screened body temperature. Figure shows also that the data for highest and lowest daily temperature screened and the total people tested are kept in books.

Figure 5.1: Book based manual gate user address recording system

Source: Churches archives, 2021

In figure below, data collected on 25th August 2021 shows 32.3^{0}C as the lowest screened temperature, 37.5^{0}C as the highest screened temperature and 1064 as the total tested gate users.

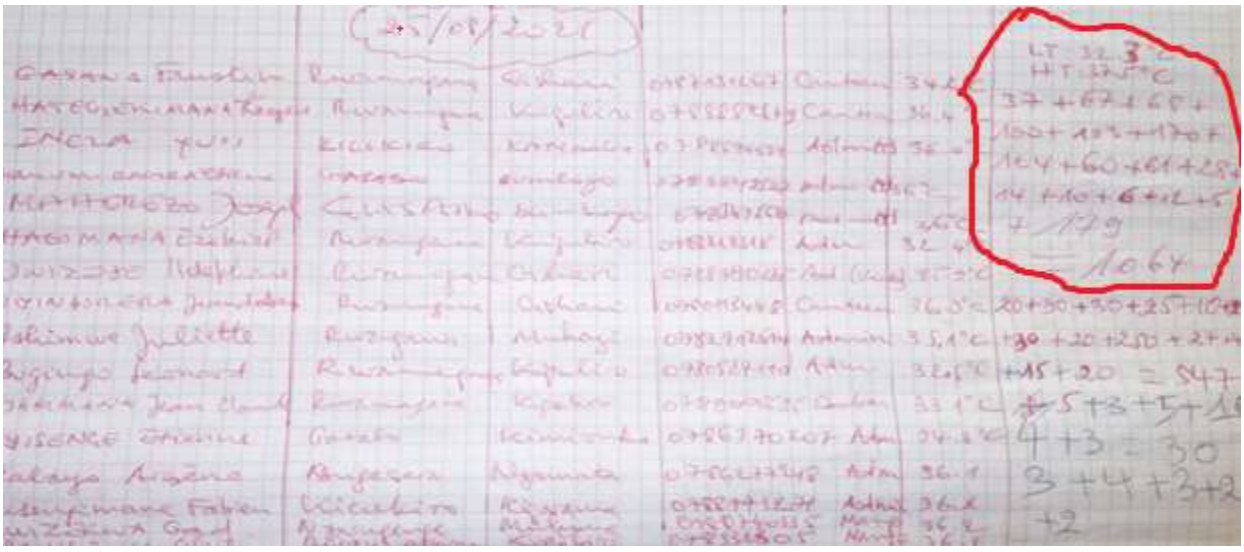

Figure 5.2: Daily lowest & highest screened body temperature and Total number of people tested

Source: Churches archives, 2021

5.1.2. Analysis of data collected through observation

Observation is a method of data collection in which researchers observe within a specific research field and get information on the system. In this research, this unobstructed method was used to observe how body temperature is screened and how customers' addresses details are recorded at different gates as the covid-19 prevention measures.

The figure below shows the people at the gate screening the body temperature of the gate user. Means after being screened, this screened person has to pass to another people to be recorded in books. Within this process, it noticed that peoples have to stand on line waiting the first people to be recorded for the next to proceed. This results even minimum compared to the 1.5 meter needed between two persons

Figure 5.3: Handheld thermometer based manual body temperature screening

Source: Photo taken on the spot 2021

5.1.3. Analysis of data collected by questionnaire

This is a tools for data collection for the aim of obtaining information from respondents. Within this method series of closed questions were asked how the body temperature are screened at entry point and how peoples addresses details are recorded as parts of Covid-19 preventions measures at churches' gates. In this survey Google form was used to collected data from five different churches and 15 people working on gates were participated.

Table 5.1: Results from analysis of data collected through questionnaire

Information asked to the respondents	**Provided answers**	**Frequency**	**Percentages**
Existence of system to record addresses details and to screen body temperature on entrance	Yes	15	100%
	No	0	0%
System used to screen Body temperature	Hand held thermometer	15	100%
	Wall mounted thermometer	0	0%
	Computerized system	0	0%
Time to screen body temperature in terms of seconds	1-5	9	60%
	6-10	5	33.3%
	11-15	1	6.7%)
	16-30	0	0%
System used to record the addresses details	Book based manual System	15	100%
	Computer System	0	0%
	Do not record	0	0%
Time to record addresses details in terms of seconds	5-10	0	0%
	10-30	0	0%
	30-60	4	26.7%
	Above	11	73.7%
Maximum body temperature allowed for people to pass	37 ^{0}C =1 (6.7%)	1	6.7%
	37.5^{0}C =9 (60%)	9	60%
	38^{0}C =5 (33.3%)	5	33.3%
	Others =0 (0%)	0	0%
Screened body temperature is recorded in data recording system for future reference and decision making	Yes	5	33.3%
	No	10	66.7%
Body temperature need to be recorded for future reference and decision making	Yes	14	93.3%
	No	1	6.7%
One people can do all these tasks alone at gate	Yes	13	86.7%
	No	2	13.3%
Number of people can implement these prevention measures smoothly at your gate	One person	1	7.6%
	Two persons	4	30.8%
	Three persons	6	46.2%
	Four persons	2	15.4%
Data needed in your report at the end of day	Daily maximum temperature	14	100%
	Daily minimum temperature	14	100%
	Total people tested =13	13	92.9%
	Details of suspected	7	50%)

Information recorded for address details	Names	15	100%
	National Identity	12	80%
	Province	3	20%
	District	15	100%
	Sector	15	100%
	Cell	15	100%
	Village	4	26%
	Phone Number	14	93.3%
	Function	0	0%
Challenges during the implementation of these covid-19 prevention measures	Big cloud when many people come	5	33.3%
	Minimum social distance	2	13%
	Testing and looking on thermometer screen	11	73.3%
	Long line during addresses details recording	13	86.7%
	More time required to record addresses details	14	93.3%
	Errors in writing people's address	7	46.7%
Expectations from automated computerized system	Decrease number of employees at gates	13	86.7%
	Speed up the process	13	86.7%
	Record more information	4	26.7%
	Accurate in data recording	9	60%
	Timely information	9	60%
	Remove long line at the gate	13	86.7%

Source: Primary data, 2021

The results from the table above show that systems to record addresses details and to screen body temperature on entrance exist in all churches considered under the current study. This implies that compliance with government requirements regarding Covid-19 prevention measures is 100%. Results also prove that hand held thermometer is the only system used to screen body temperature while book based manual system is used to record the addresses details in all churches under study. This translated the need for other better systems. The maximum body temperatures allowed for people to pass by the gate vary among the churches under study. This implies that there is need for harmonisation. The totally commonly information recorded for address related details included names, National id, district, sector, cell, sector and District. Yet, some churches record information that is detailed to include even villages.

Elsewhere, the results in terms of percentages of responses from the very same table enable to note that the outstanding challenges during the implementation of covid-19 prevention measures include mainly time required to record addresses details (93.3%), long line during addresses details recording (86%) and testing and looking on thermometer screen (73.3%). These challenges require to put in place a system that can help address them and current study is intended to help deal with such challenges. The expectations from automated computerized system are primarily equally centered on how to remove long line at the gate (86.7%), to decrease number of employees at gates (86.7%), to speed up the process (86.7%). Accuracy in data recording (60%) and generation of timely information (60%) also raise meaningful expectations. To meet such expectations, there is need to find out a more effective and efficient system that can be relied upon in the churches under consideration. The current study is intended to help meet such expectation by developing a more appropriate system that can help address many of the weaknesses the current systems in use are suffering from. The following section shows how such a system is developed and can function once implemented among the churches under study. During evaluation of the system, different screenshots were taken.

5.2. Evaluation screen shoots

5.2.1. Gate user's registration page

Each gate user was given an RFID card to uniquely identify the gate user and addresses details of this user were recorded in database. The addresses of each user were recorded with the number of given RFID card and stored in table called clients. The interface to register each user was provided and used to record the gate users. The figure bellow shows how the process was implemented.

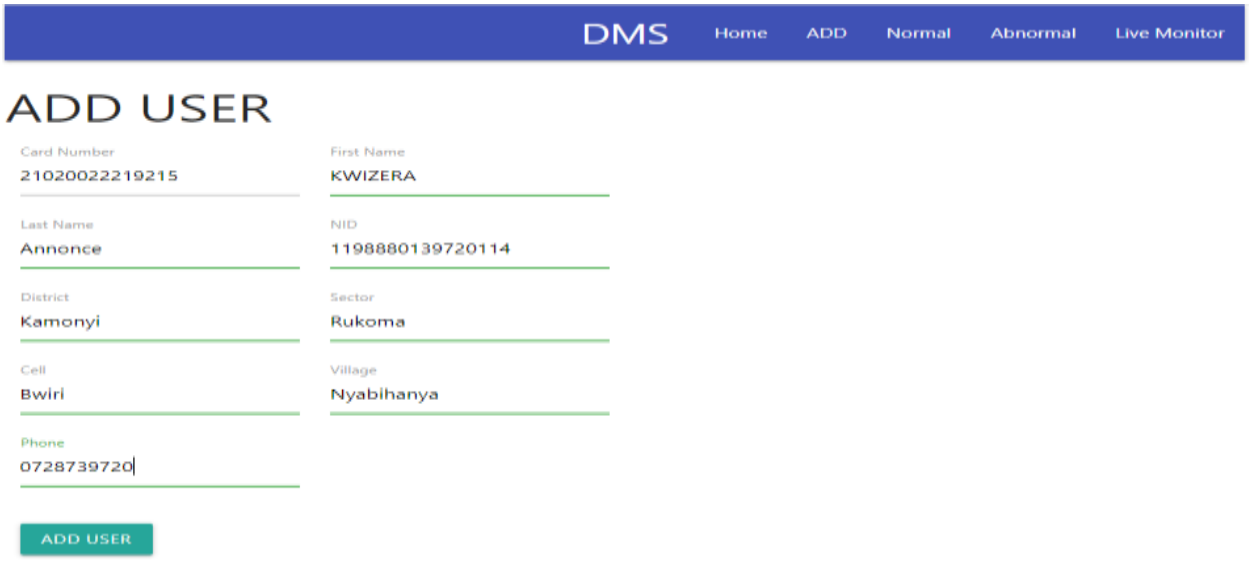

Figure 5.4: Page for New gate user's registration

Source: Primary data, 2021

5.2.2. Unregistered user denied display

For the user with unregistered card tried to enter in the place by swiping his/her card on the RFID reader, the temperature sensor detected his/her body temperature and display it on screen, but passing permission was not granted because the user was not in the system. The system informs that user to get registered first to be allowed to enter. The figure bellow shows the results from the process implemented.

Figure 5.5: Alert display page for unregistered gate user swiped his/her card to pass

Source: Primary data, 2021

5.2.3. Registered users with abnormal temperature display

For the registered user with abnormal temperature tried to enter in place, he/she swiped the card on the card reader, his/her addresses details were recorded automatically in transaction table but the system indicated that him/her that his/her body temperature was abnormal and passing permission was denied to him/her. The figure bellow shows the outcome of the process implemented.

Figure 5.6: Alert display page for registered user with abnormal temperature

Source: Primary data, 2021

5.2.4. SMS notification

For every user with abnormal temperature who tried to pass at the gate, the system have notified the gate guard informing about the suspect gate user and the screened temperature. The figure bellow shows the results from the process carried out.

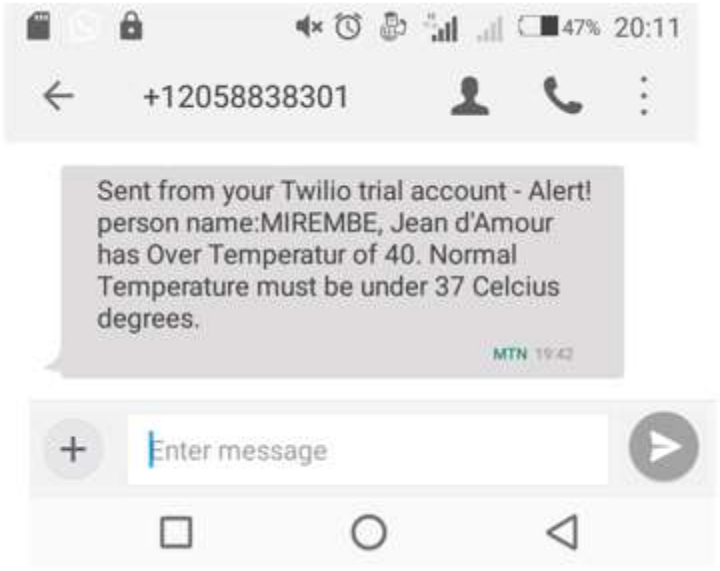

Figure 5.7: SMS notification sent to the gate guard by Twilio cloud communication platform

Source: Primary data, 2021

5.2.5. Registered user with abnormal temperature display

For the registered user with normal temperature tried to enter in place, he/she swiped the card on the card reader, his/her addresses details was recorded automatically in transaction table. The system informed him/her that his/her body temperature was normal then passing permission was granted to this user by opening the gate. The figure bellow shows the results from the process carried out.

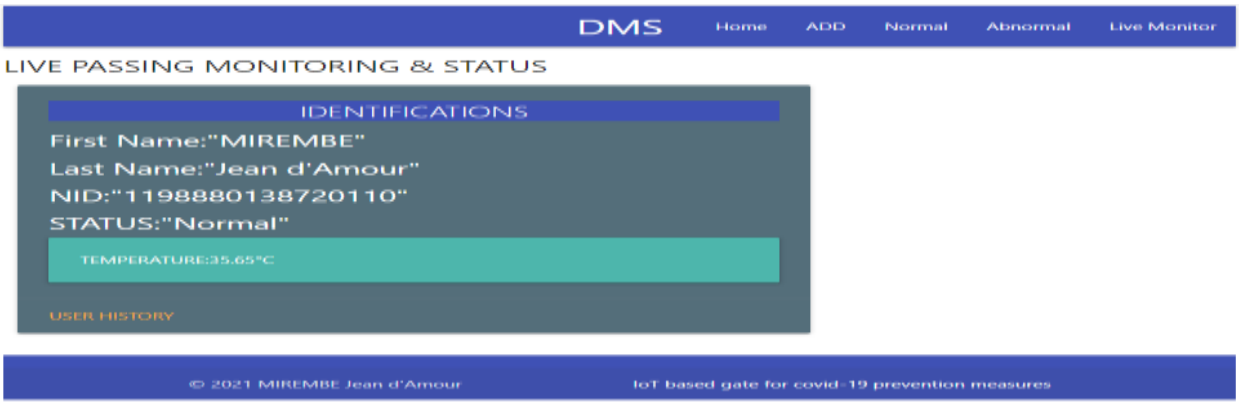

Figure 5.8: Alert display page for registered user with normal temperature

Source: Primary data, 2021

5.2.6. Users with normal temperature page

The system provided the interface to retrieve the all gate users with normal temperature recorded at the gate. This helped to know the total number of users with normal temperature and their addresses details. The figure bellow shows the results from the process carried out.

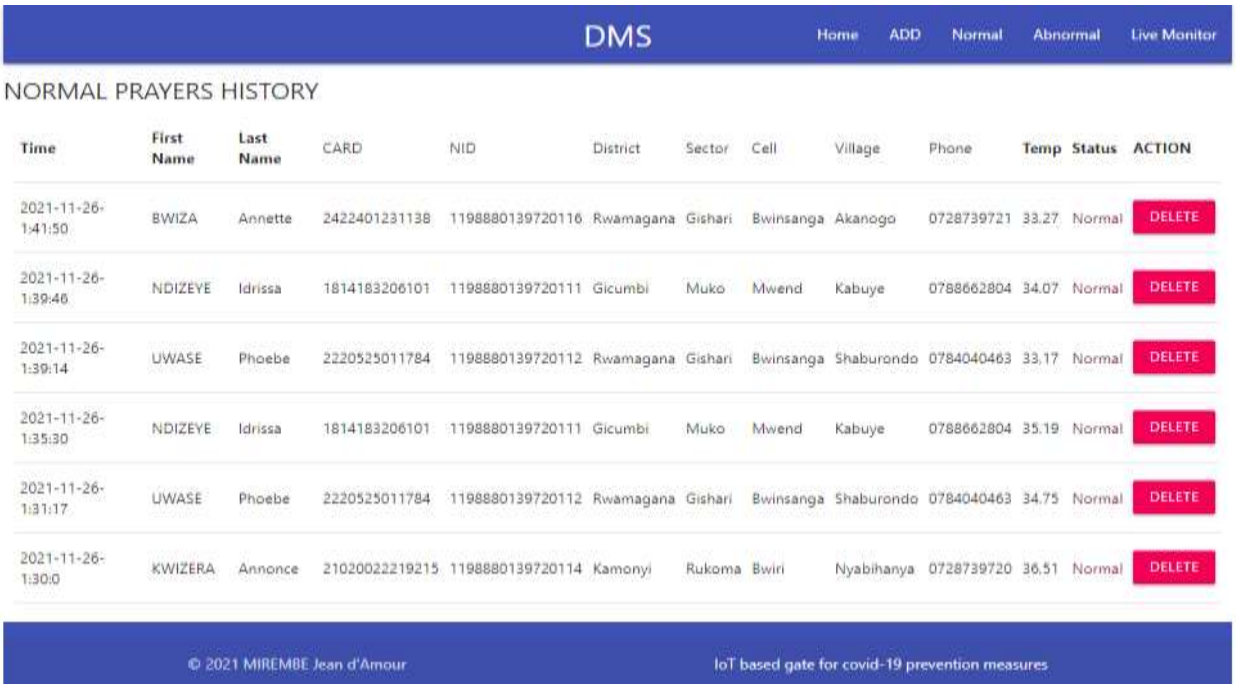

Figure 5.9: Page for list of gate users with normal temperature

Source: Primary data, 2021

5.2.7. User with abnormal temperature page

The system provided the interface to retrieve the all gate users with abnormal temperature recorded at the gate. This helped to know the total number of the gate users with abnormal temperature and their addresses details. The figure bellow shows the results from the process carried out.

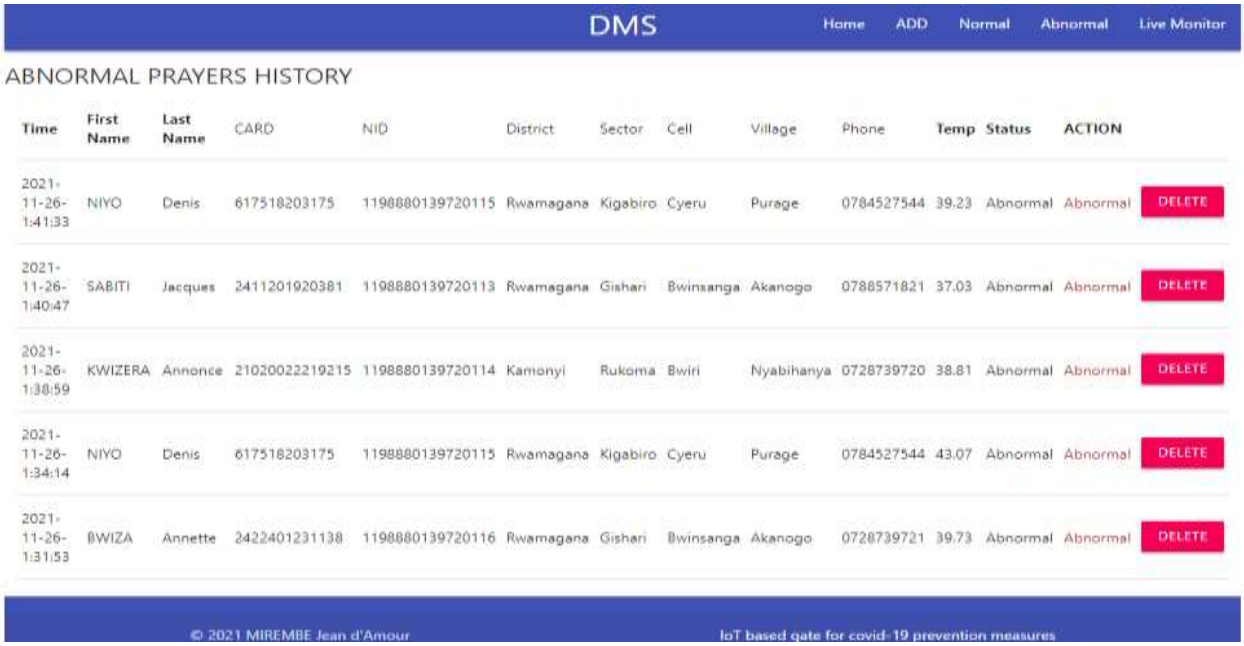

Figure 5.10: Page for list of gate users with abnormal temperature

Source: Primary data, 2021

5.2.8. Online temperature data visualization

The gate guard was able to interact with the screened body temperature value, and was able plot the daily highest and lowest body temperature screened using Adafruit IO platform. The figure bellow shows the results from the process carried out.

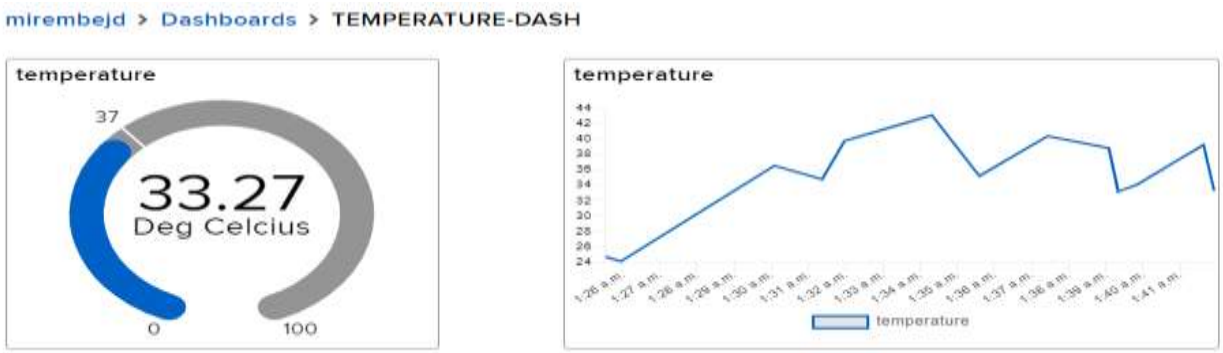

Figure 5.11: Online temperature data visualization with Adafruit IO cloud platform

Source: Primary data, 2021

5.3. Results discussion with the existing system

In this research development, existent literature was reviewed. The results showed not only some similarities but also some differences with the previous works. The related works section shows that the automation technology was implemented at the entry point of public places trough smart gates.

S. P, V. Valsan, and P. C, proposed system to open gate using RFID and Raspberry pi. But this was only for opening gate.

S. Oluwole 2014, proposed automatic gate control using infrared remote with password where users can open and close the gate with password using IR control.

D. D. Putra, M. Febriyanto 2020, have designed Smart-Gate Based on Artificial Intelligence to detect if people were wearing face mask.

Abuzairi, N. Imaniati Sumantri, 2021, have designed non-contact infrared thermometer mounted on the wall on the wall which do not require operator.

The main objective within the existing was to grant gate passing permission to the only autorised gate users. The some with these authors stated in related, IoT based gate for covid-19 prevention measures, aimed to grant gate passing permission to the authorized gate users, but the results also shows that addition to this, IoT based gate for covid-19 prevention measures was able to automatically record gate user's addresses details, automatically screen gate user's body temperature and notify the gate guard through an SMS notification in case of suspect body temperature.

Chapter 6 : CONCLUSION, RECOMMENDATIONS AND FUTURE WORK

6.1: Conclusion

The main purpose of this system was to automate body temperature screening and address details recording as covid-19 prevention measures at entry points of places with regular users such as at the churches gates. It also intended to notify the gate guard, through automatic SMS notification, in case of covid-19 suspect. These were done to simplify the work done at the entry points and minimize the number of people employed for such purpose by using cheap and available local materials and online database. The results shows that the churches can minimize the number of people employed to perfume covid-19 prevention measures and time was taken by using IoT based gate for covid-19 prevention measures. The proposed system also shows that using computerized database help speed up the process and enable users to get data and report at any time anywhere and is able to provide notification in case of suspect body temperature detection.

6.2: Recommandation and future work

As IoT based gate system proves to be cheap, timesaving and enable to reduce significantly the workers required for the implementation of Covid-19 prevention measures, church leaders should adopt this system in order to operate with increase efficiency and benefit from related advantages.

IoT based gate for covid-19 prevention measures system was designed to facilitate the work done at entry point but is not meeting all requirements to be implemented in all public places as it need database of all gate users to be in places and also each user must have a recorded RFID card. This constitutes a limitation to this system to be used at entry points of public places with regular users

For future work, as many Rwandan has national Identification card registered in Rwanda National Identification Agency (NIDA), I recommend to be extend this system and linked with NIDA system so that every people with National Id can use it at any gate without database registration requirement.

I also recommend for the future work to include machine learning in this work to help in prediction of location with high temperature than others to help health agencies to identify critical location with covid-19 suspect based on the screened body temperature at different gate.

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APPENDIX

Questionnaire used in data collection

Q1. Is there a system to record address details and screen body temperature on entrance of your church?

- ❖ Yes ☐
- ❖ No ☐

Q2. What system is used to screen Body temperature?

- ❖ Hand held thermometer ☐
- ❖ Wall mounted thermometer ☐
- ❖ Computerized system ☐

Q3. What time it takes to screen people's body temperature with the used system in terms of seconds?

- ❖ 1-5 ☐
- ❖ 6-10 ☐
- ❖ 11-15 ☐
- ❖ 16-30 ☐

Q4. What is the system is used to record the addresses details?

- ❖ Manual Book System ☐
- ❖ Computer System ☐
- ❖ Do not record ☐

Q5. What time it took to record people's address details in terms of seconds?

- ❖ 5-10 ☐
- ❖ 11-30 ☐
- ❖ 31-60 ☐
- ❖ Above 60 ☐

Q6. What is the maximum body temperature allowed for people to pass in terms of degree Celsius?

- ❖ 37 ^{0}C ☐
- ❖ 37.5^{0}C ☐
- ❖ 38^{0}C ☐

Q7. Do you record the people's screened Body temperature within your data recording system for the future reference and decision making?

- ❖ Yes ☐
- ❖ No ☐

Q8. Is it necessary to record the body temperature for future reference and decision making?

- ❖ Yes ☐
- ❖ No ☐

Q9. One people can perform all these tasks alone at gate?

- ❖ Yes ☐
- ❖ No ☐

10. How many people are required to implement these prevention measures smoothly?

- ❖ One person ☐
- ❖ Two persons ☐
- ❖ Three persons ☐
- ❖ Four persons ☐
- ❖ Five persons ☐

Q11. What kind data be reported at the end of a day?

- ❖ Daily maximum temperature ☐
- ❖ Daily minimum temperature ☐
- ❖ Total people tested ☐
- ❖ Details of suspected ☐
- ❖ Others information ☐

Q12. What kind of information you record for people addresses details?

- ❖ Names ☐
- ❖ Province ☐
- ❖ District ☐
- ❖ Sector ☐
- ❖ Cell ☐
- ❖ Village ☐
- ❖ Phone number ☐
- ❖ Occupation ☐

Q13. What challenges do you meet with during the implementation of these covid-19 prevention measures?

- ❖ Big cloud when many people come ☐
- ❖ Minimum social distance ☐
- ❖ Testing and looking on thermometer screen ☐
- ❖ Long line during addresses details recording ☐
- ❖ More time required to record addresses details ☐
- ❖ Errors in writing people's address ☐

Q14. What are your the expectations from automated computerized system?

- ❖ Reduce number of workers ☐
- ❖ Speed up the process ☐
- ❖ Record more information ☐
- ❖ Accurate in data recording ☐
- ❖ Timely information ☐
- ❖ Remove long line at the gate ☐