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# IoT based Embedded Gateway for smart Health-care Management

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**MSc in Internet of Things – Embedded Computing Systems**

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Thesis' title

# IoT based Embedded Gateway for smart Health-care Management

By

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Ref: **220014212**

A dissertation submitted in partial fulfilment of the requirements for the degree of

Masters in Internet of Things

With specialization in Embedded Computing Systems

In the College of Science and Technology

At the African Center of Excellence in IoT (ACEIoT)

Supervisor: **Dr. MUKAMURENZI Solange**

Co-Supervisor: **Dr. NSENGIYUMVA Philibert**

**BONIFIDE CERTIFICATE**

This is to certify that the project work entitled "**IoT based Embedded Gateway for smart Health-care Management**" is a record of the original work done by **NDABAHARIYE Jean Aime** registration number is **220014212**. It is in partial fulfillment of the requirement for the award of MSc with honors in Embedded Computing Systems (ECS) at the African Center of Excellence in Internet of Things, (ACEIoT) College of Science and Technology in University of Rwanda during the academic year 2020 - 2021.

Signature of supervisors

**Supervisors**

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**Dr. MUKAMURENZI Solange**

Digitally signed by Dr Solange Mukamurenzi

The Head of Masters and Trainings ACEIoT

**Dr James RWIGEMA**

Signature

**DECLARATION**

I declare that this research project report entitled "IoT BASED EMBEDDED GATEWAY FOR SMART HEALTH-CARE MANAGEMENT" is presented for the award of Master's degree in Internet of Things at African Center of Excellence in Internet of Things, especially in in Embedded Computing System, University of Rwanda, is my own work. It has never been presented or submitted in any University, Institution or High learning for the similar award.

University of Rwanda - UR
Internet of Things at African Center of Excellence in Internet of Things – ACEIoT
Embedded Computing System – ECS

November 30th, 2021

Declared by:

Jean Aime NDABAHARIYE
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**ABSTRACT**

An Internet of Things based on Embedded Gateway for smart Health-care Management using radio frequency Identification is based on the health sector combined with the available smart technologies of today, all are leading to facilitate the both sides that patients and health-based facilitators. The healthcare is very important in the human being in using the available technologies where are basing on the use of the smart devices for the dynamic some human's health information wherever. The main users of this system are doctors, laboratory, pharmacist, receptionist, consultant, cashier, patient and system agent. For the better understanding of conceptual framework for the study, theory relating the usefulness of information technology and database utilities was reviewed in the next contents

To achieve our objectives; a V-model was used as a software development process model to develop the software. Interviews, documentation and observation were used as the major data collection techniques in respect to the system analysis and requirements engineering, the design of information flow was carried out using UML Modeling software product. Implementation and deployment of the system was achieved using JAVA, PHP and MySQL technologies; graphical user interfaces have been designed with coupling of HTML, JavaScript, CSS and Macromedia Dreamweaver 6, the backend was deployed using XAMPP Server and integrated using PHP as scripting language while the connection of the sensors is designed using two platforms one is the use of RFID tag or card, and the second is the use of web service.

**Keyword**: Internet of Things, Radio frequency Identification Technology, Authentication process, Sensors, Arduino and Ethernet.

**LIST OF ACRONYMS**

**1NF**: First Normal Form

**2NF**: Second Normal Form

**3NF**: Third Normal Form

**4NF**: Fourth Normal Form

**ACEIoT**: African Center of Excellence in Internet of Things

**Ag**: Acting

**API**: Application Program Interface

**CHUK**: University Teaching Hospital of Kigali

**CLI**: Command Line Interface

**CPU**: Central Processing Unit

**CSS**: Cascading Style Sheet

**D**: Digital

**DBMS**: Database Management System

**DBMS**: Database Management System

**DFD**: Data Flow Diagram

**Dr.**: Doctor

**e.g.**: Example

**ECC**: Elgin Community College

**ERD**: Entity Relationship Diagram

**ERD**: Entity Relationship Diagram

**ESP8266**: Espressif Systems

**GND**: Ground

**GPS**: Global Position System

**HDD**: Hard Disk Driver

**HLD**: High Level Design

**HTML**: Hypertext markup language

**HTTP:** Hypertext transfer protocol

**I2C**: Inter-Integrated Circuit

**ID**: Identification

**IoT**: Internet of Things

**IoT**: Internet of Things

**IoTEGHM**: Internet of Things based on Embedded Gateway for smart Health-care Management

**IP Address**: Internet Protocol Address

**LED**: Light Emitting Diode

**LLT**: Language Learning and Technology

**LoRa**: Long Range

**Md5()**: Message Digest Algorithm

**MFRC522**: MIFARE

**MHz**: Megahertz

**MISO**: Master In Slave Out

**MOSI**: Master Out Slave In

**N**: Network

**NodeMCU**: Node Micro Controller Unit

**NXP**: Next Experience

**OS**: Operating system

**PDO**: PHP Data Object

**PHP**: Hypertext pre-processor

**RFID**: Radio Frequency Identification

**RJ45**: Registered Jack-45

**RST**: Radio Systems Technology

**SCK**: Serial Clock

**SDA**: Screen Design Aid

**SDK**: Software Development Kit

**SDLC**: Software Development Life Cycle

**SMBG**: Self-Monitoring of Blood Glucose

**SPI**: Serial Peripheral Interface

**SQL:** Structured Query Language.

**SRS**: Software Requirements Specification

**SS**: Signal input when SPI

**UART**: Universal Asynchronous Receiver- Transmitter

**UML**: Unified modelling language

**UR**: University of Rwanda

**V Model**: Verification and Validation mode

**V**: Voltage

**WiFi**: Wireless Fidelity

**XAMPP**: Cross-Platform Apache MariaDB PHP and Perl

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# Chapter 1. INTRODUCTION

## 1.1.Overview and Background

With the introduction of IoT, e-health systems are equipped with rich health related data and information that are utilized to make right and accurate decision through seamless interconnections between people, systems, service. Health-care receptionists, doctors, lab technicians, nurses, cashiers access the information of the patients through a structured manner that makes life easy and comfortable. The wellbeing and improved lives are the ultimate target of smart cities and smart nations in general. The collection, storage, and retrieval of the information are very crucial when it comes to health-care daily operations[1].

Real time sharing of medical data to the right person will be very important, such systems improves privacy, security, and time of service. Many research works have been conducted on e-health most especially in the aspects of mobile applications, and web based applications development, smart health systems that include wearable devices for personal health monitoring of key health conditions such as blood pressure, cardiac arrest, body temperature monitoring and others [2][3][4]. However, the development of hardware health devices that implements numerous smart health applications is of great importance.

In fact, we developed the system for easy communicating when a patient needs to navigate through his/her health's information and a smart card instead of papers; they use it to tap on the RFID reader near by the health facilitators and shows the patient's information and they update the current information and so. About the health facilitators, they will use an online Web service connecting to the MySQL database and desktop application developed using frontend and backend concepts where the system requires the privileges to use for getting the access to the information, requiring the username and password, the languages that we have used are JAVA, PHP, JavaScript, Arduino and database used is MySQL concepts.
Considering the case study of this research which is CHUK, accessibility of the patients' information is still organized the way that the patients have the cards branded within the details including the reference number with the barcode cipher, so that it is not easy to discover the information behind without barcode scanner or barcode reader, leads to the difficulty for the patients to for viewing their medical's information in order to make his/her own checkup, they can't use the technology tools for the medical issues like smart phones, tablets. In fact, this research is overcome the above difficulties by intervening of an IoT in health sector. And explains of how the patients and health centers or hospitals access the information using an IoT technology.

### 1.2.Motivation

In this project, an identification of the patients is enabled by using RFID. The confluence of RFID, medical sensors and web-based technologies is contributing an important responsibility in the medical information owns, and alerts that are commonly exercised in the health-care systems. An IoT based gateway device is designed and a working prototype is demonstrated that acts as a significant initial step of the system. Health professionals will be able to interact among themselves share important messages and will be able to interact with the patients through the developed system. The thought system is based on the usual health-care ecosystem but will improve the level of medical services and reduces object sharing such as hard-copy files that could easily transmit contact-transmission diseases. Information like patients' details, vital signs of patients, consulted physician, laboratory samples and tests results, prescriptions, invoices will be generated and shared among the concerned personnel. Privacy, security, and authenticity will be ensured.

### 1.3.Problem statement

In developing countries like almost all sub-Saharan Africa; record, and store the records of patients manually either using hard-copy files [1]. During these difficult times of the covid19 pandemic out-break; it is risky for health care front-desk personnel, doctors, and even patients themselves to share such files either for identification purposes, or even when doctors need to review the history of the patient [8]. The involved personnel can easily contact other diseases that are transmitted through contacting objects, fellow employee by sharing papers, books that keep the records of the patients. An automated health-care management system that could assist to fully digitize the entire health care ecosystem will serve as a cornerstone in the reduction of such risks.

An IoT based embedded gateway for smart health-care management comes to overcome the following problems. Appointment management reminder, they use papers to the patients for reminding some date, for patient's treatment can be easily spreading the pandemic of covid-19 where the doctor can touch to the patient like taking the temperature. Wasting time where the patients can wait a long time during the queue. There is no security of using the paper someone can access the patient's information easily.

## 1.4.Study objectives

### 1.4.1. General Objectives

The general objective of this project is to propose a solution to the above listed problems by design and implementation of the IoT based Embedded Gateway for smart Health-care management using RFID technology as the solution to facilitate health facilitators and the patients to gain their information easily without moving to the health centers or to hospitals.

### 1.4.2. Specific Objectives

- For the security issue, the health facilitators must have the privileges for entering into the system so that this the crucial reason for accessing the system to prevent the loss information even hacking.
- The type of the security of the information is based on the encrypted the credentials for hidden the username and password so that anyone can't access the system without authorized.
- In fact, this system has been implemented for helping both sides in terms of healthcare environment to overcomeand the tasks available in the processes of system functioned are as follow; the hospitals or health centers have the two platforms which are web services, desktop and RFID reader configured as well as the patient tap the RFID card or RFID tag for avoiding the spreading of the pandemic of covid-19 and then the system retrieve the full detail information of the patient by using both platforms.

## 1.5. Hypotheses

This complemented research system helps the health facilitators and the patients in general as the stakeholders to have full access for the specific information according to the authentication. Time wasting on queue and transportation is minimized at the lowest level from the traditional. This project is already minimized the cost for the patients whose use the cards which are not electronic. Moreover, the amount spent by the patients for buying the usual small notebook or paper to record updated health information minimized, so that may be invested in order profitable functions for both health facilitators and patients.

## 1.6.Scope of the study

During this research:

- ✓ Only one hospital is considered as the beginning of this project: **CHUK**
- ✓ **WiFi** is used as an internet connectivity
- ✓ **RFID** technology is implemented for this project.
- ✓ **NodeMCU** that plays the role of controller unit.

### 1.7. Significance of the study

The deployment of Embedded Gateway for smart Health-care management based on IoT, contributes and benefits in enhancing and promoting the minimizing money spent on the papers during the health's operations and preventing the spreading of the covid-19. With the deployment of RFID technology, the health processes become very easier to be done in efficient procedures.

### 1.8. Thesis contribution

An IoT based embedded gateway for Smart health-care management is an internet of things' solution to handle many cases appearing in the health sector. This solution helps in patients' monitoring and management.

### 1.9.Organization of the study

**Chapter one: Introduction** this is an introductory chapter. It describes the background of the study, the problem statement, the objectives of the study, the scope of the study, significance of the study, project interest and the organization of the study.

**Chapter two: Literature review** this chapter clarifies the work done by the other researchers on the IoT based on health.

**Chapter three: Research methodology** this chapter clearly shows the writer proposed methodology with all corners covered.

**Chapter four: System design and analysis** this chapter shows the prototype, corresponding to data dashboard, serial monitor, plotter monitor, and how the connectivity is done.

**Chapter five: Results and Analysis** this chapter shows the results of the prototype.

**Chapter six: Conclusion and Recommendation** this chapter gives the conclusion of the study and recommendations for the future researchers.

# Chapter 2. LITERATURE REVIEW

## 2.1. Definitions

### 2.1.1. Internet of Things

The internet of Things is the combination of the smart devices that are communicating and exchanging the data via the internet channel within short or long distance. The smart devices refer to some electronic components like NodeMCU, Arduino, LoRa Gateway which is connected to the internet server internet protocol standard and acts as the bridge, and Raspberry Pi this is a mini-computer that has the different ports to be plugged to the different devices like screen as well as the desktop, keyboard, mouse, external HDD, wireless sensors, RFID Technology connected to the internet connection and functioning with the combination of the RFID tag or card and the internet connectivity where the RJ45 is plugged on it.

### 2.1.2. Radio frequency Identification Technology

This technology is based on the electromagnetic fields produced by the connection of RFID reader and RFID tag or card made by the user for some specified purpose/ target. Radio Frequency Identification Technology is a field of computerizing recognition process that is progressively gaining thrust in recent years and is now being seen as a means of enhancing data handling procedures, complimentary in many ways to other data capture technologies such as bar coding [1].

Just as one need not know the workings of a mobile phone or personal computer to use these items; it is not obligatory to know the technicalities to identify with the principles, considerations, and potential for using RFID in a practical sense. This piece however focuses on the security aspects of the technology and various possible applications apart from regular inventory management, attendance for the school management systems.

### 2.1.3. Authentication process

According to this project and in computer science general, the authentication technology provides access control for systems by checking to see if a user's credentials match the credentials in a database of authorized users or in a data authentication server, the function of the used technology for the authentication is md5() stands for Message-Digest Algorithm, for ensuring the security and for encrypting the password, it is a powerful PHP function for encrypting the password.

### 2.1.4. Sensors, NodeMCU and Ethernet.

RFID and sensors are interfaced with Arduino which forms the embedded system. Arduino analyses the data received from the RFIDs and the sensors connected to it. The sensors are connected to the patient's system which is IoTEGHM. RFID reader is able to identify the RFID card or TAG for differentiate the patient's identity. It is the process where the patients tap on it and the system reads the ID form that card or tag, then system received the ID sent by the system and health facilitators getting the access to manipulate the provided information.

## 2.2. Related work

Evaluating the business value of RFID: Evidence from five case studies [3] [4]. Many surveys indicate more customers are surfing the Internet to access healthcare information, services and advice on particular diseases, treatment regimens, or improving their own health management, improve communications between physician and patient, and support clinical decision and disease management using Internet solutions.

Smart Hospital based on Internet of Things [5] [6]. internet to implement information exchange and communication, furthermore to implement intelligent recognition, positioning, tracking, monitoring and management, by means of radio frequency Identification (RFID), infrared sensors, GPS, laser scanners and other information sensing equipment, according to conventional protocol.

An internet of things–based personal device for diabetes therapy management in ambient assisted living (AAL) [7]. Self-monitoring blood glucose (SMBG) measurements are conventionally analyzed by the physician by visually scanning the patient's logbook.

An Analysis of RFID Authentication Schemes for Internet of Things in Healthcare Environment Using Elliptic Curve Cryptography [8]. Later, Fan et al. pointed out that all the three schemes were not secure against man-in-the-middle attack. Subsequently, Lee et al. analyses the privacy challenges in RFID systems and proposed three ECC-based RFID authentication schemes to withstand Fan et al.'s attacks.

RFID and IoT in a smart hospital: benefits and challenges of smart patient tracking [9]. Effective smart patient tracking systems are based on two core technologies: RFID and IoT. RFID enables the tracking itself, while IoT is used for data storing and analysis

IoT-based Asset Management System for Healthcare-related Industries [10]. This paper has presented a roadmap for a technological assessment of IoT in the healthcare industry in the period 2010–2020

RFID Applications and Adoptions in Healthcare: A Review on Patient Safety [11]. The main reasons for medical errors in hospitals and is considered a risk to patient safety. Positive patient Identification (PPI) applications using RFID technology may include a smart wristband with a passive RFID tag that can be scanned to identify patients and reveal information such as date of birth, name, insurance information, allergies, and blood type and medication requirements.

The Use of RFID in Healthcare: Benefits and Barriers [12] [13]. The primary goal of applying RFID technology in healthcare is to improve patient safety. First, RFID is a valuable tool for quickly retrieving patient information and monitoring patient location in hospitals so as to improve the accuracy of patient Identification and any medication a patient is taking.

# Chapter 3. RESEARCH METHODOLOGY

## 3.1. Introduction

In this project, methodology is used for analyzing the approaches and techniques that are used in patient treatment. In each system development, gathering information and defining the requirements for the system is very important. There are several methods that can be used in gathering information and requirements for the system such as referring to previous thesis, observation, interviews and through internet. For the Design and implementation of IoT based on IoT based Embedded Gateway for smart Health-care Management using RFID technology, the requirements were gathered by interviewing the doctors, nurses and the patients. Beside interview, observations also have been used in this project. This is to observe the actual business flow and processes of information's operation. Describe the research methodology/ procedure/ techniques/ tools be used in solving the proposed solution. To describe possible procedures, tools, algorithms were employed in addressing the problem identified.

### 3.1.1. Design of SDLC V- model

In this section we are introduce the design phases of the V model of software development life cycle. Under this model, the developer planned parallel the corresponding testing phase and development phase. So, this model has verification phases on one side of the V shaped model and validation phases on other side. The coding phase works as to join these two sides of the V- model and verification and validation of the developed system [18]

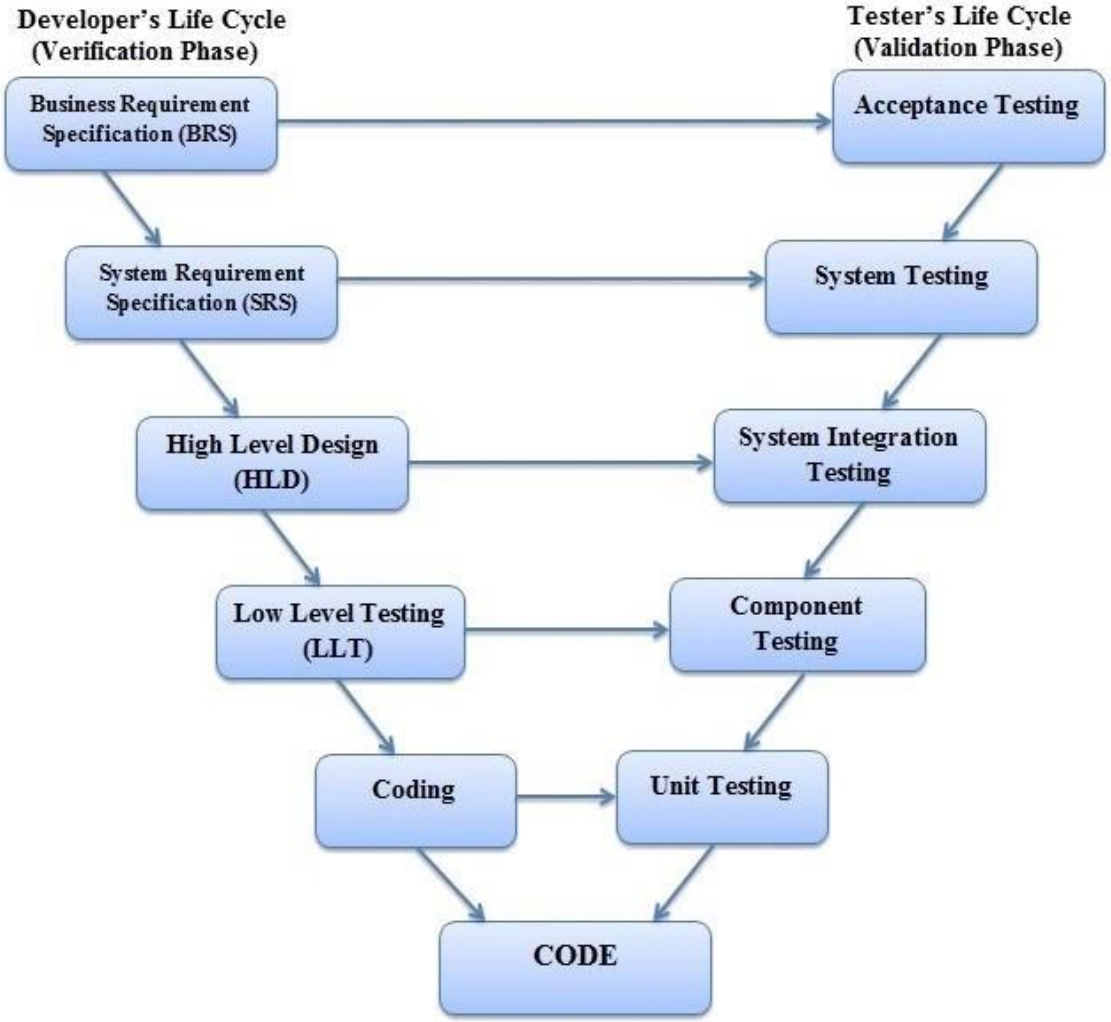



Figure 1. V model of software development life cycle [2]

## Chapter 4. SYSTEM DESIGN AND ANALYSIS

### 4.1. Introduction

In this section, I describe the proposed system architecture that is based on the usual health-care ecosystem. All health-care expected services are integrated in this architecture. Initially the patient's information is collected based on the RFID technology by the front desk officer, apart from patient's identifications, medical sensing device is implemented to capture some medical parameters.

The collected information is stored in the system and only the designated doctor that consults the patient is granted with the details of the patient. Once the doctor recommends the tests, the designated nurse, or clinical lab technician is notified. Once the samples are correctly taken, the doctor himself is granted privileges to access the results. Information about the prescriptions recommended by the medical practitioner or physician also be accessed by the pharmacist. Once treatments dozes are awarded to the patient, the information about the medical invoices is received by the cashier who also receives the payment; this marks the end point of the ecosystem.

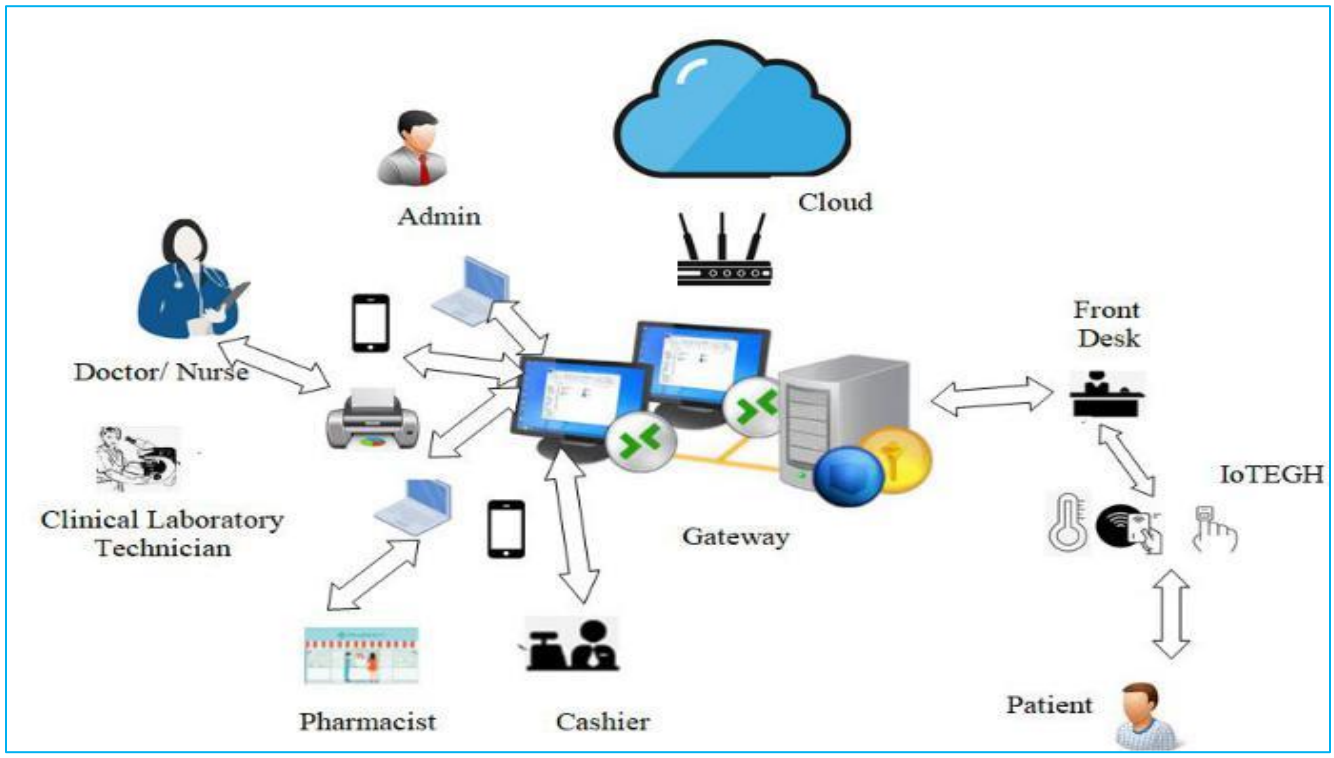



Figure 2. Architecture of IoTEGHM

### 4.2.User case diagram

The user case diagram of IoT based Embedded Gateway for smart Health-care management using RFID technology is composing the function(s) of each user to complete the task, remember that we have two categories of users, health facilitators (doctors, nurse, receptionist, lab technician, cashier, agent, pharmacist) and patient.

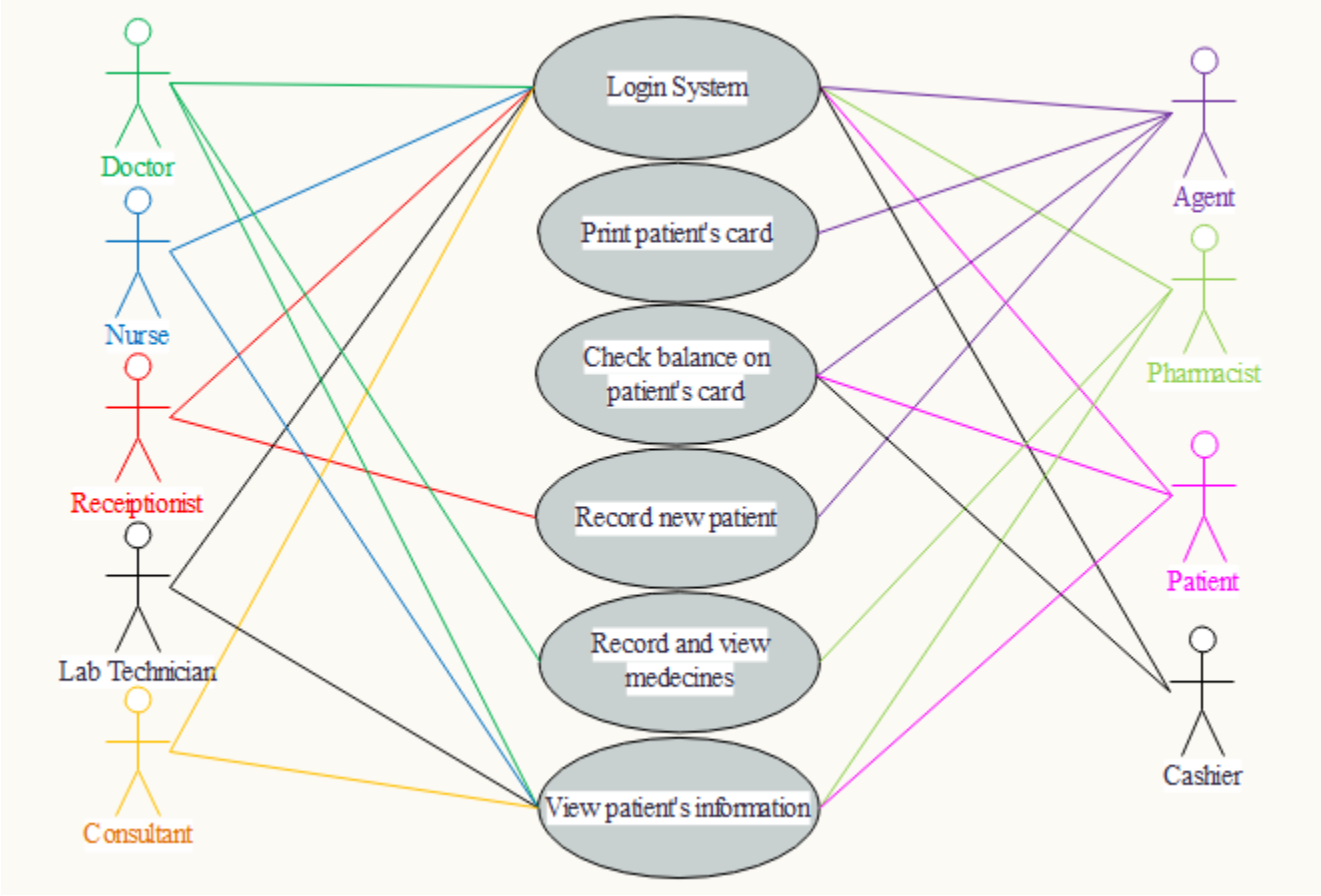



Figure 3. Use case diagram of IoTEGHM

### 4.3. Tools and components used

#### 4.3.1. Block diagram of the system

This block diagram consists of the basic circuit connection of the RFID technology to read an RFID card and tag so that involves in the interfacing of how the functions can be done. For the final diagram of this circuit is attached on the Ethernet shield to help this to send the data into database. When the system is on, the buzzer and LED indicate the users that there is some event occur. An additional, this circuit schema is designed using the software named fritzing.

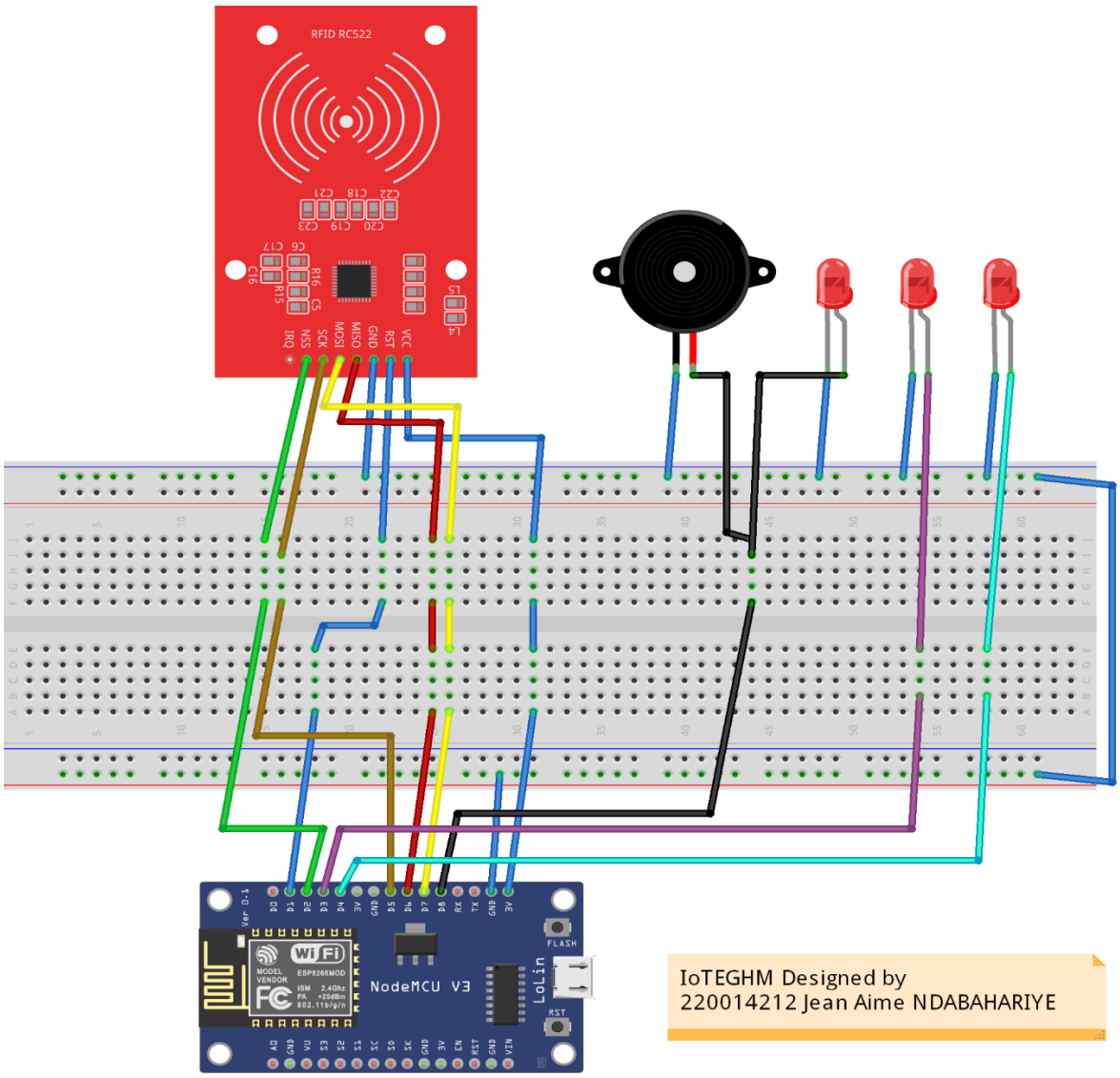



Figure 4. Block diagram of IoTEGHM

This is a block diagram is describing the connectivity of the IoTEGHM and the different alerting for whole functionality of the system. NodeMCU is branched and connected on it the different actuators and sensor, where RFID reader is acting as a sensor to detect the index number from the RFID card. The three LEDs are for alerting the time system is ON, internet connection is avail, and data detected is sent to the database.

### 4.3.2. Connection

| Components | Connection |
|---|---|
| RFID-RC522 + NodeMCU | D2 → SDA/SS<br>D5 → SCK<br>D7 → MOSI<br>D6 → MISO<br>GND → GND<br>D1 → RST<br>3V/3V3 → 3.3V |
| BUZZER + NodeMCU<br>LED (Yellow) + NodeMCU | GND → GND<br>→ Pin 9 |
| LED (Red) + NodeMCU | GND GND<br>→ Pin 8 |

Table 1. Circuit connecting diagram

### 4.3.3. Components used and their functions

| Component | Function |
|---|---|
|  | The RC522<br>It is a 13.56MHz RFID module that is based on the MFRC522 controller from NXP semiconductors. The module can support I2C, SPI and UART and normally is shipped with a RFID card and key fob. It is commonly used in attendance systems and other person/object Identification applications, now, it used in IoTEGHM system. |
|  | RFID card<br>It consists of an integrated circuit and an antenna. The tag is also composed of a protective material that holds the pieces together and shields them from various environmental conditions. |
|  | NodeMCU<br>NodeMCU is an open-source firmware for which open source prototyping board designs are available. It is a board that has the capability of accept the WiFi from different access points and also at the same time accepts the inputs from the firmware and process then according to the specific tasks and send some data into the database. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit). The firmware uses the Lua scripting language. The firmware is |

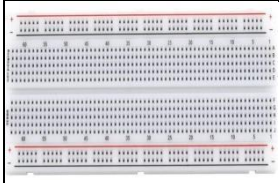
| | |
|---|---|
| | based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. |
|  | Jumper wires<br>They are used for making connections between items on your breadboard and your Arduino's header pins. Use them to wire up all your circuits according to your project. |
|  | A piezo buzzer<br>It is basically a tiny speaker that you can connect directly to an Arduino. By applying an electric signal at the right frequency, the crystal can make sound, in this system I use it for notifying the user that there is an object (RFID tag/ card) touched on RFID reader. |
|  | Breadboard<br>A breadboard is a solderless construction base used for developing an electronic circuit and wiring for projects with microcontroller boards like Arduino. It consists of the way of constructing electronics without having to use a soldering iron. |
|  | LED<br>It stands for light emitting diode. LED lighting products produce light up to 90% more efficiently than incandescent light bulbs. An electrical current pass through a microchip, which illuminates the tiny light sources we call LEDs and the result is visible light. To prevent performance issues, the heat LEDs produce is absorbed into a heat sink. |

Table 2. Functions of used components

### 4.3.4. Software (languages) used

| SOFTWARE / LANGUAGE | ROLE |
|---|---|
| 1. Arduino | For the RFID technology connectivity |
| 2. XAMPP | Server side to connect to database |
| 3. PHP, CSS, JavaScript, HTML | User interface and forms |

Table 3. Software used to implement IoTEGHM

## Chapter 5. SYSTEM RESULTS AND ANALYSIS

### 5.1. Introduction

The two fragments are based to implement this project; a backend web database is designed and implemented to store the required information. Secondly, and intuitive web-based user interface dashboard that interfaces the users with the system. A multi-fragment web-based dashboard is developed that precisely allocates each user with the interface that relates to the career or the service he/she renders.

The backend structure of the software system is based on a web-server relational database system. All medical related information own is collected and stored in the web-server database. System user's registration such as doctors, nurses, lab technicians, health-care centers receptionists, pharmacists, cashiers, and others are pre-registered and stored in the system. Fritzing is used to design the device circuit for the prototype. Fritzing is a computer aided design open source tool that makes electronic design possible before real prototyping. XAMPP server-side open source for integrating the interfaces with the database. MySQL for developing and deploying the database. JavaScript for making live for some processes like strong interactive in sending detected data by sensors to the database. PHP to make system become dynamic, Arduino IDE for writing the instructions to command the sensors and even the hardware be operated on the NodeMCU and the browsers to navigate the system, Dreamweaver to design the different interfaces to be interacted with the database.

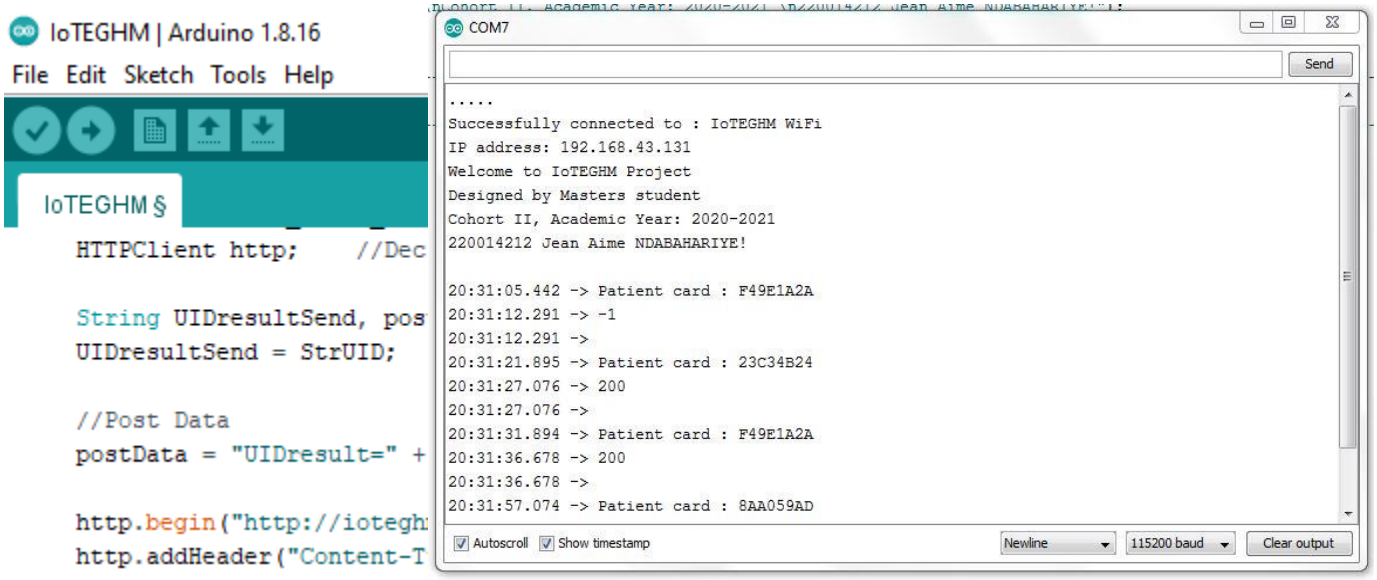



Figure 5. Serial monitor of IoTEGHM

This is the serial monitor displayed the time you switch on the system, and is displaying the Wi-Fi connectivity, IoTEGHM WiFi, IP address of 192.168.43.131 and displays the details of the owner and also the different swapped patient's cards.

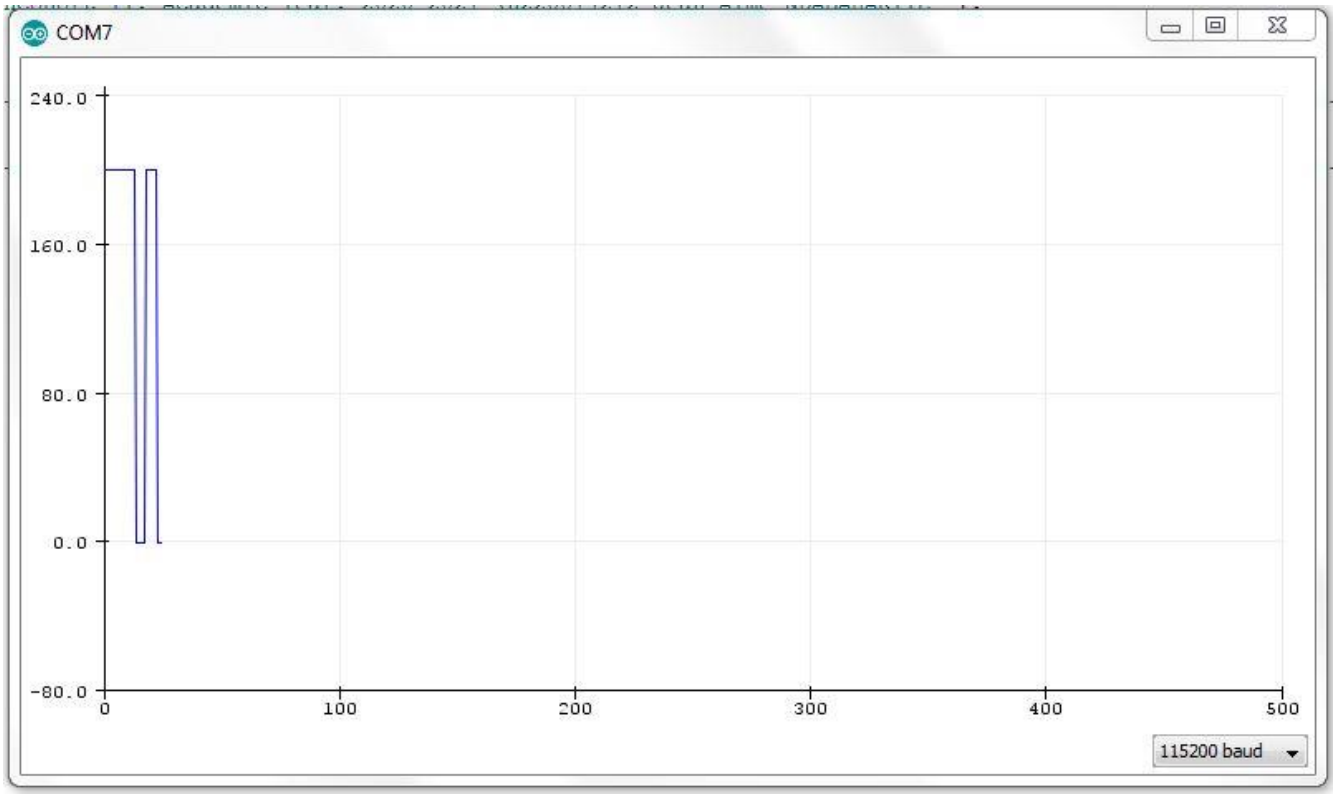



Figure 6. Serial plotter of IoTEGHM

Serial plotter displays the curve of the strength of the internet network and the range of data entry. The above, the range is -1 and 200, the time stats from -1, means there is internet connection but sensor can't send the data into the database, while 200 indicates the internet connection and data is sent well. This the confirmation provided by the system and there is an alert from the buzzer and the notification light via the LED. It is displayed the time you select the tools' menu, and choose the serial plotter option, and by the pop-up displayed is the serial plotter and when you swap a card (patient's card) it checks if the detection is done or not. The next outputs are referring to the interfaces built using the different programming languages like the PHP, JavaScript, MySQL statement for data structuring.

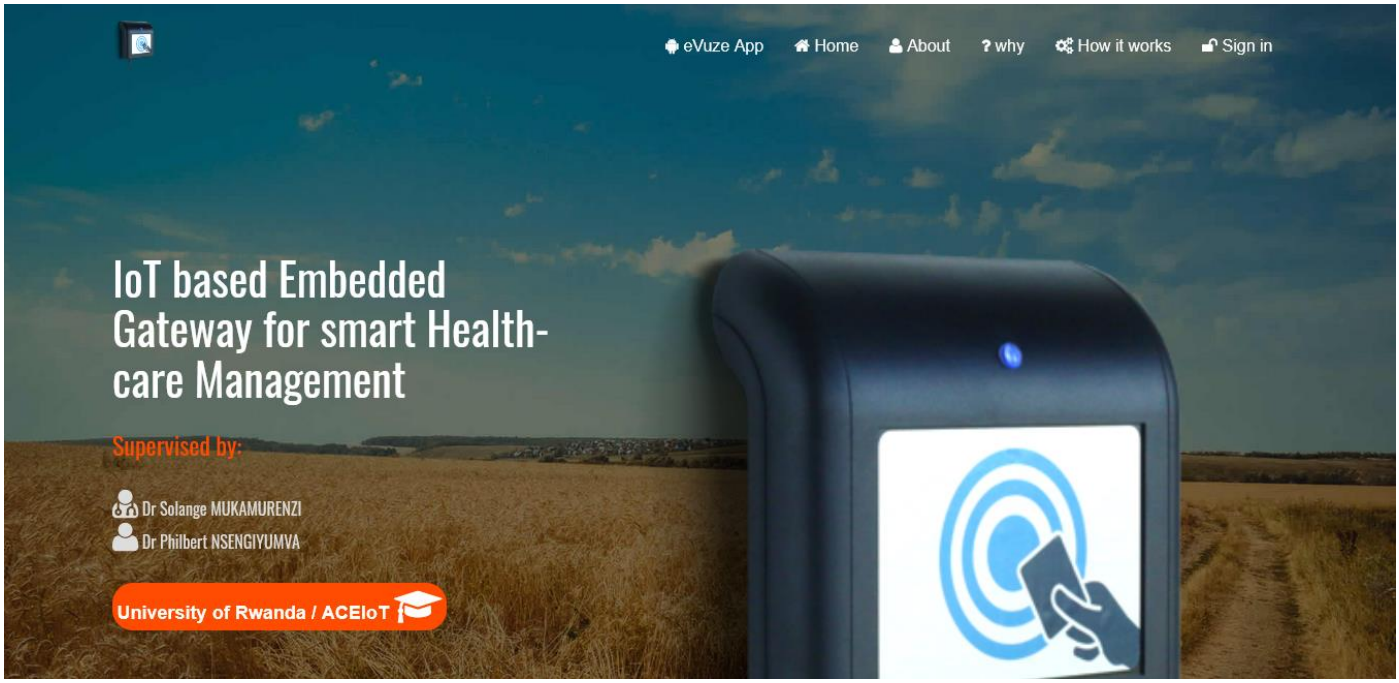



Figure 7. Home page of the IoTEGHM

This is the home page of the system displayed the time you navigate it. And the time you want to get the access of the patient's information, you must have the authentications right to make a login.

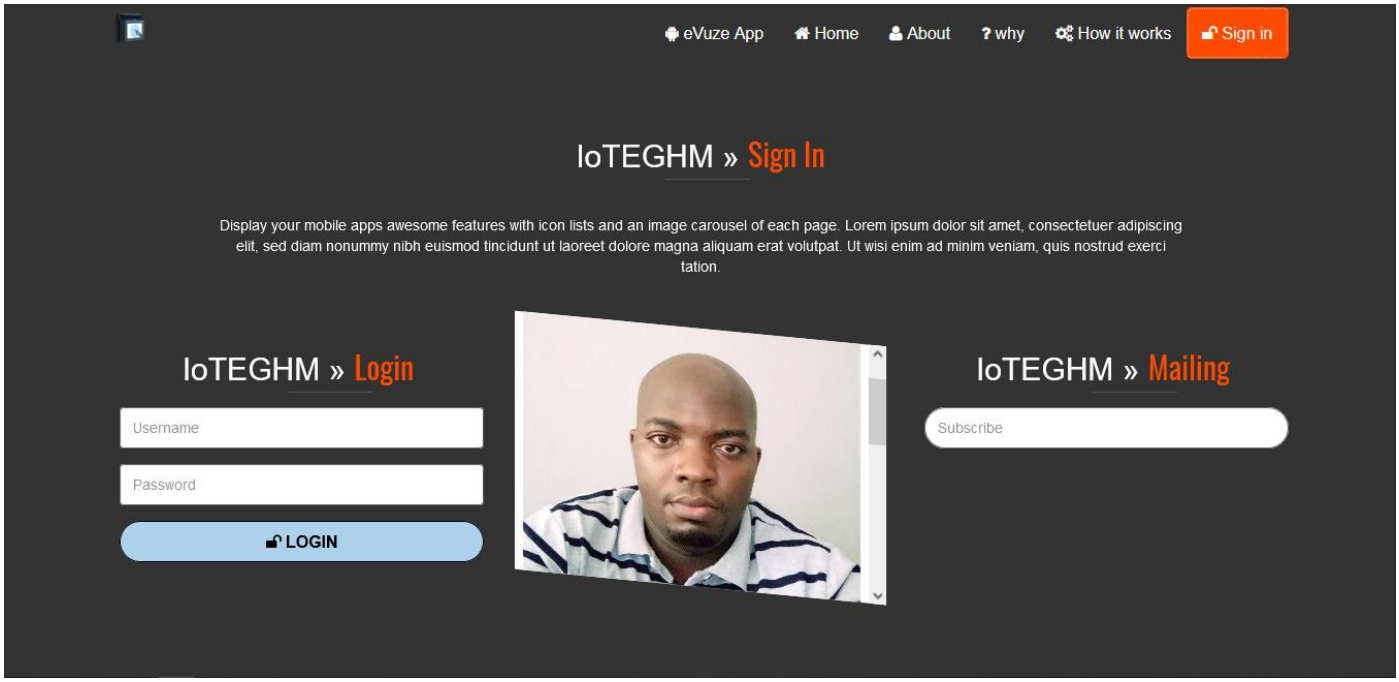



Figure 8. Login page for accessing the system

This page is very crucial for accessing the system to ensure that you have the privileges.

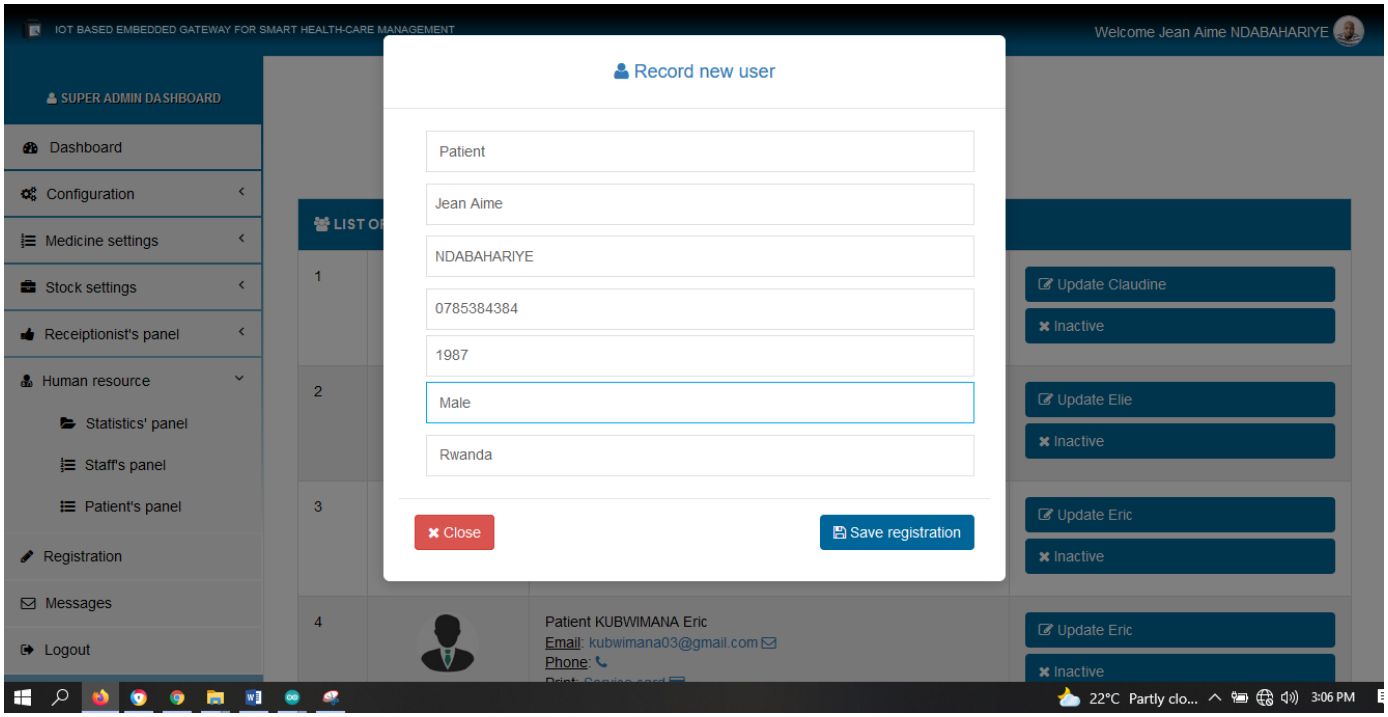



Figure 9. Form of recording the new patient

It is based on backend interface where you don't access without the right authentications.

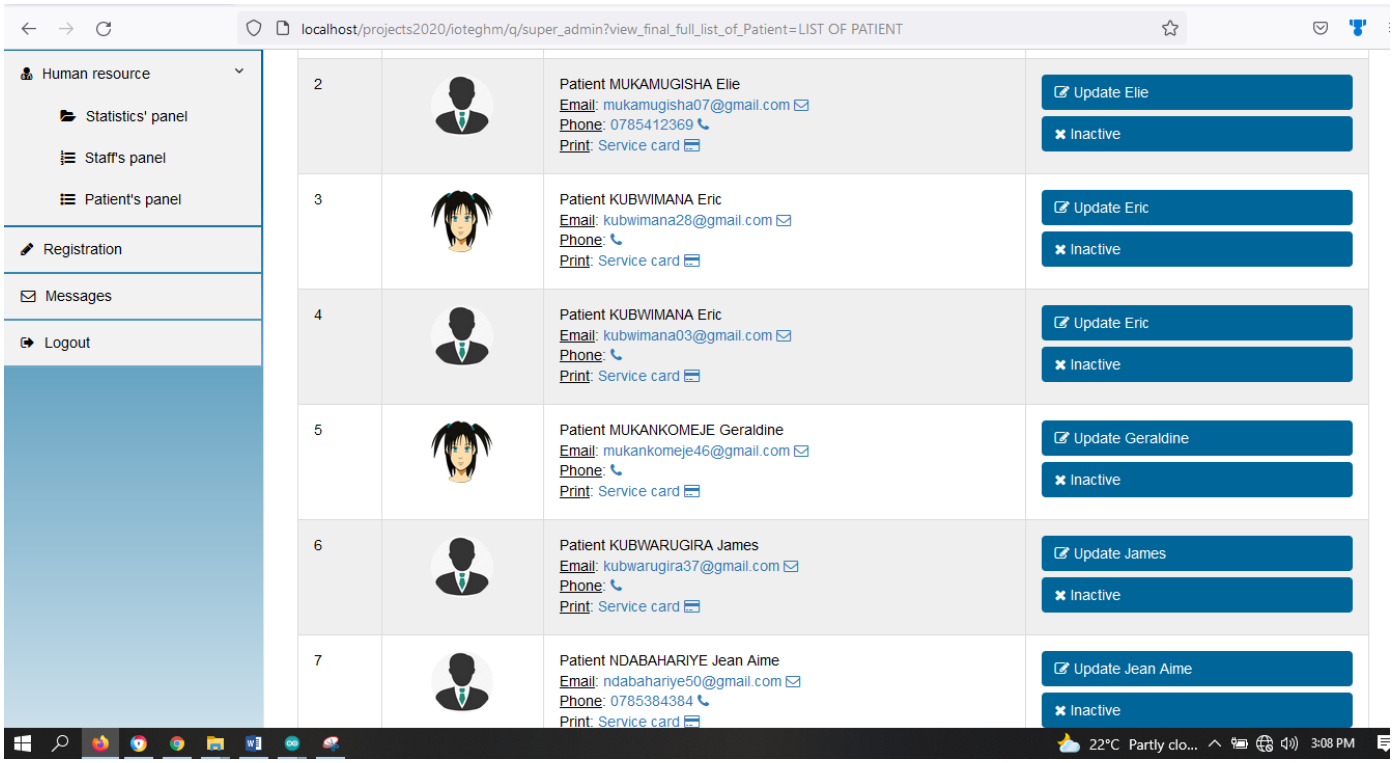



Figure 10. List of registered patients into the system

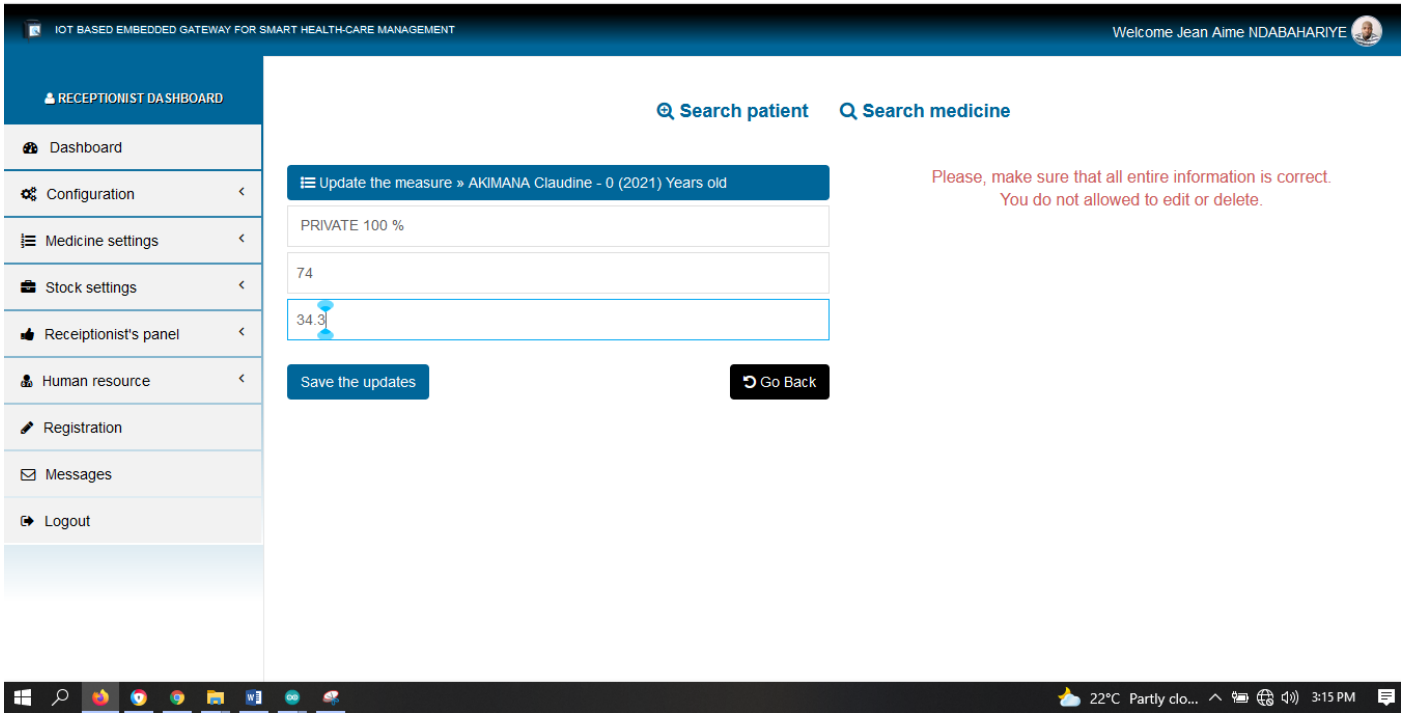



Figure 11. Interface for the receptionist

The receptionist has the right to record a new patient at the first time and the time it is lost, can be updated any time and it is done by the swapping technique where the exchange is done between the lost one by the newer.


Figure 12. Format of the patient's card.

The electronic cards are auto-generated by the system after registered. It is the card that has a number (ID)

embedded into the card, but the available numbers, is for index.

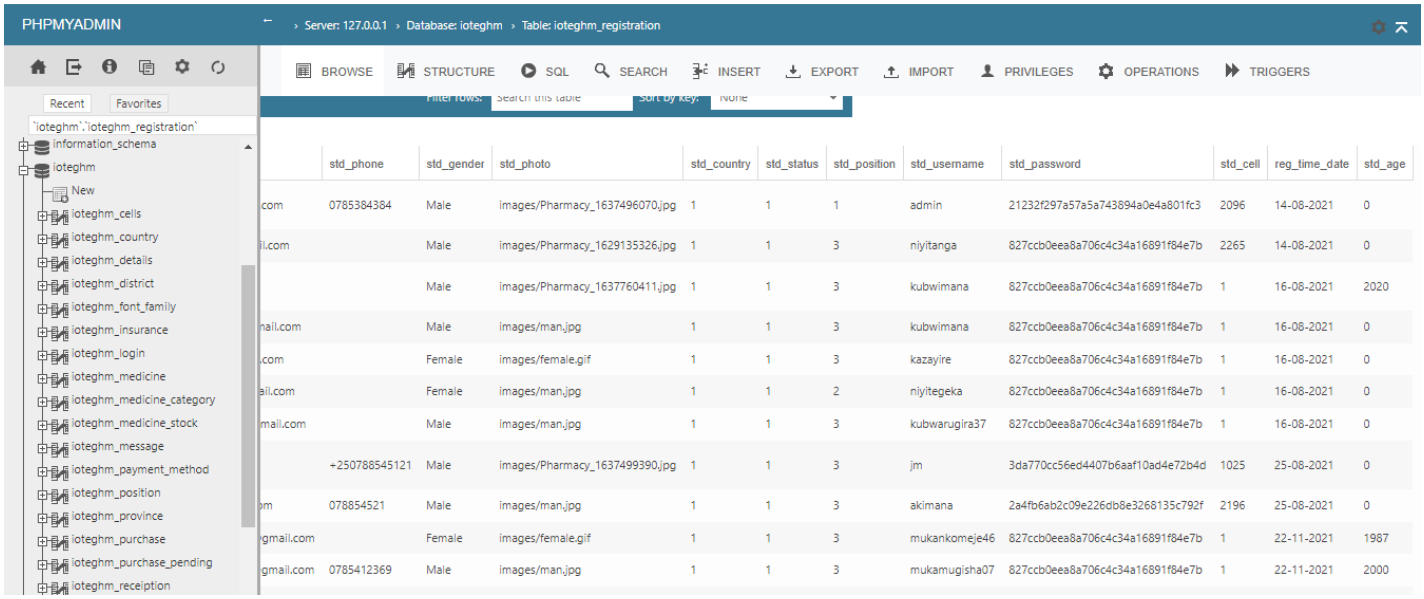



Figure 13. Security process of the system

This security process of the system it is indicating the system security for ensuring the patient's information can't be accessed by the unauthorized persons. Then the method used is encryption of password. Md5() is the one function used the encryption process, the encrypted characters that human being can't discovered the behind only who have the skills about the decryption.

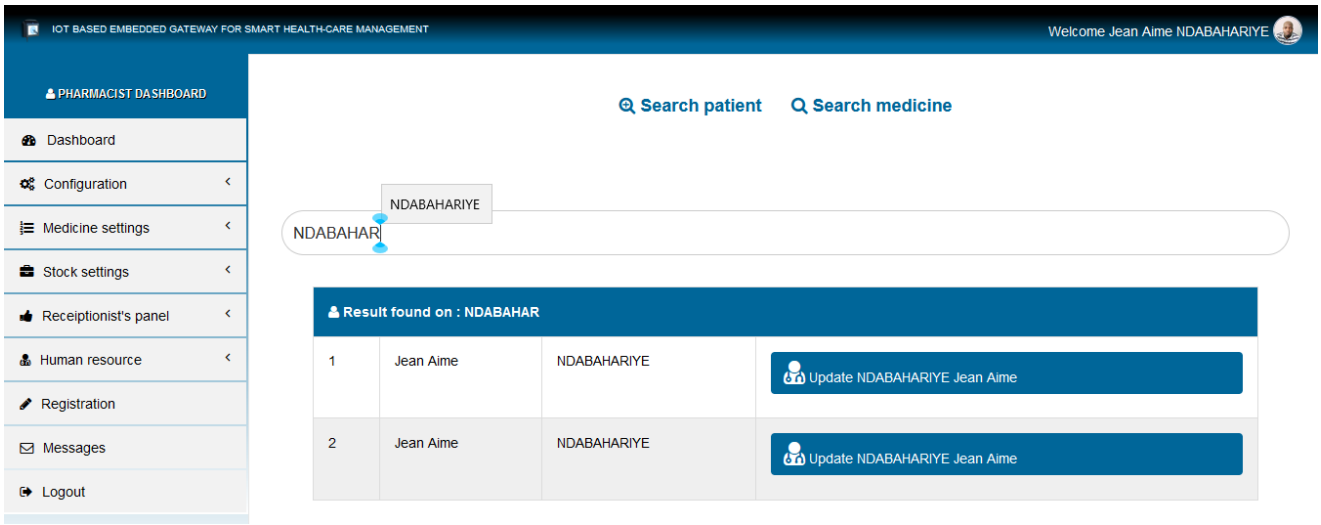



Figure 14. Dashboard of the pharmacist

The pharmacist is for medicine process where is in charge of the provide the patients' medicines.

| ALL DETAILS OF NYIRAMBARUSHIMANA Angelique | |
|---|---|
| 1 | **RECEPTION:**<br>Weight: 87.5 Kgs<br>Temperature: 36.5 °C<br>Insurance: PRIVATE 100%<br>Date: Saturday 11-12-2021 09:52:15 PM |
| 2 | **RECEPTION:**<br>Weight: 54 Kgs<br>Temperature: 36.6 °C<br>Insurance: PRIVATE 100%<br>Date: Saturday 11-12-2021 09:52:27 PM |
| 3 | **RECEPTION:**<br>Weight: 58 Kgs<br>Temperature: 35.6 °C<br>Insurance: PRIVATE 100%<br>Date: Saturday 11-12-2021 09:53:03 PM |
| 4 | **RECEPTION:**<br>Weight: 58 Kgs<br>Temperature: 35.6 °C<br>Insurance: PRIVATE 100%<br>Date: Saturday 11-12-2021 09:57:30 PM |

Figure 15. Report of the patient details.

The time that the patient access to the hospital, system keep the information, the time that they want to print them they do so, and the patient own have the access to get that information.

LIST PURCHASED

+ Selling

| # | medicine | Category | Quantity | U.Price | T.Price | Date | Customer | Delete All | Print all |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Abarelix | Men & Women | 2 Boxes | 300 Frws | 600 Frws | 12-12-2021 | NDABAHARIYE Jean Aime | Delete | Invoice |
| 2 | Abarelix | Men & Women | 12 Boxes | 300 Frws | 3600 Frws | 21-11-2021 | Akimana Elie | Delete | Invoice |

Figure 16. List of the invoice of bought medicines.

The time there is order from the patient, system redirect to the pharmacist to confirm that request, the time of payment, patient can get the result and the invoice after paying to the cashier.

IOT BASED EMBEDDED GATEWAY FOR SMART HEALTH-CARE MANAGEMENT

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Website : www.evuze.xyz
**********

medicine : Abarelix
Category : Men & Women
Mfg.Date : 2021-06-08
Exp.Date : 2023-05-17
Quantity : 2 Boxes
U.Price : 300 Frws
Patient name : NDABAHARIYE Jean Aime
Patient phone: 0785384384
Patient email : ndabahariye50@gmail.com
Seller : Admin NDABAHARIYE Jean Aime
Issued date : 12-12-2021
Payment method : Airtel Money: 0735214562
**********
TOTAL AMOUNT PAID: 600 Frws
**********

Generated by using IoTEL Ltd
On Wednesday 05-01-2022 06:40:29 PM
Done by Admin Jean Aime NDABAHARIYE

Figure 17. Invoice generated by the system

This invoice is generated by the system after the confirmation of the requesting of purchased medicines.

# Chapter 6. CONCLUSION AND RECOMMENDATION

## 6.1. Conclusion

IoT is used in health care industry where the information can be transferred to the users about the patient in a less amount of time. If patient require any medical assistance immediately then the doctor and nurse would receive the information and the situation can be handled as soon as possible. This project provides the smart health care system which could be used not only hospitals but also in homes to navigate the necessary information. Using this system patient's health condition can be monitored and necessary medication can be provided. As the implementation of this project, the social impact will be positive on both the owner and the users, due to simplify the manual work.

## 6.2. Recommendation

Future researchers should investigate the issues affecting RFID adoption in healthcare, particularly those related to the patients' privacy and security, as these were found to be important factors affecting the adoption of RFID for patient safety related purposes. In addition, there is another option to integrate this system but can be auto synchronous of the information, using the internet may cause some delaying leads to lack of information the time is needed, so will be very crucial if there will include the use of USSD for the patients to access their specific medical's information.

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**APPENDIX**

1. Codes of the NodeMCU

NodeMCU_RFIDv2.0 §

```
#include <ESP8266WebServer.h>
#include <ESP8266HTTPClient.h>
#include <SPI.h>
#include <MFRC522.h>
#define SS_PIN D2  //--> SDA / SS is connected to pinout D2
#define RST_PIN D1  //--> RST is connected to pinout D1
MFRC522 mfrc522(SS_PIN, RST_PIN);  //--> Create MFRC522 instance.
#define ON_Board_LED 2  //--> Defining an On Board LED,
const char* ssid = "IoTEGHM";
const char* password = "..................";
ESP8266WebServer server(80);  //--> Server on port 80
int readsuccess;
int blue=4;
byte readcard[4];
char str[32] = "";
String StrUID;
void setup() {
Serial.begin(115200); //--> Initialize serial communications with the PC
SPI.begin();      //--> Init SPI bus
mfrc522.PCD_Init(); //--> Init MFRC522 card
delay(500);
WiFi.begin(ssid, password); //--> Connect to your WiFi router
Serial.println("");
pinMode(ON_Board_LED, OUTPUT);
pinMode(blue, OUTPUT);
digitalWrite(ON_Board_LED, HIGH); //--> Turn off Led On Board
Serial.print("Connecting");
while (WiFi.status() != WL_CONNECTED) {
Serial.print(".");
```

```
Serial.print(".");
digitalWrite(ON_Board_LED, LOW);
delay(250);
digitalWrite(ON_Board_LED, HIGH);
delay(250);
}
digitalWrite(ON_Board_LED, HIGH); //--> Turn off the On Board LED
Serial.println("");
Serial.print("Successfully connected to : ");
Serial.println(ssid);
Serial.print("IP address: ");
Serial.println(WiFi.localIP());
Serial.println("Welcome to IOTEGHM Project\nDesigned by Jean Aime NDABAHARIYE!");
Serial.println("");
}

void loop() {
readsuccess = getid();
if (readsuccess) {
digitalWrite(ON_Board_LED, LOW);
HTTPClient http;    //Declare object of class HTTPClient
String UIDresultSend, postData;
UIDresultSend = StrUID;
//Post Data
postData = "UIDresult=" + UIDresultSend;
http.begin("http://eschool.rw/ioteghm/getUID.php");  //Specify request destination
http.addHeader("Content-Type", "application/x-www-form-urlencoded");
int httpCode = http.POST(postData);   //Send the request
String payload = http.getString();    //Get the response payload
Serial.println(UIDresultSend);
```

```
http.end();  //Close connection
}}
int getid() {
if (!mfrc522.PICC_IsNewCardPresent()) {
return 0;
}
if (!mfrc522.PICC_ReadCardSerial()) {
return 0;
}
Serial.print("The patient card : ");
for (int i = 0; i < 4; i++) {
readcard[i] = mfrc522.uid.uidByte[i]; //storing the UID of the tag in readcard
array_to_string(readcard, 4, str);
StrUID = str;
}
mfrc522.PICC_HaltA();
return 1;
}
void array_to_string(byte array[], unsigned int len, char buffer[]) {
for (unsigned int i = 0; i < len; i++)
{
byte nibl = (array[i] >> 4) & 0x0F;
byte nib2 = (array[i] >> 0) & 0x0F;
buffer[i * 2 + 0] = nibl  < 0xA ? '0' + nibl  : 'A' + nibl  - 0xA;
buffer[i * 2 + 1] = nib2  < 0xA ? '0' + nib2  : 'A' + nib2  - 0xA;
digitalWrite(blue, HIGH);
}
buffer[len * 2] = '\0';
}
```

## 2. Codes of the web application

```php
<?php
@session_start();
$DB_host = "localhost";
$DB_user = "root";
$DB_pass = "";
$DB_name = "ioteghm";
try
{
$DB_con = new PDO("mysql:host={$DB_host};dbname={$DB_name}",$DB_user,$DB_pass);
$DB_con->setAttribute(PDO::ATTR_ERRMODE, PDO::ERRMODE_EXCEPTION);
$DB_con->setAttribute(PDO::ATTR_EMULATE_PREPARES, false);
}catch(PDOException $e){echo $e->getMessage();}
?>
```

```php
<?php
include("header.php");
include("connection.php");
include('address_data.php');
if($_SESSION['std_id']) { } else {  header("Location:logout?logout"); }
?>


<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<ul class="nav navbar-nav navbar-right">

<li class="dropdown">
<a href="#" class="dropdown-toggle avatar" data-toggle="dropdown">
<span style="color:#fff; font-weight:normal; font-size:14px;">Welcome <?php echo $_SESSION['std_name'].' '.$_SESSION['std_names']; ?> <img src="<?php
echo $_SESSION['std_photo']; ?>" style='height:30px;'></span>
<span class="badge"></span></a>
<ul class="dropdown-menu">
<li class="m_2"><a href="patient?profile=<?php echo $_SESSION['std_id']; ?>"><i class="fa fa-pencil" style="color:#006699;"></i> Update your profile</a>
</li>
<li class="m_2"><a href="logout?logout" onclick="return confirm('Are you sure ?')"><i class="fa fa-sign-out" style="color:#006699;"></i> Logout</a></li>
</ul>
</li>
</ul>

<div class="navbar-default sidebar" role="navigation">
<div class="sidebar-nav navbar-collapse">
<center>
<span style="color:#FFF; font-size:12px; text-transform:capitalize; font-weight:bolder; text-align:center; text-decoration:none; text-shadow:1px 1px #000
;"><i class="fa fa-user"></i> <span style="text-transform: uppercase;"><?php echo $_SESSION['position_name']; ?> Dashboard</span><br><br>
</span>
</center>

<ul class="nav" id="side-menu">
<li class="menu_format"><a href="patient?medicine_payment_method=Payment_methods"><i class="fa fa-folder-o nav_icon"></i> Payment method</a></li>
```

```php
<?php
if(isset($_GET['logout']) && isset($_SESSION['std_id']))
{
@$logout_time= date('h:i:s A');
@$logout_date= date('d-m-Y');
@$logout_day= date('l');
@$login_status= 'Offline';
@$login_user_id= $_SESSION['std_id'];

@$sql = "UPDATE ioteghm_login SET logout_time = :logout_time, logout_date = :logout_date, logout_day = :logout_day, login_status = :login_status
WHERE ioteghm_login.login_user_id = :login_user_id";
@$stmt = $DB_con->prepare($sql);
@$stmt->bindParam(':logout_time', $logout_time, PDO::PARAM_INT);
@$stmt->bindParam(':logout_date', $logout_date, PDO::PARAM_INT);
@$stmt->bindParam(':logout_day', $logout_day, PDO::PARAM_INT);
@$stmt->bindParam(':login_status', $login_status, PDO::PARAM_INT);
@$stmt->bindParam(':login_user_id', $login_user_id, PDO::PARAM_INT);
@$stmt->execute();

@session_unset();
@session_destroy();
}
echo '<meta http-equiv="refresh"'.'content="0; URL=../index?Welcome&Welcome_to_Pharmacy_System_today_'.date('l_d/m/Y_h:i:s_A').'">';
?>
```