



Web-Based RFID Patient Identification System: A Case Study of UNILORIN Clinic

T. C. Adeniran^{1,*}, R. O. Odebiyi², L. A. Olawoyin³, Nasir Faruk⁴, Q. R. Adebowale⁵, Salisu Garba⁶
^{1,2,3,5}Department of Telecommunication Science, University of Ilorin, Ilorin, Kwara State, Nigeria

⁴Directorate of Information and Communication Technology, Sule Lamido University Kafin Hausa

⁶Department of Computer Science, Sule Lamido University, Kafin Hausa, Nigeria

Email: adeniran.tc@unilorin.edu.ng; odebiyiridwan@gmail.com; lolawoyin@gmail.com; faruk.n@slu.edu.ng; adebowale.qr@unilorin.edu.ng; salisu.garba@slu.edu.ng

Abstract

A smooth workflow in a clinic is very essential to ease the workload of the staff. However, the current workflow of identifying patients in clinics has proven to be tedious and thus brought about this solution that streamlines the patient identification processes. Different identification mechanisms have come into existence over the years, including barcode technology. This paper presents a design and implementation of an RFID (Radio Frequency Identification) technology to address the issues of the conventional way of identifying patients in a healthcare organization. This involves the use of a web-based application (WBA) that serves as a working interface between the healthcare staff and the system. The WBA is written in JavaScript and hosted on Firebase, which registers and holds the details of all registered patients. The developed system identifies a valid patient using the assigned RFID tags and displays the basic information of the patient upon requested use of the healthcare service.

Keywords: RFID, Web-Based Application, Clinic, Patients, Registration

1. Introduction

It is often noticed that the primary goal of this ICT is really to maximize the productivity of the employees who work there, as well as the integrity of the information available to the clinic to attain the intended outcomes. In clinics, ICT serves as the foundation for providing high-quality care (Abugabah, Nizamuddin, & Abuqabbah, 2020). University Clinics are well familiar with the advantages of incorporating ICT into their day-to-day operations to solve various obstacles such as budgetary restrictions, misdiagnoses, inefficiency in patient identification, and so on. RFID technology offers an economical and dependable alternative to dealing with the aforementioned issues (Kariapper, Suhail Razeeth, Pirapuraj, & Nafrees, 2020).

RFID is one of the modern technologies thanks to its distinctive ability to monitor as well as track items instantaneously. RFID is a wireless Automatic Identifying and Data Capture (AIDC) technology that employs embedded sensors to keep identification information as well as other relevant information (Khalil & Osman, 2019). The primary goal of any RFID-based patient identification system in clinics is to enable an RFID tag linked to a patient to carry certain carrier-related data, such as identifying data, and the most important patient's medical record. However, the sufficiency of memory is always an issue which seems to be the case for most memory-based systems (Cerlinca, Prodan, Turcu, & Cerlinca, 2010).

Conversely, it is commonly acknowledged that high-memory RFID tags are extremely pricey for use in a university clinic in Nigeria, and the alternative option to lower the costs is to employ low-memory transponders. However, it is evident that a limited-memory transponder cannot keep all of the relevant patient information. These issues might be overcome by keeping the essential information on the RFID tag and the extra information in a remote server



depending on the format of the tag (Raad, Deriche, & Kanoun, 2021). One more key element of an RFID-based patient identification system is the capacity to interface and share data with diverse medical systems.

Despite the availability of online medical record systems, Nigerian University clinics are currently experiencing a variety of issues which includes the problems in recognizing patients in accidents, or collapses, among other things (Muhammad & Garba, 2019). In many circumstances, university clinicians struggle to identify the patient or his medical history, because they may lack sufficient information regarding prior medications (Aldeer, Howard, Martin, & Ortiz, 2021; García Betances & Huerta, 2012). This results in inefficient use of time when providing treatment. availability of medical information of unconscious/unresponsive patients gives significant adaptability in several emergency instances, making it easy to deliver the patients' records. This may be accomplished via RFID-based systems, where the patient is recognized by radio frequency via a transponder placed in the body of the patient by the appropriate authority.

Khalil & Osman, (2019) proposed that the RFID technology offers healthcare practitioners various advantages to improve the safety of the patient, time-saving, and cost reduction. It also causes critical issues for the successful implementation of the RFID based technology. To increase the acceptance and wide use of RFID in healthcare, more customized RFID systems, more institutional support, integration with existing HIS, and various regulations to protect privacy are needed. The RFID-based system can also aid the clinical operations in Nigerian Universities. Even though the majority of existing RFID-based systems are still in the experimental stage in clinics in Nigerian Universities, the future seems bright. As a result, this research presented a web-based RFID patient identification system using Unilorin Clinic as a case study.

The rest of the paper is organized as follows: The related works are discussed in Section 2; The research materials and methodology are discussed in Section 3; The proposed system is provided in Section 4; The System Testing And implementation is provided in Section 5; Finally, the concluding remarks and recommendations for future work are provided in Section 6.

2. Related Works

Radio Frequency Identification is a rapidly growing technology with the potential of creating substantial economic impacts on many industries. RFID is outlined as a technology that utilizes small computer chips, otherwise known as microchips, to trace items like consumer commodities at a distance, supported by radio frequency's functionalities (Abugabah et al., 2020; Kariapper et al., 2020). Many studies on existing patient identification systems (RFID-based and Non-RFID-based) need to be considered to know the system requirements for designing an RFID-based patient identification system.

To tackle patient misidentification in medical industries, Aldeer et al., (2021) developed a Patient Identification System utilizing RFID. This was achieved by developing a hand-held wireless RFID device interconnected wirelessly via LAN with an operating system and an interface that facilitates scanning, patient identification, and access to patients' medical records. The use of wireless networks, combined with the use of clinical knowledge systems, adequate training of medical personnel, IT and network support, and the employment of wireless hand-held devices, might offer the ability to reinforce the quality of tending delivery hospitals. The major limitation here is the level of technical knowledge required to run the system; there would always need to be a qualified technician at the close call, in case of any issues in the system's operation.

Automatic access management for student ID card-supported RFID technology (Geoffrey, 2012) has evolved from preventing illegal folks from entering a building and preventing unauthorized folks from accessing specific organization resources. The access management system functions in real-time. That is, the door opens as soon as the user scans the tag. The system conjointly stores the login and logout data of the user. While this technology is very effective in intrusion prevention, anyone trying to break past the system could simply obtain an authentic RFID tag (by any means) and duplicate it, thereby gaining its ID.



An RFID and SMS notification-based system designed by Mojares, Litan, & Mojares, (2018) called iNotified, permits parents to monitor their children's presence at a particular time. Whenever any student's ID card is scanned at the gate, an SMS notification to the student is sent to their parents. However, this method has a limitation: it does not indicate or show any acknowledgement between the sender and the receiver. One major importance of using RFID technology in library management is that it saves the library staff time and energy by automating their tasks (Nisha, 2018).

An automatic access system was developed through exploration by Beaver, (2016) using students' ID cards supported by RFID technology. The system prevents unauthorized access to buildings and specific college resources. The system was designed to function in real-time, such that a user was required to scan his tag before being granted access, even if they are cleared for entry into that specific building. The system, in turn, stored the ID of the tag on a log so that it could be reviewed anytime required. The only vulnerability in this system is the exposure to cloning of RFID tags by unauthorized users as there is no visual authentication in identifying a registered user of the system. As such, a successfully cloned card (now having a registered ID) could be used to beat the security system.

Such similarity to Beaver, (2016), an identification card for staff and students integrated with RFID Adeniran, (2015) also shares similar constraints and issues. Anyone with such a card can quickly gain entry into higher levels of the organization or use the system as an imposter with no visual or a more solid authentication (such as biometrics or facial recognition, for example) to verify if it is the actual owner of the card that intends to gain entry, validate the system or an imposter then decide if it is a valid user or not, in such case, either grant, deny access or make use of the system.

Looking at all the works taken in the aforementioned reviews, their various strengths and weaknesses were analyzed, ranging from their scope to their means of operation. It is clear from the literature that works on Patient identification (PI) using conventional methods or techniques have been ditched for RFID. This is because an RFID-based identification system is an efficient and economical tool compared to the conventional patient identification system used in university clinics. Hence, a web-based RFID patient identification system in unilorin clinic is essential.

3. Materials and Methods

In this section, the materials and methods used in the design and implementation of an RFID-based patient identification system for unilorin clinic are discussed. These include the RFID and its principles, RFID readers and RFID frequencies, while other specific system development methodologies are discussed in the implementation section to avoid repetition.

3.1 Radio Frequency Identification (RFID)

Three components make up an RFID system; a transceiver, a transponder, and a scanning antenna (Abugabah et al., 2020; Khalil & Osman, 2019). An 'RFID reader' is obtained from the combination of a transceiver and scanning antenna. It is usually portable, but sometimes permanently attached. The transponder is embedded in the RFID tag. The tag is triggered by radiofrequency signals received from the RFID reader, after which it sends a signal back to the antenna (the reader) where it is interpreted into data. The read range for RFID tags varies based on the type of reader, type of tag, RFID, and interference within the surrounding environment or other RFID tags and readers.

Given that there are two types of RFID tags; the passive tag and the active tag (Cerlinca et al., 2010; Faruk et al., 2021; Yadav & Jha, 2019). It's necessary to choose the best fit for the design and implementation of an RFID-based patient identification system for unilorin clinic. A passive tag is widely used thanks to its cost-effectiveness and requires no battery power within the tag circuits. The standard range for a passive tag is about 3 meters but is often up to 10 meters, depending on the tag design. Thanks to its range, passive RFID involves asset management, industrial automation, electronic article surveillance, access control, and animal tracking.

Meanwhile, unlike passive tags, an active tag consists of a microchip, antennas, and the power source used to run the microchip's circuitry and broadcast radio waves (T. Adeniran, Sanni, Faruk, & Olawoyin, 2019; Beaver, 2016; Wibowo & Habib, 2017). Therefore, under equivalent restrictions, a reader reaches active tags from a long distance more often than passive tags. This also requires more frequent battery replacement for active tags. However, it is not always practicable to change batteries, leading to the design of active tags with low-energy consumption by reducing their total identification time and active time.

3.2 Principles of RFID

There have been many misconceptions when the principles of RFID are explained. Many people tend to view RFID from only the tag perspective while forgetting the apparent fact that RFID technology is a complete system that includes tags and other essential components. RFID systems are composed of at least three core components, RFID tags, RFID reader and the database (Villupuram, 2015; Yadav & Jha, 2019). Figure 1 illustrates the interaction between the RFID-based system components.

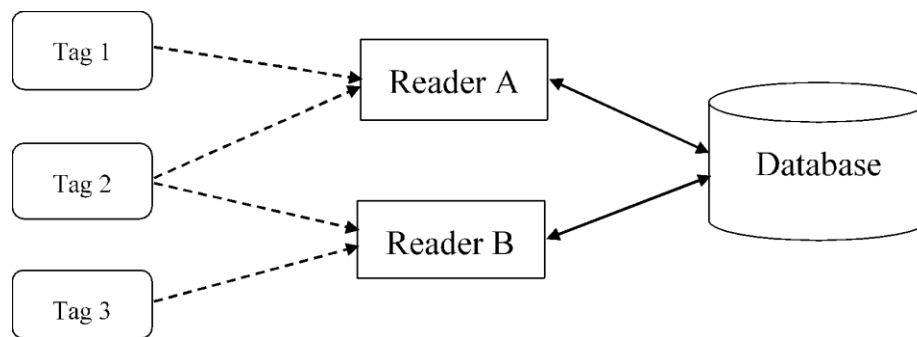


Figure 1: Illustration of RFID System Interaction (Mahmood et al., 2014).

3.3 RFID Reader

The communication between an RFID reader and a tag is done via an RF channel to obtain information. Readers read data on tags and send them to the end system for processing, but some advanced readers can write on tags. Depending on the tag type, the tag and reader's communication may be a simple ping or a more complex multi-round protocol. RFID readers must perform an anti-collision protocol, especially in environments with plenty of tags, to ensure that communication conflicts do not occur. This anti-collision protocol allows the reader to communicate rapidly with many serial order tags (Villupuram, 2015; Yadav & Jha, 2019). Passive tags are also powered through the RF communication channels of RFID readers.

As stated earlier, passive tags are tags with no power source embedded within them but rather depend on power from the RFID reader. Apart from this, readers also come in various forms, operate on different frequencies, and have different functionalities. Some RFID readers possess their own storage and processing power, and even offer network connectivity, with the capacity to store data locally (Geoffrey, 2012). Some other RFID readers can be combined with hand-held mobile devices and used for taking inventory of a physical storage location by walking around it (Abugabah et al., 2020; Raad et al., 2021).

3.4 RFID Frequencies

Even though they can operate on any frequency, RFID frequencies are classified based on distance, namely near-field RFID and far-field RFID. Near-Field RFID is used for designs in which the distance between the tag and the reader is small. Based on Faraday's principle of magnetic induction, a large alternating current is passed by a reader that, in turn, it allows it to radiate an alternating magnetic field within its radius. If a tag with a smaller coil is placed in the field, it will result in an alternating voltage that will, in the end, send data back to the reader.

For near-field RFID, the readers and tags use a minor magnetic induction (c/21rf), which causes the magnetic range to be smaller (Abugabah et al., 2020; García Betances & Huerta, 2012). Near-field RFID is the most common RFID implementation and is applied for cases when the tag is needed to be closer to the reader (Villupuram, 2015). However, far-field RFID uses a high magnetic induction that causes higher radiation of the magnetic field, causing a high-field tag to send data at a considerable distance (up to 100 feet). For far-field RFID, the tags often operate at a greater frequency of more than 100MHz, typically the Ultra High Band (such as 2.45GHz). Near-field RFID operates on lower frequencies below 100MHz (Geoffrey, 2012; Khalil & Osman, 2019).

4. Proposed RFID-based patient identification System

In this section, the proposed RFID-based patient identification system for unilorin clinic is discussed. These include the design methodology, the hardware components of the system as well as the operation procedure of the proposed RFID-based patient identification System.

4.1 Methodology

The connection structure shown in Figure 2 depicts the proposed system. The RFID tag is placed within a distance of 1.5 meters from the RFID reader. The identification information is then broadcasted to the RFID reader. The RFID reader comprises two various hardware components: an MFRC522 and an Arduino Uno R3 board. The RFID reader is connected to the Patient Identification system, backed up with a preferable database.

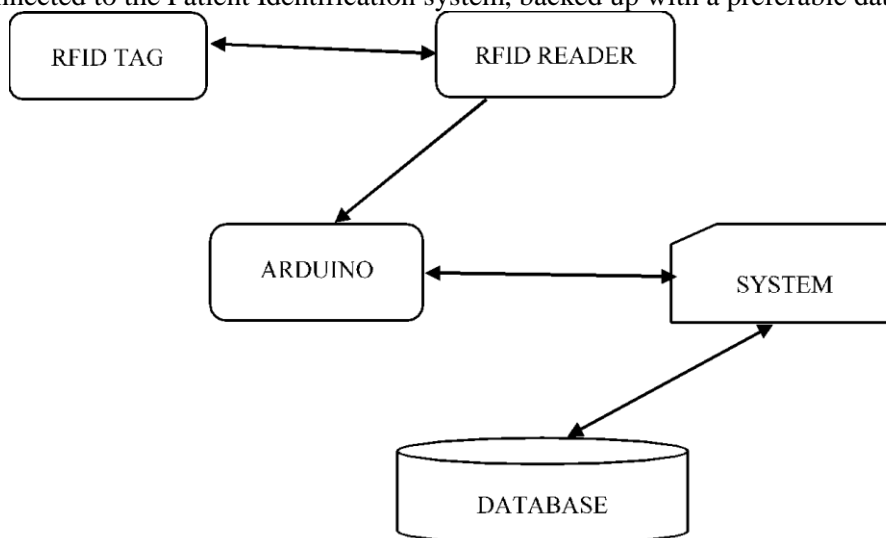


Figure 2: Architecture of the proposed system.

4.2 Design Phases

The two design phases (Enrolment phase and verification phase) of the proposed RFID-based patient identification system for unilorin clinic are discussed here.

4.2.1 Enrolment Phase

This phase involves the enrolment of patients into the system. In this phase, the RFID tag, which also serves as an identifier of the patient, is entered into the system as 'valid'. Thus, readings from it can be saved in the Patient Authentication System database (PASD). The enrolment phase allows the administrator to input the patient's details and his/her RFID tag number into the database. This invariably allows the system to easily search the patient's ID using the RFID tag number as the search metrics and display the information on the screen.

4.2.2 Verification Phase

Once a patient has been enrolled in the Patient Authentication System, the patient's tag can be used for easy identification at the receptionist's office and at the doctor's ward. The design's verification phase takes charge of verifying if the tag number is present in the database before displaying it on the screen. The verification phase also serves as a mechanism that denies tags with no existing tag number in the database access to the healthcare services. The flow chart shown in Figure 3, starts when the user places the RFID tag on the RFID reader, the reader gets the user ID (UID) for the tag, and the system runs a search for the retrieved tag UID and displays a proportionate result if the tag has been registered or not. If the tag information is available, then the result would be displayed on the screen, and if there is no information, then the get request remains active.

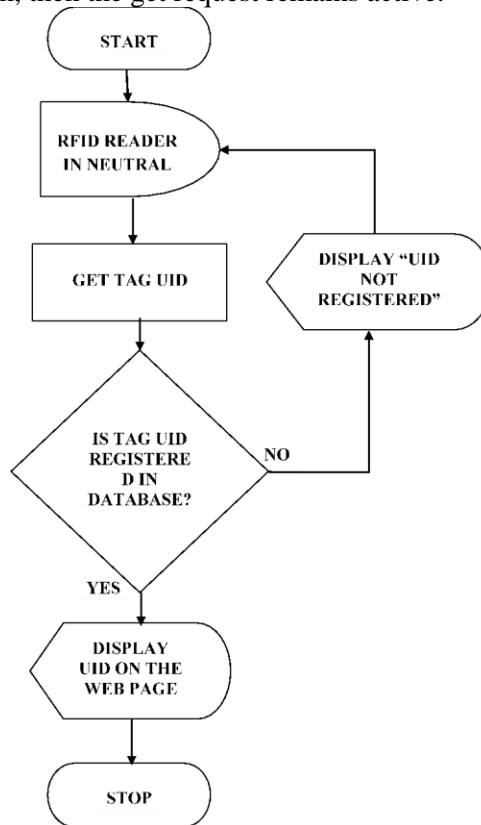


Figure 3: Flow chart showing the Identification Process.

4.3 Hardware Components

As mentioned in Section 3.1, the components of the RFID reader, the RFID tag, as well as other hardware components that are used in the design and development of the proposed RFID-based patient identification system for unilorin clinic are discussed here.

4.3.1 RFID Card Reader

RFID reader comprises a Control Unit, a Power Supply Unit (PSU), a communication interface (COM Port), and the casing that encloses all these components (T. C. Adeniran, 2015; Mahmood et al., 2014). The control unit's function is to primarily process signals received using DSP (Digital Signal Processing). Due to this function, the control unit is programmed in the form of a modem to perform Digital-To-Analogue Conversion (DAC) and Analogue-To-Digital Conversion (ADC). A microprocessor on the control unit processes data received according to some predefined rules in the program. The reader also has an antenna that allows it to pick up RF Signals from Tags.

4.3.2 RFID Tag

An RFID tag is ideally a transponder that stores the required unique information about an object (Kariapper et al., 2020; Yadav & Jha, 2019). For a web-based patient authentication system, part of the tag's information includes the patient's name, residential address, age, etc. An RFID tag is an essential component in any RFID system design as it represents the item been scanned and used. In this case, the RFID tag represents the patient, and it has embedded in it details concerning the patient's medical records and details.

4.3.3 RC522 RFID Module 13.56MHz

Mifare RC522 is a highly-integrated RFID card reader designed by Next eXPerience (NXP) that supports non-contact 13.56MHz communication. MF RC522 is a new 13.56MHz RFID reader and has many similarities to MF RC5200 and MF RC530, and also has more new features. The choice of MF RC522 for this project's design is majorly due to its non-contact reading ability and its operating frequency. With the MF RC522, each patient tag is automatically scanned as they tender it to the receptionist for verification. The tag is within the reader's range, and there is no need for contact with the reader before scanning.

4.3.4 Arduino UNO R3

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). The microcontroller comprises 14 digital input/output pins, out of which 6 are used as Pulse Width Modulation (PWM) outputs. Arduino Uno R3 helps to enable interaction between different devices, in this case, the RFID module and the computer program. The microcontroller accepts the radio signal information from the RFID module, converts it into digital data, and then passes it to the computer (Abugabah et al., 2020; Beaver, 2016).

4.3.5 LCD Component

A Liquid Crystal Display (LCD) device is a thin, flat panel used for electronically displaying information such as text, images and moving pictures. It is an electronically modulated optical device made up of many pixels filled with liquid crystals and arrayed in front of a light source or reflector to produce images or texts in colour or monochrome, depending on the type of LCD. The LCD used in this project will display just the RFID (number) of the tag read by the RFID reader. The connections of all the hardware components were done with the use of a PCB (Printed Board Circuit) shown in Figure 4.

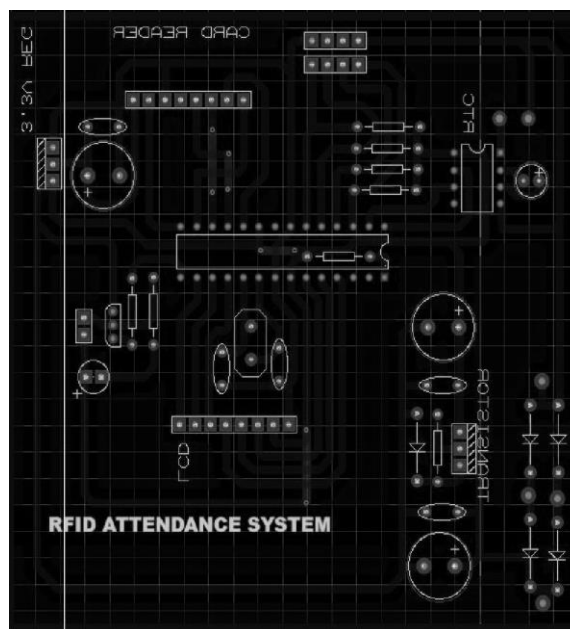


Figure 4: PCB board design.

4.4 Operational Procedure

The ATmega 328 component handles the RFID code, processes the signal received from the MFRC 522 RFID Module and sends the signal information received to the LCD component to display the tag UID details received. All components are interconnected with the bundled wire. The final coupling of all the hardware components, based on the PCB design, can be seen in Figure 5.

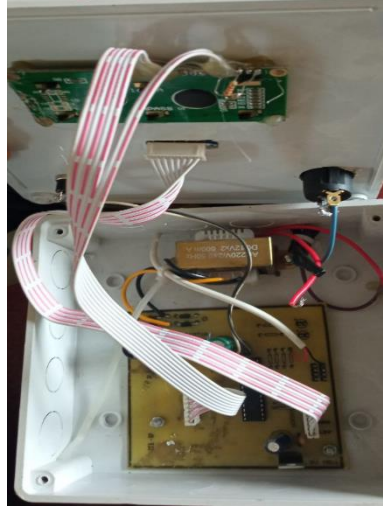


Figure 5: Interior view of the final component board.

4.4.1 Firebase

Firebase is a development platform made by Google. It serves as a database platform that can be used across multiple devices such as web and mobile apps. It allows a user to perform real-time data requests. All data are hosted in the firebase cloud storage. The data request and storage are handled by firebase. This is an alternative to other database structures such as MySQL, etc. The firebase interface is shown in Figure 6.

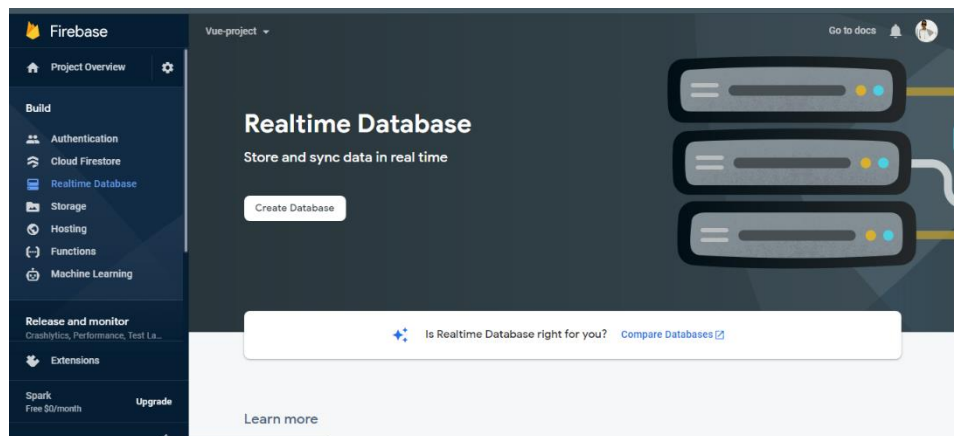


Figure 6: Firebase interface.

5. System Implementation

The two modules (registration module and verification module) of the proposed RFID-based patient identification system for unilorin clinic are discussed here.

5.1 Enrollment Module

This module involves the enrolment of basic necessary patient details, as shown in Figure 9, for identification in the database. The admin handles all registration processes. To access the admin interface, as shown in Figure 7, which facilitates the registration process, a default login detail is used. This empowers the admin to oversee the

information of everyone registered in the system, as shown in Figure 8. Before starting this process, the coupled RFID reader is connected and actively working via the Arduino IDE. A unique digit called UID represents each RFID tag. The UID is registered to each patient and enables us to search through an already registered patient database. Upon successful registration of the required details of the patient, the data is sent to the firebase data storage, as shown in Figure 10. All data requests and connections are made with active internet access.

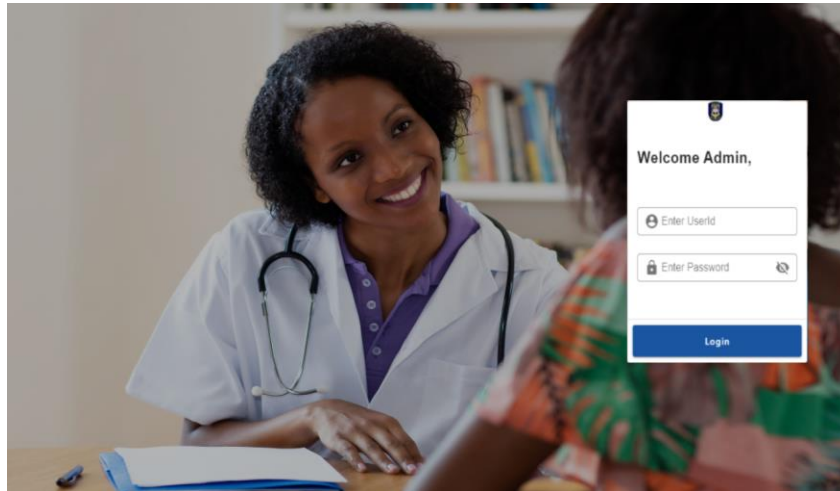
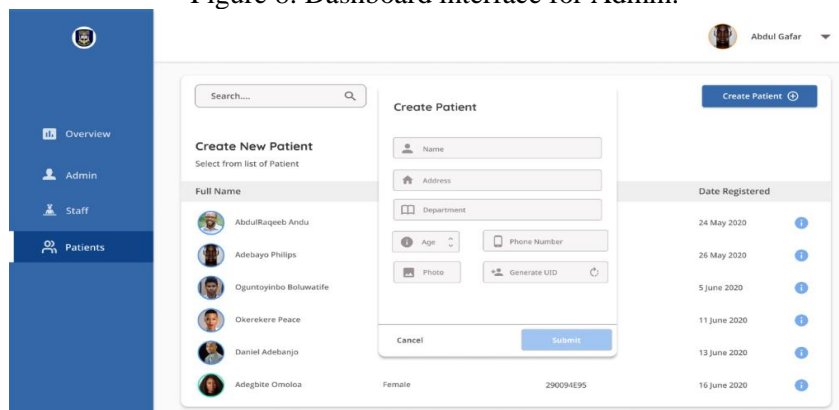


Figure 7: Login interface for Admin.



Figure 8: Dashboard interface for Admin.



Full Name	Date Registered
AbdulRaqeeb Andu	24 May 2020
Adebayo Phillips	26 May 2020
Oguntoyinbo Boluwatife	5 June 2020
Okerekere Peace	11 June 2020
Daniel Adebanjo	13 June 2020
Adegbite Omolola	16 June 2020

Figure 9: "Create Patient" interface.

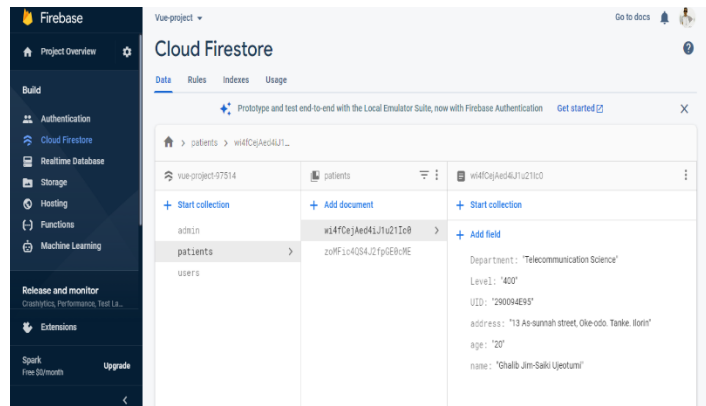


Figure 10: Firebase database.

5.2 Verification Module

This module is achieved in the staff screen. Both the staff and Admin have respective detail to access their sections of the web interface. Upon successfully registering a patient's details to the database, such detail can go through verification, which involves reading the RFID tag on the RFID reader. The web system actively searches for the patient's unique RFID UID across the firebase database and displays the patients' details on the staff web interface section, as shown in Figure 11. Response time was less than 5 seconds. Such a system's response time as this, which involves actively fetching data from the firebase database, depends on the network quality at that specific moment.

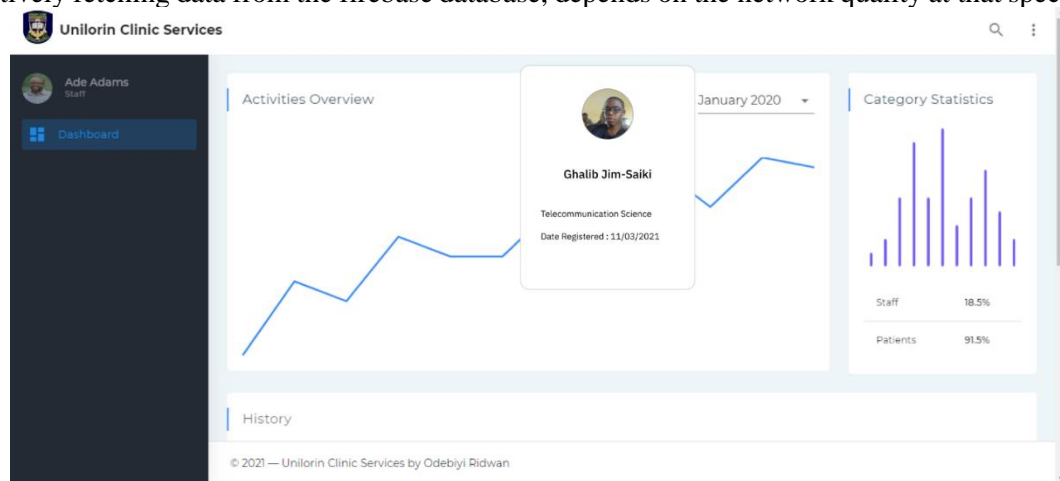


Figure 11: Patient search result.

5.3 Discussion

The conventional way of identifying patients is a very cumbersome process, but this web-based RFID system brings ease of use and fastens the whole process of identifying multitudes of intending patients seeking healthcare services from the University of Ilorin Clinic. The process of providing the clinic call card and searching across hundreds or possibly thousands of files in store, before confirming the authenticity of the patient as a registered client of the hospital and attended to by the doctor. To eradicate such a strenuous process, the use of an RFID identification system integrated with a web service has proved useful, preferable, and efficient.

This is achieved by setting up a two-standpoint consisting of two systems, with two personnel, each serving a role as the Admin or Staff. The admin is entrusted with the role of enrolling every patient detail in the web database using the interface provided and assigning RFID tags to each patient. These details are necessary to facilitate the verification procedures of the system. Secondly, the staff is in charge of overseeing the verification process at the



reception. Whenever the patient intends to use the clinic service places the tag on the RFID reader at the reception, the system scans the tag details and fetches the details from the database. Once gotten, it displays the necessary details of the patient including pictorial evidence, which will give the patient access to the medical personnel. The process of verifying a different tag detail on the database takes an average time of 610.4ms. And of course, the whole-time duration is dependent on the quality of the network at that particular moment. All personnel in charge of enrolling and verifying procedures are given login details to access the web interface for their respective duties. This prevents the misappropriate use of such privileges by non-corresponding personnel.

6. Conclusion and Recommendations

Compared to the currently existing operational infrastructure, this RFID Identification system can help eradicate or reduce the University of Ilorin Clinic's slow operational system. It features two-way verification such as by tag ID and personal photo of a particular patient trying to access the clinic's services. Thus, the project's main objective is to ease the means of identifying each patient in the clinic and thus fasten the process of getting medical attention. It is effortless to use and cost-effective. With this system put in place, there cannot be an imposter trying to claim the identity of a valid beneficiary of the clinic service, as there is facial evidence in place to be used as a comparison. From the result of the testing session, it can be concluded that the RFID identification system is an efficient tool compared to the conventional method of searching for files before giving access to visit the doctor for necessary medical treatment. However, a delay could be experienced due to certain conditions, such as cable damage or human errors. As such, recommendations are provided for the improvement of the proposed system as well as future research. The recommendation is as follows:

1. A contact tag's use proved to increase the time taken in the registration process because the RFID tag's information can only be retrieved when it is swiped on the reader. Thus, a contactless RFID tag is recommended to eliminate such delays.
2. Naturally, the MFRC522 reader is incapable of reading tags above the 50mm range. An external antenna can be attached to the RFID reader to make it possible to read data easily from contactless tags.
3. The MFRC522 reader is inefficient for handling multiple scans simultaneously. Thus, advancing the SPI protocol is recommended for the reader to allow it to communicate with multiple tags at once without causing collision effects.
4. The system does not have adequate security techniques in place to tackle threats such as remote attacks, denial of service (DoS), viruses, and other malicious attacks. Thus, it is advisable to implement these in future works.
5. This could further be developed into an advanced healthcare management system. That can handle all patient's databases, past medical records, and activities. Basically, to transfer the whole operation to a full digitalized system.

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