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RESEARCH ARTICLE

DESIGN AND CONSTRUCTION OF AN INTELLIGENT DRUG PRESCRIPTION AND PATIENT RECORD MANAGEMENT SYSTEM USING RFID TECHNOLOGY

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ABSTRACT

The modern healthcare sector faces significant challenges regarding medication errors and manual record-keeping inefficiencies. This study proposes an intelligent medical mechanism utilizing a modified grouping proof process to enhance medication safety for inpatients. By embedding Radio-Frequency Identification (RFID) tags in patient bracelets and drug containers, medical staff can verify the authenticity and integrity of prescriptions through mutual authentication between the medication server and the tag. The system utilizes a web server and RFID database tracking to prevent drug abuse and capture real-time, accurate patient data. Results indicate that the automated verification process significantly reduces human error, ensuring the right medication is delivered to the right patient while maintaining data privacy.

KEYWORDS

RFID (Radio frequency identification), patient record management, drug prescription systems, medication safety, Data privacy.

1. INTRODUCTION

Efficient healthcare delivery relies heavily on the accuracy of patient records and the timely administration of prescriptions (Salman et al 2025). In many developing regions, including Nigeria, hospitals still rely on manual documentation, which is often inefficient, error-prone, and incapable of meeting the demands of modern medicine (Profetto, et al., 2022). According to the World Health Organization (WHO, 2022), medication errors affect millions of patients annually, leading to adverse reactions and fatalities (rachmat and 2024. Modernizing healthcare through efficient management software is essential for economic and social development (Balog et al., 2020; Husar, and Iakovets, 2019).

Radio Frequency Identification (RFID) technology offers a robust solution by using electromagnetic fields to automatically identify and track tagged objects in real-time. Unlike traditional barcodes, RFID does not require a line-of-sight to function, allowing for bulk reading and increased operational speed (Abugabah, et al., 2020). This research aims to develop a centralized, secure database that integrates RFID technology to automate patient identification and drug prescription monitoring, thereby aligning Nigerian healthcare facilities with global digital health trends.

2. METHODOLOGY

2.1 RFID System Architecture

An RFID framework consists of five primary components: tags (transponders), antennas, readers, middleware, and a backend database (Zhou, and Lin, 2023).

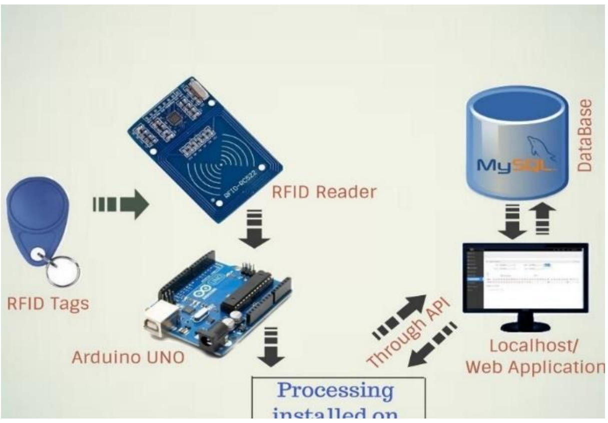

Figure 2.1: Block diagram of an RFID system (Zhou, and Lin, 2023)

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- Tags: Consist of a chip and an antenna; they can be passive (powered by the reader) or active (self-powered).
- Reader: A scanning device that identifies nearby tags by sending signals at specific frequencies.
- Middleware: Acts as a correspondence interface to process and translate reader data for the backend system.

2.2 The Internet of Things (IoT) in Healthcare

The rapid growth of internet-connected devices has facilitated more seamless integration between computer systems and real-world medical applications (Magaret, and Rouse, 2019). The Internet of Things (IoT) involves a network of physical objects equipped with sensors and software to exchange data online (Profetto, et al., 2022). In the medical sector, IoT and RFID technologies collaborate to reduce paperwork and misidentification errors (Shivani, and Avinash, 2020). Electronic Medical Records (EMRs) provide the foundation for these systems; however, in Nigeria, infrastructural challenges such as power instability and lack of internet connectivity hinder consistent adoption (Adeyemi, et al., 2024).

2.3 Hardware Design

RFID implementations have expanded beyond industrial use to include social media integration and secure access control in restricted environments (Amirjan, 2011). The system hardware is built around a microcontroller that communicates with an RDM6300 RFID reader and an ESP8266 Wi-Fi module.

- **Power Unit:** Utilizes a 12V DC input regulated by an LM2596 buck converter to a stable 5V output.

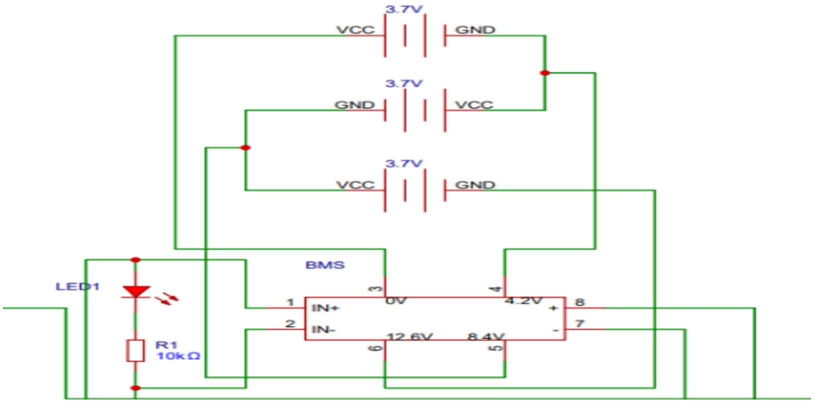


Figure 2.2: Power Supply Unit

Source: Proteus Professional v 8.1 SPI, 2014.

The 12-V DC jack acts as the primary charging and input source. Power from this jack is routed to the **3S1P Battery Management System (BMS)**, which regulates the charging and discharging behavior of the lithium battery pack. The BMS provides overcharge, over-discharge, short-circuit, and thermal protection critical features that ensure the longevity and safety of the battery pack (Marin et al. 2025).

- Identification: 125 kHz passive RFID key cards were selected for their durability and low cost (Zhou, and Lin, 2023).
- Output: A 16x2 LCD module provides real-time feedback to the user.

Table 2.1: LCD Display pin Description

Pin	Symbol	I/O	Description
1	V_{SS}	--	Ground
2	V_{CC}	--	+5 V power supply
3	V_{EE}	--	Power supply to control contrast
4	RS	I	RS = 0 to select command register, RS = 1 to select data register
5	R/W	I	R/W = 0 for write, R/W = 1 for read
6	E	I/O	Enable
7	DB0	I/O	The 8-bit data bus
8	DB1	I/O	The 8-bit data bus
9	DB2	I/O	The 8-bit data bus
10	DB3	I/O	The 8-bit data bus
11	DB4	I/O	The 8-bit data bus
12	DB5	I/O	The 8-bit data bus
13	DB6	I/O	The 8-bit data bus
14	DB7	I/O	The 8-bit data bus

Source: (Alexander, and Sadiku, 2021).

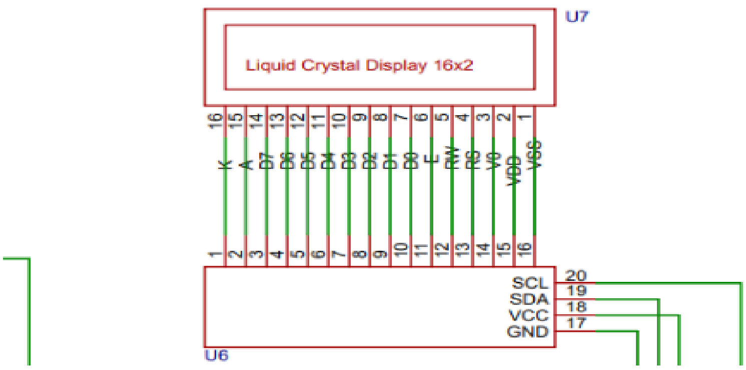


Figure 2.3: Display Unit.

Source: Proteus Professional ISIS

2.4 Software Development (Iterative Model)

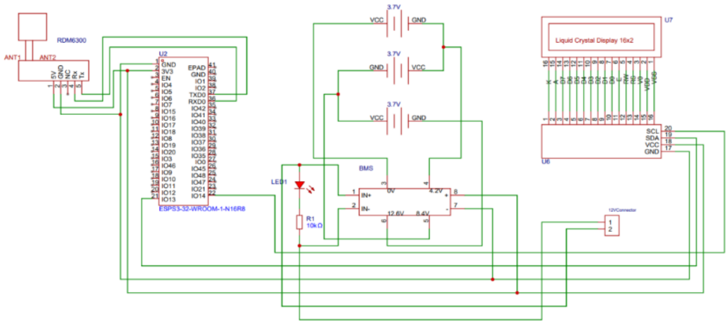
To handle the complexity of healthcare workflows, the Iterative and Incremental Software Development Model was adopted.

Table 2.2: Breakdown of Iterative Cycles Used

Iteration	Main Activities	Output
Iteration 1	Requirements gathering, initial UI sketches, database concept	Conceptual model
Iteration 2	Implementation of basic UI and authentication module	Basic working UI
Iteration 3	RFID reading module, drug tagging logic	Working RFID interface
Iteration 4	Prescription engine, drug–patient verification logic	Full prescription workflow
Iteration 5	Integration, debugging, user testing	Functional system prototype

- Requirement Elicitation: Interviews with doctors and pharmacists revealed that handwritten prescriptions and lost sheets were primary drivers of error.
- Implementation: The backend was developed using ASP.NET Core 7.0 and Microsoft SQL Server, with a frontend built on Bootstrap 5 and JavaScript.

2.5 Working Principle Of The Complete Circuit



Source: Proteus ISIS

2.6 Flow Chart

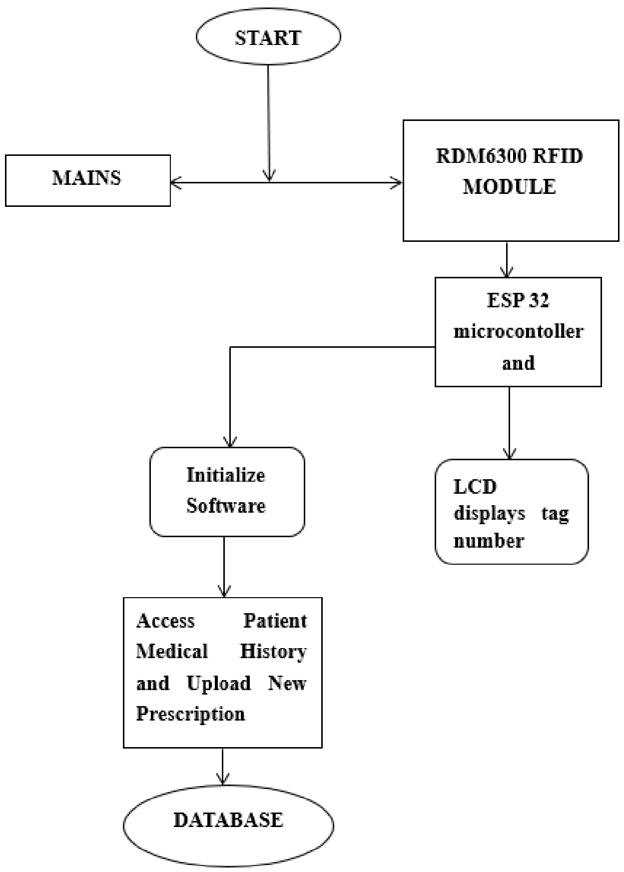


Figure 2.4: Flow chart showing the working principle of the circuit.

With the help of the diagram, it is easy to understand the actual working principle of the system. The working principle of the design is anchored on the electromagnetic coupling that occurs between the RFID tag and the reader, supported by coordinated processing, sensing, switching, and display operations. When the system is powered, the RFID reader continuously generates a low-power radio frequency field through its antenna. As an RFID tag enters this field, the tag's antenna captures the electromagnetic energy and uses it to activate its internal circuitry. In the case of passive tags, this harvested energy is sufficient for the tag to modulate and transmit its unique identification code back to the reader through load modulation. The RFID reader then demodulates this returned signal and extracts the tag's digital data, which is forwarded to the microcontroller via a communication interface such as UART or SPI.

Upon receiving the tag data, the microcontroller initiates a sequence of validation and decision-making processes. It compares the detected tag ID with predefined records stored in its memory or in an external database, depending on the system conFigureuration. If the tag ID is authenticated, the processing unit triggers the appropriate system response. This may involve activating the switching unit to control electromechanical loads, updating the display unit with real-time operational feedback, or logging the event for backend processing. Meanwhile, the sensing unit continuously monitors parameters such as system voltage, environmental conditions, or device state to ensure safe and stable operation. The power unit regulates incoming electrical energy from the supply, providing clean and stable DC voltage to all hardware components to prevent malfunction or data corruption.

Through this integrated workflow RF excitation, tag activation, signal modulation, data retrieval, microcontroller processing, sensing support, and controlled output activation, The design achieves reliable, automated, and real-time RFID based identification and system control. This systematic interaction of functional modules ensures high operational accuracy, rapid response, and enhanced efficiency, which are essential for embedded RFID solutions deployed in modern applications.

3. Results and Discussion

3.1 System Operation

The system follows a structured workflow where the RFID reader scans the patient's UID. If found in the database, the system loads the patient's profile and history.

3.2 Admin Login

Upon visiting the system url (https://izhedhealthcare.netlify.app/), the admin is first presented with the secure login interface. The admin enters his/her username and password. Once authenticated, the administrator dashboard loads with system-level controls.

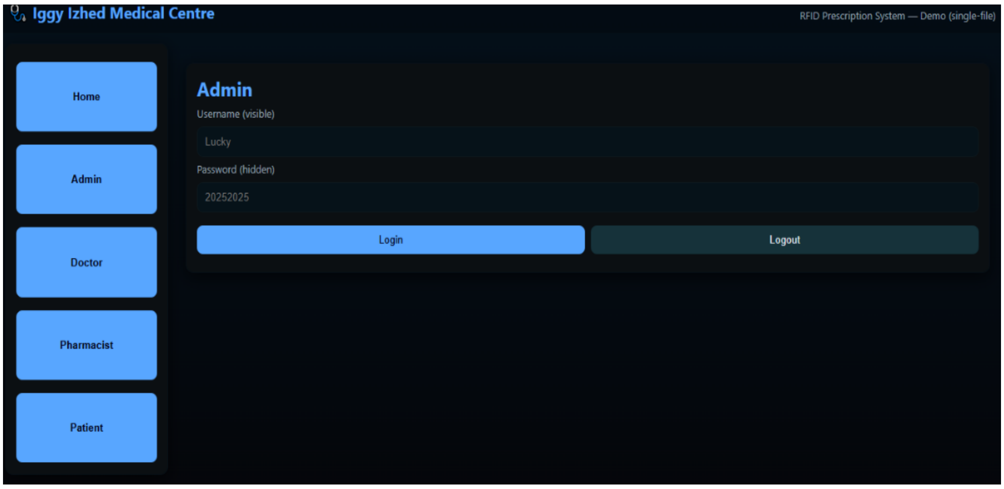


Figure 3.1: Admin Dashboard

Source: Izehise and Ojo

Using the dashboard, the admin can register new patients into the system by swiping a new rfid tag to the hardware device, by doing this a unique patient ID is generated. The admin creates digital profiles for patients by entering their:

- Full name
- Gender
- Date of birth
- Medical history (if available)

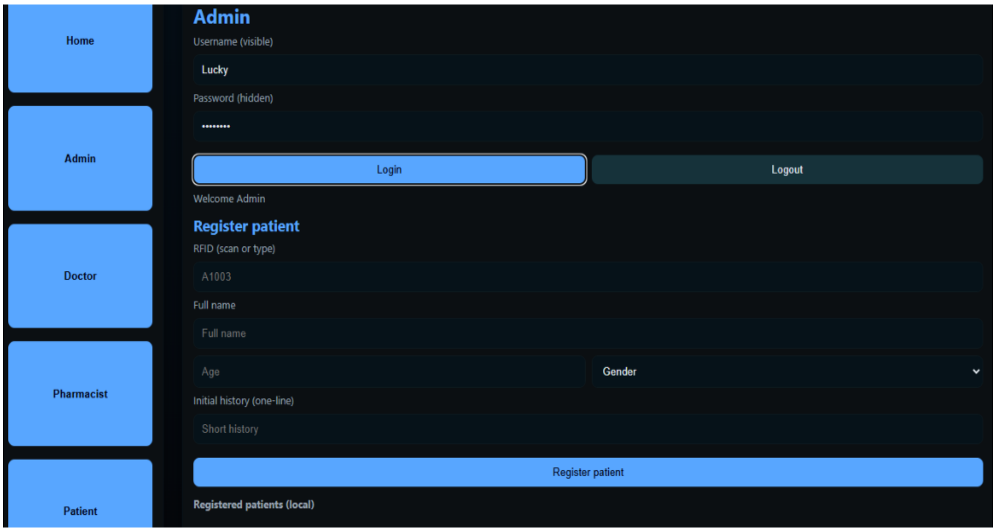


Figure 3.2: Admin dashboard

Source: Izehise and Ojo

3.3 Doctor Module Activation and Use

Doctors are the main users responsible for generating prescriptions. The doctor logs in using a unique username and password, the system interface displays: Patients RFID (Scan or enter).

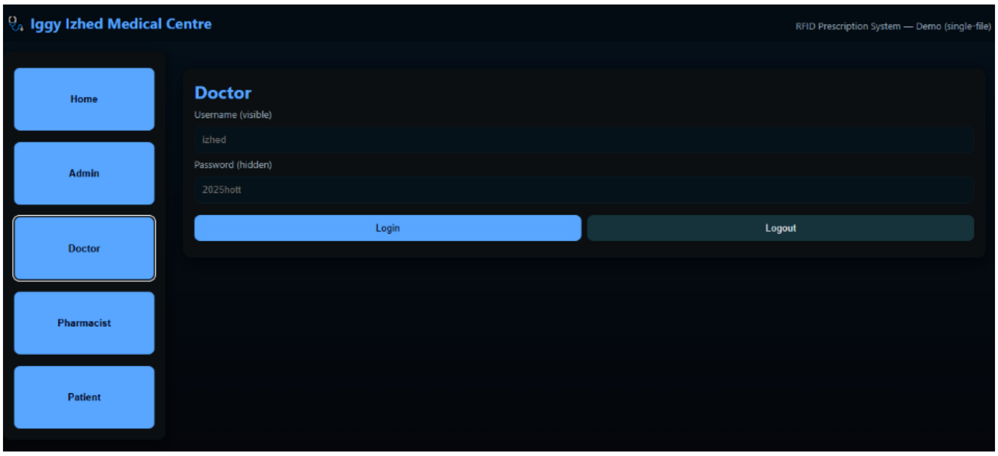


Figure 3.3: Doctor's dashboard

Source: Izehise and Ojo

After scanning the tag, the doctor can now do the following thing;

- Add new prescription.
- New appointment.
- Chat with the patient.
- Make video call to visually see the condition of the patient in case of an emergency.

3.3.1 Accessing Patient Profile via RFID Scan

When a patient arrives:

- Patient presents their RFID card.
- Card is placed near the RFID scanner or input the tag number into the web manually.
- The patient's profile loads automatically within seconds.

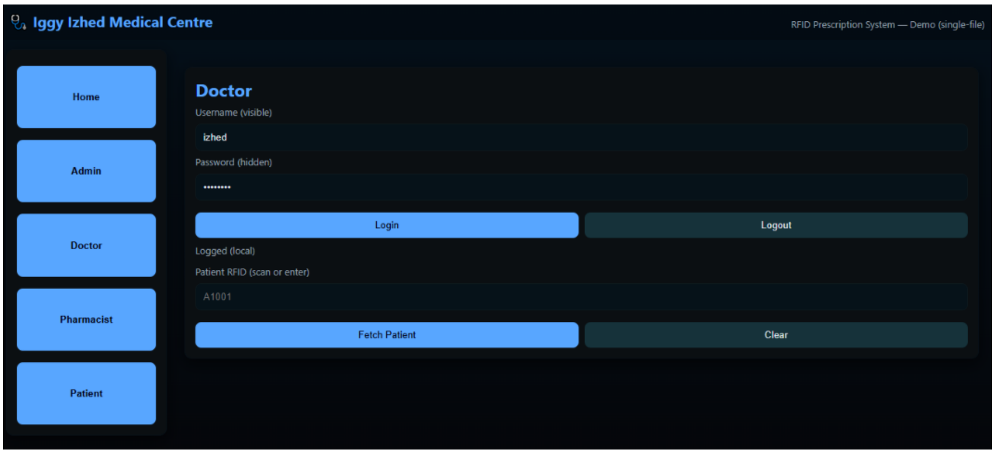


Figure 3.4: Doctor accessing patient's profile

Source: Izehise and Ojo

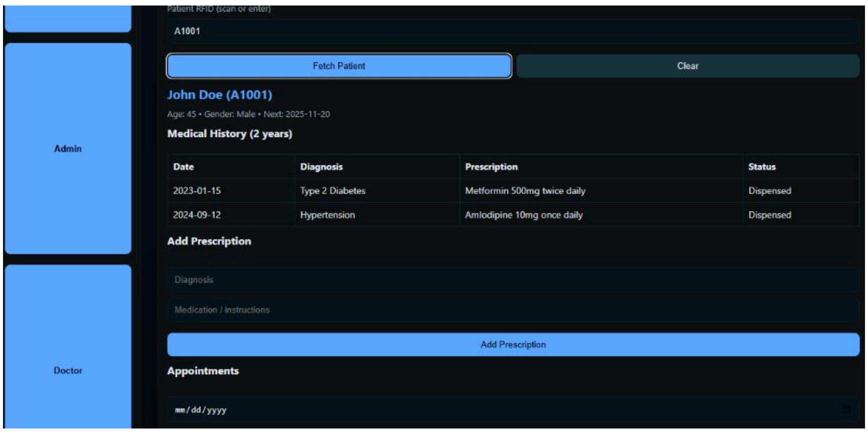
3.3.2 Creating a new digital prescription

After consulting with the patient, the doctor:

1. Opens "Create New Prescription"

   Types in the name of the drug(s)
2. Specifies:
   - Dosage
   - Frequency
   - Duration
3. Submits the prescription

   A unique prescription code is generated and stored in the SQL database.
4. The doctor can chat and make video call with the patient while the patient is away.



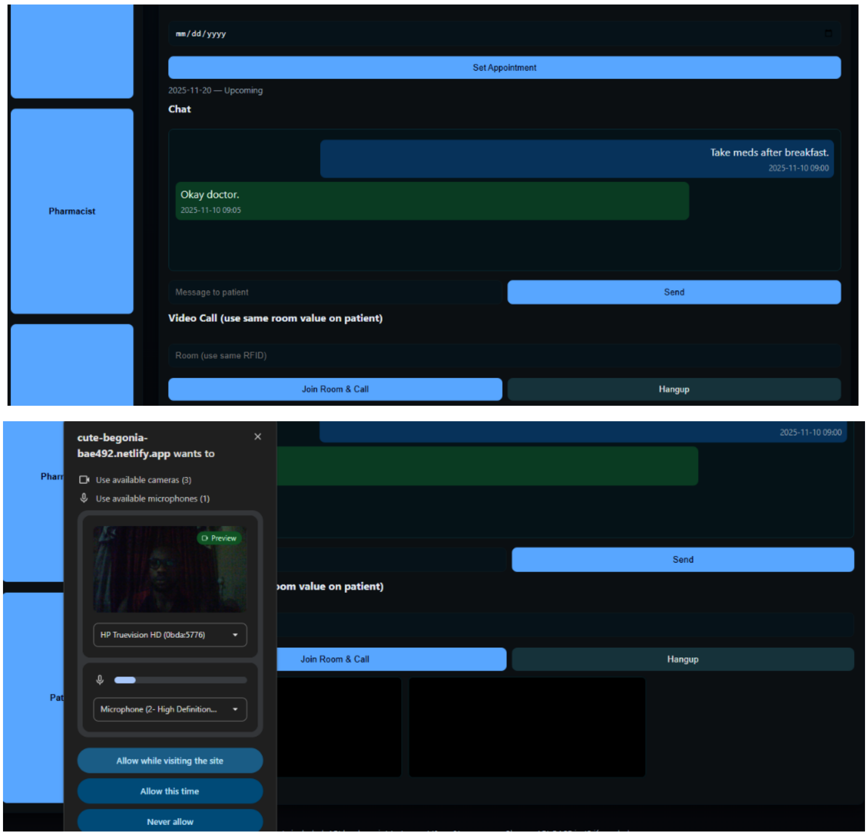


Figure 3.5: Doctor interacting with patient

Source: Izehise and Ojo

3.4 Pharmacist Module Activation and Use

The pharmacy interface is focused on drug dispensing and stock management.

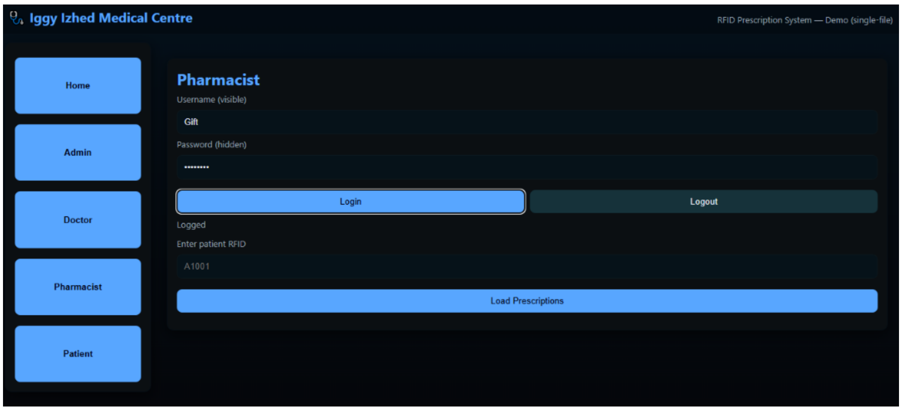


Figure 3.6: Pharmacist Dashboard

Source: Izehise and Ojo

3.4.1 Loading Prescriptions

When a patient arrives at the pharmacy:

- They scan their RFID card or manually input the tag number
- Their active prescriptions load automatically
- Pharmacist reviews and selects the prescription to dispense

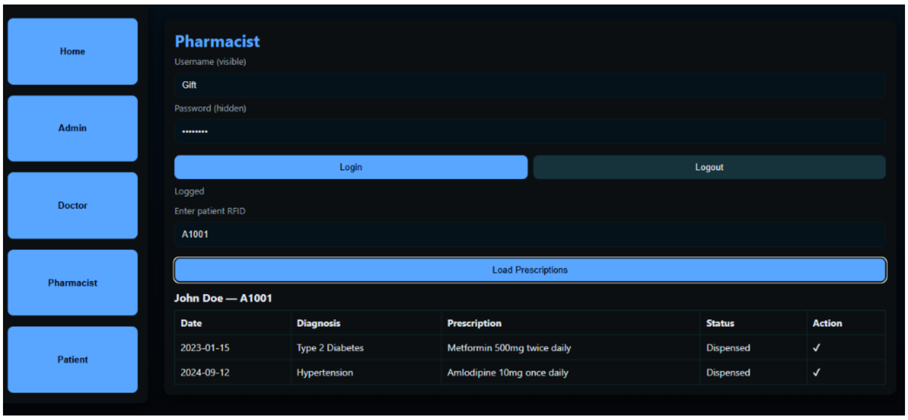


Figure 3.7: Pharmacist accessing patient's portal

Source: Izehise and Ojo

3.5 Patient Interaction and Experience

The patient's interaction with the system is minimal yet critical. Their primary engagement is through the RFID card.

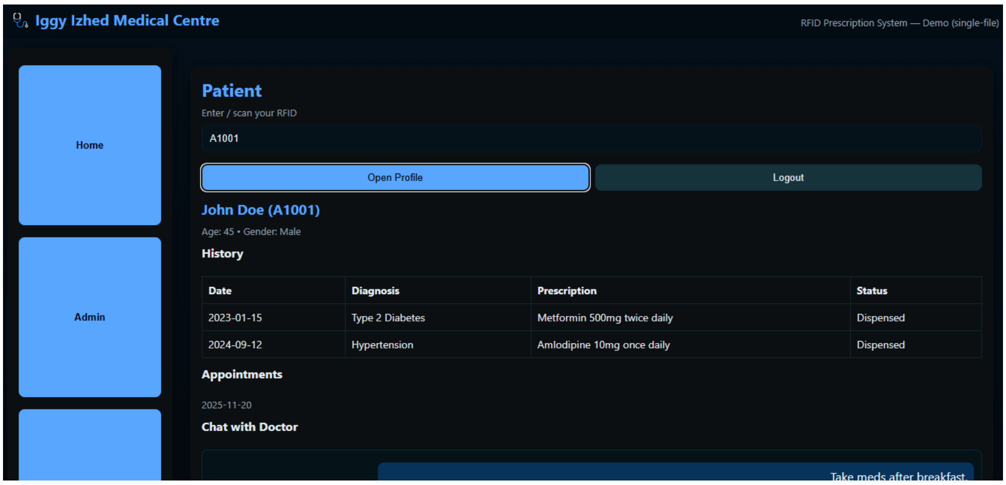


Figure 3.8: Patient's Dashboard

Source: Izehise and Ojo

3.5.1 Patient Arrival at Clinic

(1) Patient submits RFID card

(2) Identity verification is automatic

(3) Reduces waiting time

(4) Eliminates wrong-file retrieval risk

(5) Receive chat and call from the doctor.

3.5.2 During Consultation

- No forms to fill manually
- Doctor already sees their medical history

Faster diagnosis and treatment decisions

- Doctor Module: Allows for the creation of digital prescriptions which are validated against dosage rules and drug interactions.
- Pharmacist Module: Scans the patient card to retrieve prescriptions and automatically updates inventory upon dispensing.

3.6 System Testing and Calibration

After complete assembly:

- The RFID reader is tested for range, accuracy, and responsiveness.
- The MCU is checked for correct firmware execution.
- Communication modules are verified for connectivity.
- Power stability tests are performed under different load conditions.

This ensures the entire hardware subsystem functions as expected before integration with the software component.

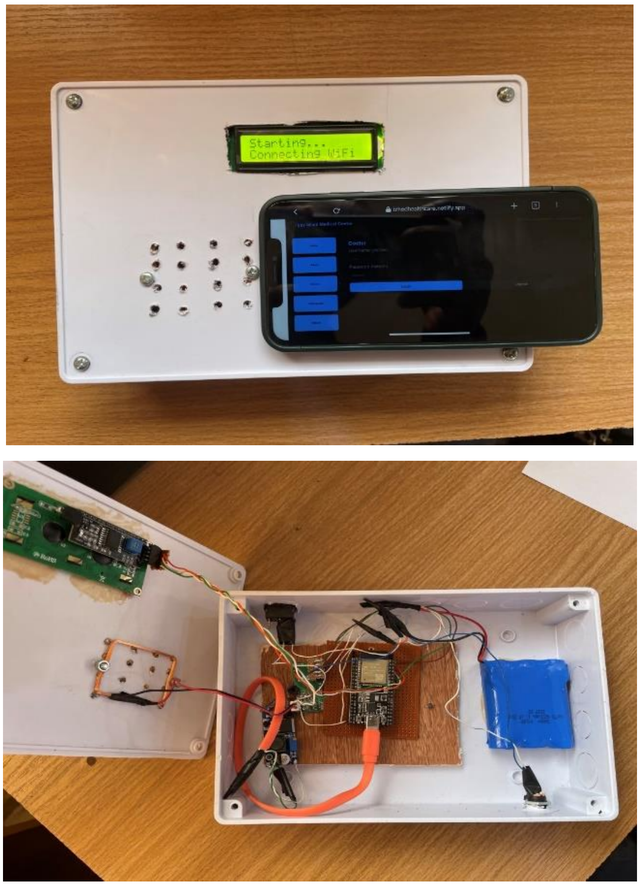


Plate 3.1: Images of Construction of the Hardware Circuit

Photo Credit: Izehise and Ojo

3.7 Packaging

A plastic case of suitable insulation for electrical protection and simple use is utilized as seen below.

Plate 3.2: Packaging of the Hardware Circuit

Photo credit: Izehise and Ojo

3.8 Challenges and Performance

Technical challenges included achieving stable serial communication between the RFID reader and the microcontroller. It was discovered through testing that the microcontroller could only communicate with one module (RFID or Wi-Fi) at a time, requiring a sequential transmission program.

Compared to barcode systems, the RFID solution proved more effective as it eliminated the need for line-of-sight and allowed for concurrent tag reading, which is essential in high-volume hospital wards (Profetto, et al., 2022).

4. Conclusion and Recommendations

The proposed RFID-based system successfully enhances patient safety by reducing the likelihood of pharmaceutical errors from prescription to administration. It is recommended that future versions integrate cloud-based backup solutions to mitigate data loss during power failures. Furthermore, expanding the system to include billing and laboratory modules would create a fully unified hospital information system.

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