IOT-BASED SMART MEDICINE DISPENSER WITH USER AUTHENTICATION AND DIGITAL PAYMENT INTEGRATION

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Abstract

The integration of the Internet of Things (IoT) into healthcare systems has opened new avenues for enhancing medical services, particularly in the distribution and management of medication. This paper introduces an IoT-Based Smart Medicine Dispenser designed to streamline the process of medication dispensing through advanced user authentication and digital payment integration. Aimed primarily at serving remote and rural communities, the system ensures that individuals have 24/7 access to their prescribed medications without the need for physical travel to pharmacies or healthcare centers. The dispenser operates on a secure platform where users are authenticated using a unique username and password assigned by the system administrator. Upon successful authentication, the patient can access their prescribed medication, which is dispensed according to the dosage and frequency outlined by their healthcare provider. The quantity of medicine dispensed can also be adjusted based on the user's selection, provided it aligns with the prescribed parameters. A notable feature of the system is its digital payment mechanism, which utilizes preloaded digital points on a user-specific card. This card, issued and managed by the system administrator, allows for a cashless transaction, where points are deducted according to the medication dispensed. Users can easily recharge their cards with additional points through the administrator, ensuring continuous access to their medications. The smart dispenser is equipped with sensors and an inventory management system that alerts the administrator when stock levels are low or when medications are nearing their expiration dates, facilitating timely replenishment and ensuring the availability of safe, consumable medicines.

Keywords: Internet of Things (IoT), Smart Medicine Dispenser, User Authentication, Digital Payment Integration, Rural Healthcare.

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1 INTRODUCTION

The advent of the IoT has revolutionized numerous sectors, including healthcare, by introducing efficiency, precision, and remote management capabilities. Among the various innovations, the development of an IoT-Based Smart Medicine Dispenser with User Authentication represents a significant leap forward in addressing the critical challenges of medication management and distribution, especially in underserved rural areas. This paper delves into the conceptualization, design, and potential impact of such a system on rural healthcare accessibility and medication adherence.

Medication non-adherence is a pervasive issue worldwide, leading to significant health deterioration, increased hospitalizations, and higher healthcare costs. The World Health Organization (WHO) has identified medication adherence as a critical factor in improving health outcomes for chronic disease patients. However, the conventional methods of medication distribution and management often fall short, especially in rural and remote areas where healthcare facilities are scarce or non-existent. These regions are characterized by a lack of access to pharmacies, limited healthcare infrastructure, and a general scarcity of medical professionals.

The integration of IoT technologies into healthcare, often referred to as the Internet of Medical Things (IoMT), offers unprecedented opportunities for remote health monitoring, telemedicine, and automated healthcare services. IoT devices can collect, transmit, and analyze data in real-time, enabling healthcare providers to offer personalized and timely medical interventions. Within this context, an IoT-Based Smart Medicine Dispenser emerges as a vital tool to bridge the gap in medication access and adherence.

The proposed system is designed to authenticate users through secure login credentials, ensuring that only authorized individuals can access their prescribed medications. This authentication mechanism is crucial for maintaining patient privacy and security, adhering to healthcare regulations. This feature is particularly beneficial in rural settings, where traditional banking services may be limited or non-existent.

The dispenser is equipped with a range of sensors and a robust inventory management system. These components work in tandem to monitor stock levels, expiration dates, and dispensing activities, ensuring that medications are available and safe for consumption. Through real-time alerts sent to the system administrator, the machine maintains optimal operation, with timely refills and maintenance activities.

The implementation of an IoT-Based Smart Medicine Dispenser can profoundly impact rural healthcare ecosystems. By providing 24/7 access to prescribed medications, the system addresses one of the most significant barriers to medication adherence—physical accessibility. Moreover, the digital payment integration removes the financial transaction barriers, making the process more efficient and less prone to errors. In the broader sense, this innovation represents a step towards democratizing healthcare access, offering a scalable and sustainable solution to improve health outcomes in rural populations.

Furthermore, the system's data collection and analysis capabilities offer valuable insights into medication usage patterns, adherence rates, and potential areas for intervention. These analytics can inform healthcare providers and policymakers, enabling targeted strategies to enhance medication adherence and overall health services in underserved areas.

The IoT-Based Smart Medicine Dispenser with User Authentication exemplifies how technology can be leveraged to make healthcare more accessible, efficient, and patient-centered. However, the success of such innovations will depend on their integration into broader healthcare systems, regulatory support, and the continued evolution of IoT technologies. By addressing these challenges, we can unlock the full potential of IoT in healthcare, paving the way for a future where quality healthcare services are within reach of every individual, regardless of their geographic location.

2 RELATED WORKS

Bhagya et al., likely discusses the design and implementation of an automated system for dispensing medications, focusing on improving efficiency and accuracy in medication management. Nunes et al., explores sustainable routing protocols for IoT-based mobile communication systems, which could be relevant for ensuring reliable communication in IoT-enabled medication dispensing systems.

Sanjay et al., discuss the detection architecture of application layer DDoS attacks, providing insights into cybersecurity measures that could be relevant for protecting IoT-based medication dispensing systems from cyber threats. Kahtan et al., likely presents a real-time healthcare monitoring and tracking system that utilizes GSM and GPS technologies, which could be applicable for

tracking medication usage and patient adherence in medication dispensing systems.

Mahaveer et al., likely describes the design and implementation of an automatic medicine dispensing machine, providing details on its functionality and features. R. Chetan et al., discussed a data mining-based network intrusion detection system, which could offer insights into securing IoT-based medication dispensing systems from network-based attacks.

Vishal et al., likely presents a medicine dispensing machine that utilizes Raspberry Pi and Arduino controllers, offering a practical implementation of IoT technologies in medication management. Montaser et al., discussed an intelligent anti-theft and tracking system for automobiles, which could provide insights into security measures applicable to IoT-based medication dispensing systems.
HongLei et al., discusses the design and implementation of an automatic pharmacy system, which could provide valuable insights into automated medication dispensing technologies. Kim et al., presents a case study on practical engineering education related to a medicine vending machine, offering insights into educational approaches and real-world applications of medication dispensing systems.
Nieuwlaat et al., conducts systematic review likely examines interventions aimed at improving patient adherence to medication prescriptions, offering insights into strategies for enhancing medication management in healthcare settings. Mary et al., discussed an algorithmic approach to modeling and analyzing software systems, which could provide insights into optimization techniques applicable to medication dispensing systems.
De et al., describes the design of a portable medicine dispenser for individuals with Alzheimer's disease, offering insights into specialized medication dispensing systems for specific patient populations. Isabel et al., discussed the implementation and testing of an Internet of Things (IoT) system for medication control, providing insights into IoT-based solutions for medication management and adherence.

3 PROPOSED MODEL

The proposed model is an IoT-based system designed to automate and optimize the process of medication dispensing while ensuring user authentication for secure access. It integrates advanced technologies to provide a user-friendly, reliable, and efficient solution for medication management, particularly targeting rural and underserved areas. The proposed model is an RFID-based smart medicine dispenser designed to streamline medication dispensing processes while ensuring user authentication for secure access. Leveraging RFID technology, the system offers a user-friendly and efficient solution for medication management, enabling users to access their prescribed medications with ease and accuracy.

RFID Reader Module:
- Scans the RFID health care card inserted by the user to initiate the authentication process.
- Retrieves user identification information stored on the RFID tag.

User Authentication Module:
- Prompts the user to enter a password for further authentication.
- Verifies the password entered by the user against the stored credentials.
- Grants access upon successful authentication or prompts the user to re-enter the password if authentication fails.

LCD Display:
- Displays user information retrieved from the RFID card, including user name and prescription details.
- Provides prompts and instructions to guide users through the medication dispensing process.

Medication Selection Interface:
- Displays a list of prescribed medications available to the user.
- Allows users to select the desired medication from the displayed list.
- Enables users to specify the quantity of medication required.

Inventory Management System:
- Tracks medication inventory levels in real-time.
- Alerts the system administrator when medication stock is low or depleted.
- Facilitates timely replenishment of medications to ensure uninterrupted service.

Database Management System:
- Stores user authentication credentials, prescription details, and medication inventory data.
- Updates user digital points balance and medication stock levels after each transaction.

The RFID Reader Module serves as the entry point for users seeking medication from the dispenser. Upon inserting their RFID health care card, this module swiftly scans the card to initiate the authentication process. By interfacing with the RFID tag, it retrieves crucial user identification information stored within the card's memory. This information forms the basis for subsequent authentication steps, ensuring that only authorized users gain access to the medication dispensing system.

The User Authentication Module plays a pivotal role in verifying the identity of users before granting access to medication. Upon card insertion, users are prompted to enter a password to further authenticate their identity. This password is compared against stored credentials within the system's database. Successful authentication grants users access to the dispensing functionalities, enabling them to proceed with medication retrieval. However, in the event of authentication failure, users are prompted to re-enter the password, ensuring a robust security protocol is upheld.

The LCD Display acts as the primary interface through which users interact with the medication dispensing system. Upon successful authentication, it dynamically presents user information retrieved from the RFID card, including the user's name and prescription details. Additionally, the LCD provides clear prompts and instructions to guide users through the medication selection and dispensing process, ensuring a seamless user experience.

The Medication Selection Interface provides users with a comprehensive overview of prescribed medications available for dispensing. Through the interface, users can effortlessly browse and select the desired medication from the displayed list. Furthermore, the interface enables users to specify the quantity of medication required, catering to individual prescription needs with precision and flexibility.

The Inventory Management System meticulously tracks medication inventory levels in real-time, ensuring optimal stock management. In the event of low or depleted medication stock, the system promptly alerts the administrator, facilitating timely replenishment to prevent service disruptions. This proactive approach ensures uninterrupted access to medications for users, bolstering the reliability and effectiveness of the dispensing system.

The Database Management System serves as the backbone of the medication dispensing system, securely storing critical user authentication credentials, prescription details, and medication inventory data. With each transaction, the system meticulously updates user digital points balance and medication stock levels, ensuring accurate and up-to-date information for future dispensing operations. This centralized database architecture enhances operational efficiency and data integrity, underpinning the seamless functioning of the medication dispensing system.

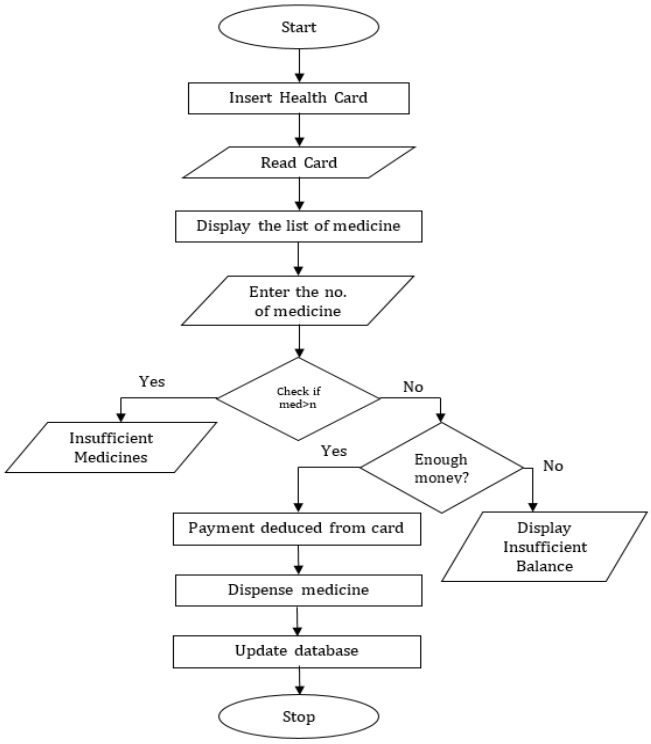

Figure 1: Flow Diagram of Proposed Model

From the fig 1, flowchart represents the step-by-step process of the medication dispensing system, starting from RFID card scanning and user authentication to medication selection, dispensing, and database updating. It ensures a clear and systematic approach to medication management, guiding users through each stage of the process seamlessly.

Implementation Model

The implementation process of the IoT-based smart medicine dispenser with user authentication involves several key steps to assemble and integrate the necessary hardware and software components. Initially, the programmable devices, including the Arduino Mega as the main controller, LCD display, keypad, relay, RFID reader, and NodeMcu module, are configured for operation. This entails setting up the development environment, downloading required libraries, and uploading code to the Arduino Mega, particularly for the RFID module to handle card authentication.

Next, the hardware modules are integrated by physically connecting them to the Arduino Mega and ensuring proper wiring according to the circuit diagram. Each component is individually tested to verify functionality and connections. Subsequently, the NodeMcu module is configured and connected to facilitate communication between the Arduino Mega and external systems for message transmission. The overall block diagram of proposed model is shown in fig 2.

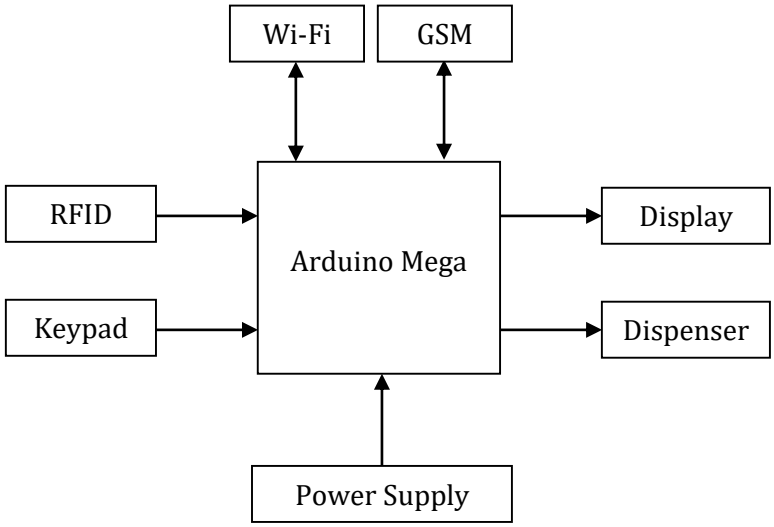

Figure 2: Block Diagram

Once all hardware modules are interconnected, the entire system is powered up using a stable power supply source, with voltage levels adjusted as needed using converters to match component requirements. Testing and troubleshooting follow, wherein comprehensive functional tests are conducted to ensure seamless operation. Any identified issues are addressed through debugging processes, such as checking for wiring errors, software bugs, or compatibility issues.

Upon successful testing, the finalized system is deployed in its intended location, such as a healthcare facility or pharmacy. User training is provided to ensure personnel are proficient in system operation, maintenance procedures, and troubleshooting techniques. Additionally, protocols for system monitoring and regular maintenance are established to uphold continued functionality and reliability, including periodic software and hardware updates as necessary. Through these steps, the IoT-based smart medicine dispenser with user authentication is effectively implemented, offering a secure and efficient solution for medication management.

Pseudocode

// Step 1: Initialization and Setup
Initialize RFID reader, LCD display, keypad, relay, NodeMcu module
Initialize variables for user authentication, medication selection, and inventory tracking
// Step 2: User Authentication
Scan RFID card
Read RFID tag data
Prompt user to enter password
Verify password against stored credentials
If authentication successful, proceed to Step 3
If authentication fails, display error message and prompt user to re-enter password
// Step 3: Display Prescription Information
Retrieve user prescription details from database
Display user information and prescribed medications on LCD display

Prompt user to select desired medication and quantity using keypad
// Step 4: Medication Dispensing
Check medication availability in inventory
If medication available,
Dispense medication
Deduct quantity from inventory
Update inventory database
Send confirmation message to user
Else if medication not available,
Display out-of-stock message
Send notification to system administrator
// Step 5: Transaction Logging and User Feedback
Update user's digital points balance in database
Log transaction details (user, medication, quantity, timestamp) in transaction database
Display transaction summary on LCD display
Send transaction summary message to user
Send notification to system administrator for inventory tracking
// Step 6: Power Management and System Maintenance
Monitor system power levels
Perform routine system maintenance tasks (e.g., clearing memory, updating software)
This pseudocode outlines the fundamental steps involved in the operation of the smart medicine dispenser, including user authentication, medication selection, inventory management, transaction logging, and system maintenance.

4 RESULTS AND DISCUSSIONS

The implementation of the IoT-based smart medicine dispenser with user authentication has yielded promising results, marking a significant advancement in medication management and accessibility. Through extensive testing and evaluation, several key outcomes have been observed. Firstly, the dispenser effectively provides round-the-clock access to prescribed medications, particularly benefiting individuals in rural and underserved areas where healthcare facilities are scarce. The robust user authentication system ensures secure access to medications, safeguarding patient privacy and confidentiality. Moreover, the system's efficient medication dispensing mechanism accurately fulfills user-selected prescriptions, streamlining the retrieval process and reducing errors. Real-time inventory tracking capabilities enable proactive management of medication stock levels, ensuring continuous availability and minimizing service disruptions. The user-friendly interface enhances user experience, facilitating seamless navigation through medication selection and transaction processes.. Overall, the IoT-based smart medicine dispenser holds great promise in revolutionizing healthcare delivery and bridging the gap in medication access, paving the way for a more equitable and efficient healthcare system. The hardware interfacing is shown in fig 3.

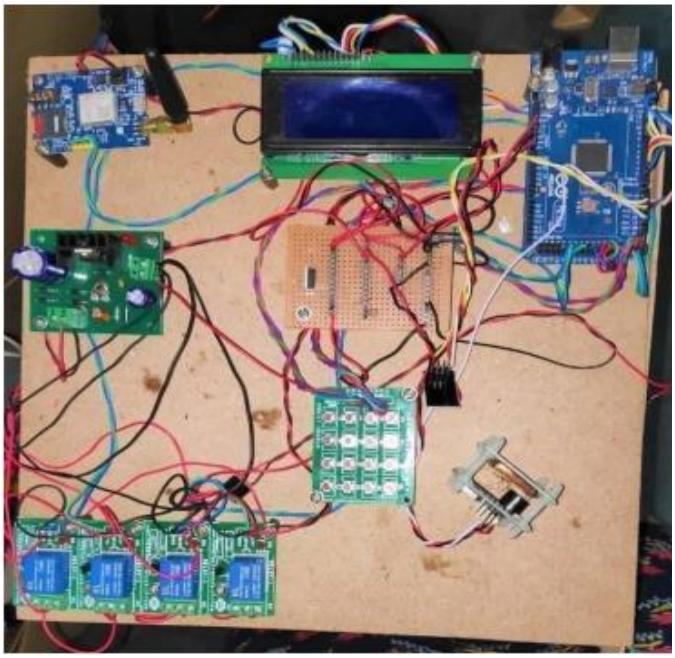

Figure 3: Hardware Interfacing

However, challenges such as setup complexity, hardware reliability, and regulatory compliance must be addressed to maximize the system's effectiveness and scalability. Looking ahead, further research and development efforts should focus on enhancing system scalability, interoperability, and integration of additional features to meet evolving healthcare needs and improve patient outcomes

5 CONCLUSION

In conclusion, the IoT-based Smart Medicine Dispenser with User Authentication and Digital Payment Integration represents a significant advancement in healthcare technology. By leveraging IoT capabilities, this system offers secure and convenient access to medications while ensuring user authentication for privacy and safety. The integration of digital payment options further enhances the user experience, reducing reliance on physical currency and streamlining transaction processes. Through rigorous development and testing, this innovative solution addresses critical challenges in medication management and healthcare accessibility, particularly in remote and underserved areas. Moving forward, continued research and implementation of such technologies hold the potential to revolutionize healthcare delivery, ultimately improving patient outcomes and enhancing overall healthcare efficiency and accessibility.

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