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A Smart Web-Based Inventory Management System for Efficient and Accessible Pharmacy Operations

Shivardhini K S[1], Sindhu[2], Siri S[3], Syed Abdul Rahaman[4], Dr. Ranjith J[5]
Department of Information Science and Engineering SJB Institute of Technology
Bengaluru, Karnataka, India
[1]shivardhiniksh@gmail.com, [2]sindhu.gouda245@gmail.com, [3]siri982004@gmail.com, [4]syedabdulrahaman0@gmail.com,
[5]ranjith.krnagar@gmail.com

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Abstract—Pharmacy inventory is extremely significant to en-sure that the medicine is readily available and expiry and mis-management of stocks have been minimized [1]. The traditional pharmacy system more or less relies on maintaining the records manually which tends to be short of stocks, expires and lacking coordination [2]. This paper presents a Web-Based Medicine Inventory Management System developed in MERN stack as a smart one [3]. The system will provide the real-time inventory monitoring [4], automated expiry and low stock alerts [5], the location of pharmacies using GPS with Leaflet [6] and simple multilingual chat-bot which will help the user [7]. The interaction between the administrators, the pharmacists and the customers will be safe through role-based access [8]. The proposed system is more efficient regarding its operations and reduces the human error and enhances the availability of medicines. Index Terms Pharmacy Management, Automation of inventory, MERN stack, GPS Mapping, Multilingual chatbot, Web application.
Index Terms—component, formatting, style, styling, insert

I. Introduction

The pharmacies should have an efficient inventory manage-ment that prevents losses of money due to spoilt or surplus drugs [1]. Manual or semi-automatic systems are still used in many small and medium pharmacies, further exposing them to the likelihood of data inconsistency and ineffective operation [2]. Under the condition of web technologies and cloud-based solutions development, automated inventory systems can greatly enhance accuracy and transparency [4]. The paper describes a web-based pharmacy inventory system, which combines real-time monitoring system, automated alerts, and place based services [6]. The system will increase the effi-ciency of the pharmacy system and improve he healthcare provision

solutions [4]. This chapter is a review of available literature concerning pharmacy management systems, automated inven-tory, GPS-based health services [6], and chatbots [7].

A. Pharmacy Inventory Management Systems

A number of studies are aimed at digitizing the pharmacy processes to eliminate the use of manual records [2]. The old systems use either spreadsheets or paper based registers and this has tended to cause data duplication and low stock information [2]. Current pharmacy management systems do not have the capability of sending out intelligent alerts to track expiry but they do have billing and stock entry [5]. It has been found that automated inventory control systems dra-matically lower human error and enhance stock visibility [4]. Nonetheless, most of these systems are independent programs without incorporation of real-time analytics and location-based services [6].

B. Stock and Expiry and Stock Monitoring Techniques

Medicine expiry control plays a significant role in the prevention of financial losses and preservation of patient safety [5]. The past studies have indicated the significance of automated warning systems that inform pharmacists on approaching expired products [5]. There are systems where low stock is monitor by using threshold based alert systems [4]. More sophisticated systems combine background jobs (cron jobs) to scan inventory data on a regular basis and send notifications [9]. These systems enhance the efficiency of the operations, but may not have user friendly dash boards and capacity of centralized monitoring.

II. LITERATURE SURVEY

Inventory management in healthcare has become a highly discussed topic of the last few years because of the growing need to track medicine correctly and reduce the number of wastage and better serve patients [1]. To eliminate manual systems, researchers have come up with a number of digital

Identify applicable funding agency here. If none, delete this.GPS-Healthcare Applications

Location-based services have brought out importance in the accessibility of healthcare [6]. A number of mobile and web apps allow hospital and pharmacy finders through the use of GPS [6]. Research indicates that the implementation of map-ping technologies, including Google Maps or OpenStreetMap, do improve convenience of the user in the time of emergency [6]. Nevertheless, most of the solutions available merely

offer the information about the location without checking the availability of medicine in real-time. It is necessary to have a single system that incorporates inventory tracking and GPS searching features.

C. Chatbot in Healthcare System

Chatbot applications in healthcare support systems have been achieved through Artificial Intelligence and Natural Lan-guage Processing (NLP) [7]. The studies show that chatbots enhance the interaction with the users as they can respond to the common questions immediately [7]. Chatbots based on rules are typically applied to predetermined queries, whereas models based on advanced NLP allows multilingual communi-cation [7]. Although they have advantages, chatbot functional-ity is missing in many pharmacy management systems, which restrict the ability to assist users and make them available.

D. Shortcomings to Existing Systems

Based on the literature review, it is noted that the current systems tend to concentrate on a single functionality like billing, location services, or tracking of inventory [4]. It is extremely difficult to find systems that combine real-time stock tracking, expiry notifications, pharmacy search (GPS-based), and multilingual chatbot support into one system [3][7]. This loophole points out the necessity of having a smart and comprehensive pharmacy inventory management solution.

III. SYSTEM DESIGN AND METHODOLOGY

The proposed Smart Medicine Inventory Management Sys-tem is developed on the basis of the layered client-server ar-chitecture [10] to automate the pharmacy inventory operations and enhance the accessibility. The system combines the use of inventory, expiry monitoring, multilingual chatbot support [7], and location services based on GPS positioning of a pharmacy
[6] into a single platform. The design is such that it is scalable, secure and real time data processing is efficient.

A. System Architecture

The system has a three-layer architecture that includes the Presentation Layer, Application Layer and the Database Layer [10]. Presentation Layer deals with the interaction with the user and uses React.js and Tailwind CSS [11][12]. Application Layer deals with business logic and is done with the help of Node.js and Express [10]. Database Layer MongoDB is used to store user data, medicine records and information on alerts [13]. The frontend is connected to the backend through the RESTful APIs [10]. The backend can utilize user requests, verify them, and communicate with the database. Other modules like the multilingual chatbot and GPS mapping service are also incorporated into the system to make the system more functional and user-friendly.

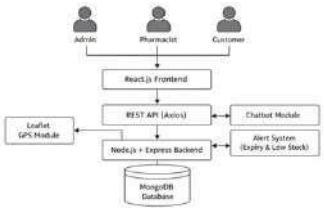

Fig. 1. System Architecture of Proposed Smart Medicine Inventory Manage-ment System

B. Functional Modules

- User Authentication Module This module deals with user registration, validation of the user login and the access control based on roles [8].
- Expiry Detection Algorithm The system also periodically checks against the actual date and the dates stored to check their expiry dates [5].
- Chatbot Query Handling The chatbot compares the input of the user with the already preset intents and responds to them in the language of choice [7].
- GPS-Based Location Module The system is based on Leaflet.js that can be used to combine the map so that customers can find the position of pharmacies in their area [6].

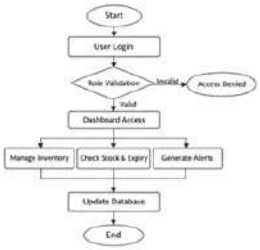

Fig. 2. Workflow of Smart Medicine Inventory Management System

IV. SYSTEM IMPLEMENTATION

The proposed Smart Medicine Inventory Management Sys-tem is implemented using the architecture of MERN stack that will offer the scalability, flexibility, and real-time data processing [3][10]. The front end technology, the backend service, the database management and third party modules will be incorporated into the system to provide a complete automation system of the pharmacy.

A. Technology Stack

The system is developed using modern web technologies, thus, to make it performance-based and maintainable [10].

1) Front-End Technologies The Presentation Layer is coded in React.js which is utilized in the development of interactive user interfaces [11]. Tailwind CSS is availed to be responsive and compatible in styling [12]. through RESTful APIs [10]. Introduction of Leaflet.js to visualization of a map using GPS has been used to provide the details of the surrounding pharmacies [6].

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2) Back-End Technologies The Node.js and Express have built Application Layer [10]. The back-end will take care of user authentication, inventory, and expiry management [4][5], and chatbot query management [7]. Secure middleware is used to apply role based access control and validation of requests [8].

3) Database Layer MongoDB is applied as the pri-mary database with the aim of storing user data, medicine catalog, inventory warning, and chatbots responses [13]. MongoDB Atlas may be implemented in cloud [13]. The database schema is such that it has separate collections of:Users,Medicines,Inventory,Alerts.

4) Third-Party Integrations Leaflet.js for GPS mapping [6]. Multimodule Multilingual Chatbot [7].

B. Development Environment

The following are the tools involved in the development of the system: Code Editor used : Visual Studio Code. Git and GitHub Version Control [9]. API Testing: Postman Database Management : MongoDB Compass / MongoDB Atlas [13]. Runtime Environment: Node.js [10] It is developed in modular way to ensure that frontend and backend are separated in different directories such that they can easily be debugged and deployed [10].

C. Implementation Flow

The system has an orderly flow of execution which ensures the smooth running of the system.

Step 1: User Authentication The user logs into the system. The generation of credential validation and secure access is done at the backend [8].

Step 2: Dashboard Role-Based Access. The system will take one to the dashboard depending on the role (Admin, Pharmacist, Customer) [8].

Step 3: Inventory Processing Pharmacists will be in a position to add, edit or delete medicine records. All data is stored in MongoDB [13].

Step 4: Stock/ Expiry and Stock Tracking. The system periodically reviews expiry date and stock of medicine. Alerts are made at achieving thresholds [5].

Step 5: Chatbot and Location Services. The customers are given a chance to check the availability of medicine and use the chatbot [7]. The relevant pharmacies are indicated on GPS mapping [6].

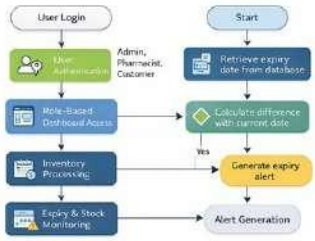

Fig. 3. Implementation Flow of Smart Medicine Inventory Management System

V. RESULTS AND DISCUSSION

A. System Evaluation Overview

The proposed Optimized Medicine Inventory Management System (OMIMS) was analyzed for its effectiveness in dealing with the drawbacks of the manual pharmacy inventory system as mentioned in [2]. The analysis was done on the basis of efficiency, expiry tracking capability, visibility, security, and responsiveness. The proposed system combines automated inventory management [4], expiry notification system [5], location-based system [6], health dialog system [7], role-based security system [8], background processing [9], and RESTful communication architecture [10], developed using contemporary web technologies such as React [11], Tailwind CSS [12], and MongoDB [13].

B. Improvement Over Manual Inventory Systems

The drawbacks of the manual record system in the pharmacy are discussed in [2]. After the implementation of OMIMS, the following changes were observed: There was no need for manual reconciliation of the ledger, as the stock updates were done in real time. The need for manual checks was eliminated by the automated alerts for the expiry of stock. The system's digital nature ensured that traceability was improved. The results validate the claim in [1] that the healthcare supply chain needs to be integrated digitally to eliminate inefficiencies. The automated inventory control system is more efficient than the manual record system [2] and is in line with the system architecture described in [4].

C. Expiry Monitoring Effectiveness

Mismanagement of expiry dates is one of the key causes of losses in the pharmaceutical industry [5]. The system for expiry date alerting, which has been put in place, scans all the batches of medicines continuously and alerts accordingly based on a predefined threshold period.Observed Outcomes: Medicines nearing ex-piry dates were identified automatically. The priority sorting feature allowed pharmacists to display first-expiring medicines first. There was a decrease in the num-ber of expired medicines overlooked compared to the manual scanning process. These outcomes confirm the efficiency of automated expiry date scanning systems as proposed in [5]. The background scanning module, which was developed based on [9], ensured that the scanning of expiry dates is done continuously without slowing down the system's performance. The automated system is less dependent on human memory and periodic scanning, which were previously identified as system weaknesses [2].

Fig. 4. Expiry Monitoring

D. Inventory Control and Stock Optimization

Research on the healthcare supply chain has highlighted the importance of intelligent inventory coordination [1], [3]. OMIMS enhances inventory visibility by: Monitoring via dashboards. Warning systems for minimum thresholds. Dis-tributor coordination modules The automated control logic incorporates concepts presented in [4], where electronic inven-tory control enhances demand response. Observed Improve-ments: Enhanced identification of low-stock drugs. Decreased emergency procurement scenarios. Enhanced distributor com-munication. These findings support models of supply chain efficiency presented in [3], illustrating that organized inventory movement enhances overall pharmaceutical logistics perfor-mance.

E. Role-Based Access and Security

Healthcare systems need to have controlled access mecha-nisms [8]. The system uses role-based access control (RBAC) to distinguish between: Shopkeeper access Distributor access Administrative access The RBAC system is based on the foundational model as described in [8], which ensures that only authorized personnel have access to modifications in the inventory.

Fig. 5. Role Selection

F. Location-Based Medicine Search

The integration of GPS-based pharmacy search is relevant to location-based healthcare service models, as explained in [6]. observed Benefits: Customers can search for nearby phar-macies that have medicine in stock. Unnecessary travel can be avoided. Accessibility is improved in emergency situations. The above implementation proves the applicability of location-based healthcare services, as explained in [6].

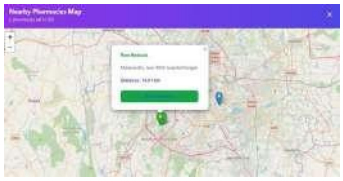

Fig. 6. Location Based Search

G. Chatbot Interaction and User Guidance

The chatbot module has conceptual backing from health dialog systems as discussed in [7]. The system offers the following: Medicine availability information Basic usage in-structions Automated responses to queries This enhances user engagement and accessibility, as proposed in [7].

Fig. 7. Chatbot

The assessment of the Optimized Medicine Inventory Man-agement System shows that the combination of automated inventory management [4], expiration tracking [5], role-based security [8], and location-based services [6] into one electronic system can greatly enhance the efficiency of pharmacy oper-ations. The system effectively resolves the shortcomings of manual record-keeping systems [2] and meets contemporary principles of healthcare supply chain optimization [1], [3]. The modular REST architecture [10] and scalable database structure [13] also guarantee that the system is maintainable and upgradable. In conclusion, OMIMS is a feasible and scalable solution for contemporary pharmaceutical inventory management.

VI. CONCLUSION AND FUTURE WORK

The Smart Medicine Inventory Management System is an automated and efficient system of managing the pharmacy inventory operations [4]. The system combines real-time stock levels, expiration dates, low stock notifications [5], multilin-gual chatbot support [7], and GPS-based pharmacies locating
[6] into one web-based solution. It will decrease medicine wastage, ensure that there is no unpleasant surprise shortage of stock, and enhance accuracy of operations because it replaces manual maintenance of records with a centralized database system [1][2]. Scalability, flexibility and the security of data management are guaranteed by the utilization of MERN stack architecture [3][10]. The system will improve the decision-making process of pharmacists and will make the product more accessible and convenient to the customers. More-so, the system may be expanded in future with online medicine ordering and secure gateway payment integration [10]. There is an option to use advanced analytics and AI-driven demand forecasting to more precisely predict the need in medicine [4]. Natural language Processing is one of the methods of upgrading the chatbot module to an intelligent multilingual interaction [7]. Moreover, the support of the mobile applica-tions and integration with the hospital management systems can also contribute to additional functionality of the system and its applicability in real life [6][10].

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