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A Computerized System to Solve Difficulties in Finding Medicines under the Medicine Shortages in Sri Lanka

B.B. Punchihewa[1], B.M.S.L. Bandaranayaka[2], G.S. Premachandra[3], D. I. De Silva[4] and S.P. Vidhanaarachchi[5]
[1]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[2]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[3]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[4]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[5]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA

[1]Corresponding Author: benukabinoth1999@gmail.com

ABSTRACT

Due to ongoing financial crisis in Sri Lanka, patients are starting to suffer from medicine shortages at an increasing rate. Patients are having to go to multiple pharmacies to find certain medicines which could result in health complications. Although e-pharmacy platforms provide the functionality to order medicines by uploading the prescription sheet, they do not provide alternatives on where to find the medicines that are not available in the pharmacy. This research introduces a new functionality to provide patients suggestion on where exactly to find missing medicines. This is found through checking the stock availability of the medicine in other pharmacies in sorted order with respect to the delivery location of the patient taken via Google map API to make the process much more efficient and practical. This is achieved by implementing a global identifier for each medicine where all pharmacies keep the records of the medicines in reference to the defined global identifier of that medicine. In addition to that, the system allows patients to view all the pharmacies nearest to their delivery location and give the freedom to place orders to whichever pharmacy they prefer. If a medicine is not available in the pharmacy which the order was placed for, the system will give suggestions to the patient on where exactly to buy the medicine.

Keywords-- e-Pharmacy, Medicine Shortages, Pharmacy Management, Order Medicine

I. INTRODUCTION

Medicine shortages are becoming very dominant issue in Sri Lanka [1] due to the ongoing financial crisis [2]. Many incidents have been reported of doctors not having supplies to carry out crucial treatments [3]. In addition to that, patients who are suffering from chronic diseases who require to take medications in proper schedule are having hard times to find medicines. Due to that, patients are having to go from pharmacy to pharmacy to find the medicines which could result in complications for taking the medication late.

Although there are existing e pharmacy platforms available, patients have no way to find out which pharmacy has which medicines in stock because an average patient has no ability to read prescription sheets. In addition to that, existing platforms not providing ability find out pharmacies nearest to their location makes it inefficient to order medicines. Implementation of the proposed solution will provide functionalities to view pharmacies sorted by the location. In addition to that, if a medicine is not available in the pharmacy that the order was initially placed for, the proposed solution will search the other pharmacies nearest to the delivery location and provides suggestions on where exactly the medicine is available which then the user can use to place the order directly.

The research is started by comparing the work done by other authors which addresses the research problem. In this section, gaps in the research are identified and addressed. In the next section, system architecture is explained with tools and technologies, mathematical formulas, external services, and APIs used in implementing the proposed solution. In addition to that, database design & client-side and server-side resource requirements are also explained. Then, the proposed solution to address the research problem is explained with the methodologies mentioned in the above section. In this section all the main functionalities and how they interact with each other will be highlighted. Finally, the research will be concluded followed by the discussion section which explains how proposed solution addresses the research problem with the support of the research done by other authors.

II. LITERATURE REVIEWES

Key problem is to provide patients a solution to order medicines with minimal effort with an e pharmacy platform under the ongoing medicine crisis in Sri Lanka. Many researchers have addressed this problem with providing various solutions.

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The research paper written by Ganeshan Subramanian, et al.[4] introduces a new innovating methodology to order medicines utilizing the concepts of hybrid blockchain. This methodology excludes the existence of third parties in the purchases allowing patients order medicines directly from the reliable suppliers. In addition to that they have also addressed the use of IOT devices to preserve the quality of the medicines in storage.

The research written by J.K.T.S. Perera [5] addresses the problem and provides with a methodology to place an order by uploading drug details, but the provided solution does not address the cases of a medicines being unavailable in the pharmacy.

The research written by D. D. Udugampola [6] addresses the problem by proposing approaches to create an order by,

1. Searching the medicines by name.
2. Uploading the prescription sheet.

Option 1 is not optimal because most of the average patients in Sri Lanka do not possess the ability to read prescription sheets. Option 2 is like the methodology proposed by the by J.K.T.S. Perera's research [5] and has downsides addressed above

The research paper written by Asan Baker Kanbar, et al. [7] and the research paper written by Madhavi Mali, et al. [8] do not directly contribute to the problem statement but they address approaches used for inventory control which is a problem to be addressed in maintaining an e pharmacy platform. For example, handling expirations of medicine batches with an alert system, etc.

The proposed solution under this research addresses most of the issues with the previous researches by providing solutions in giving patients suggestions on pharmacies nearest to their delivery location to buy unavailable medicines in an order.

III. METHODOLOGY

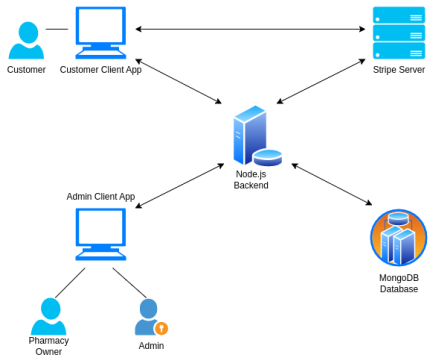

Figure 1: System overview diagram

Frontend development is done using React.js (Version 18.2.0). React.js is a JavaScript frontend library which is used to build user interfaces. React.js is selected as the preferred technology for frontend development due to its stability, performance, and flexibility. React.js is very fast with respect to other libraries or frameworks due to its usage of virtual DOM.

As the styling framework MUI (Version 5.10.3) is preferred. MUI is selected over bootstrap which is another popular styling framework due to its native compatibility with react. In addition to that MUI is easy to scale and maintain.

The backend development is done using Express.js (Version 4.18.1). Express.js is a Node.js framework which is simple and flexible. Node.js is a JavaScript runtime environment based on Google's V8 JavaScript engine. Express.js was preferred as the backend framework because of its impressive I/O performance. In addition to that, Express.js is highly scalable. Furthermore, the backend implementation follows a modular architectural pattern.

As the data persistence solution MongoDB is preferred. MongoDB is a NoSQL database which stores documents in the format of JSON. MongoDB is used as the database because it allows to write very powerful queries. In addition to that, the ability to save unstructured data is crucial in the process of saving pharmacy suggestions, etc.

A. MongoDB Collections & Models

Note – MongoDB Antipatterns are followed in schema design

- Global Medicines
  - _id: ObjectId
  - name: String
  - strength: Number
  - brand: String
  - manufacturer: String
  - type: String (Prescription/Non-Prescription)
  - createdAt: DateTime
  - updatedAt: DateTime
- Medicines
  - global: {
    _id: ObjectId (reference to Global Medicine document),
    doc: GlobalMedicine.schema
    }
  - pharmacy: ObjectId (reference to Pharmacy document)
  - stockLevel: Number
  - unitPrice: Number
  - createdAt: DateTime
  - updatedAt: DateTime
- Pharmacies
  - _id: ObjectId

- Name: String
- registrationNumber: String
- address: String
- contactNumber: String
- email: String
- image: String (Firebase URL)
- location: {
  latitude: Number,
  longitude: Number
  }
- owner: {
  _id: ObjectId (reference to User document)
  }
- createdAt: DateTime
- updatedAt: DateTime

- Orders
  - _id: String
  - pharmacy: {
    _id: ObjectId (reference to Pharmacy document),
    name: String
    }
  - status: String (Pending/ Requires Customer Confirmation/ Confirmed, Cancelled, Completed)
  - Customer: {
    _id: ObjectId (reference to User document)
    }
  - prescriptionSheet: String (Firebase URL)
  - medicines: Array< {
    _id : ObjectId (reference to Medicine Document),
    globalMedicine: {
    _id : ObjectId (reference to Global Medicine Document)
    name: String
    }
    quantity: Number,
    availability: Boolean,
    subTotal: Number,
    suggestion: Object (if the medicine is unavailable, pharmacy suggestion data will be persisted here)
    } >
  - patient: {
    name: String,
    NIC: String,
    email: String,
    contactNumber: Sting
    }
  - delivery: {
    address: String
    location: {
    latitude: Number,
    longitude: Number
    }
    }
  - payment: {
    method: String (Card/Cash on Delivery),
    status: Boolean,
    subTotal: Number,
    total: Number,
    delivery: Number
    }
  - isHidden: Boolean
  - createdAt: DateTime
  - updatedAt: DateTime
- Users
  - firstName: String
  - lastName: String
  - NIC: String
  - address: String
  - mobile: String
  - email: String
  - birthday: String
  - role: String (Customer/Pharmacy Owner/Admin)
  - pharmacies: Array< {
    _id: ObjectId (reference to Pharmacy document)
    name: String
    } >
  - createdAt: DateTime
  - updatedAt: DateTime
- Auths
  - _id: String
  - password: String (Encrypted)
  - user: {
    _id: ObjectId (reference to the user document)
    }
  - createdAt: DateTime
  - updatedAt: DateTime

As the cloud storage solution, firebase cloud storage is used. Firebase is a BaaS (Backend-as-a-Service). It provides functionalities such as Realtime database, firebase cloud messaging, firebase cloud storage. Firebase cloud storage is preferred here because of its simplicity.

B. Minimum Client-Side Resource Requirements

- OS – Any OS with web browser support
- CPU – Intel Pentium 4
- RAM – 2GB
- HDD – 20GB
- Display – 1024 x 768 Resolution

C. Minimum Server-Side Resource Requirements

- OS – Ubuntu LTS

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- CPU – Intel Xeon 5600 Series
- RAM – 2GB
- HDD – 20GB

To authenticate user with the server JWT token authentication is used. It is used as a solution to resolve the hassle of maintaining user sessions in the backend. In addition, user passwords are encrypted before saving.

Online payments are processed through Stripe payment gateway. Instead of Stripe custom payment flow, prebuilt checkout pages are preferred to aid rapid development. Stripe webhook events are used to receive payment confirmation events which backend uses to confirm approved orders. As soon as a payment intent gets succeeded, stripe servers will call the webhook endpoint to notice the backend.

To get user location i.e., latitude & longitude google map API is used with the help of react-google-maps/api package (Version 2.13.1).

To calculate the distance between the user and the pharmacy the Haversine formula (1) is used [9].

$$dlon = lon2 - lon1 \quad (1)$$

$$dlat = lat2 - lat1$$

$$a = (sin(dlat/2))\text{^}2 + cos(lat1) * cos(lat2) * (sin(dlon/2))\text{^}2$$

$$c = 2 * atan2(sqrt(a), sqrt(1-a))$$

$$d = R * c$$

Where,
lon1 = longitude of location 1
lat1 = latitude of location 1
lon2 = longitude of location 2
lat2 = latitude of location 2
R = radius of the earth
c = great circle distance in radians
d = distance between the given points

Git is used for version controlling & all repositories are hosted in GitHub. For project management, Microsoft Azure Boards is used. In addition to that the quality of the code is validated through SonarQube and Quality assurance testing is done using Selenium IDE.

IV. PROPOSED SYSTEM

The proposed system consists of 2 web applications. A separate web application for customers. An admin dashboard for admins (i.e., Ministry of Health) and pharmacy owners. Customer app facilitates customers to place orders, view orders, find pharmacies etc. Admin dashboard facilitates features for pharmacy management, global medicine management, order management, payment management, stock management etc.

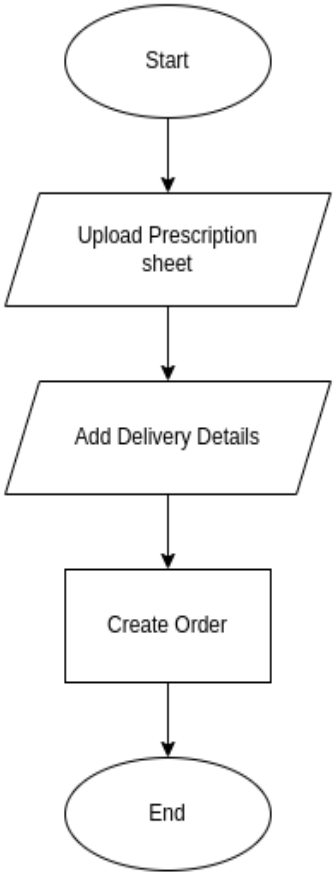

Figure 2: Flow chart - Place order

When a user places an order by uploading the prescription sheet to a selected pharmacy. Selected delivery location is also saved alongside with other details such as name, age, address, and contact number (Figure 2). The order will be available to be approved in the orders view.

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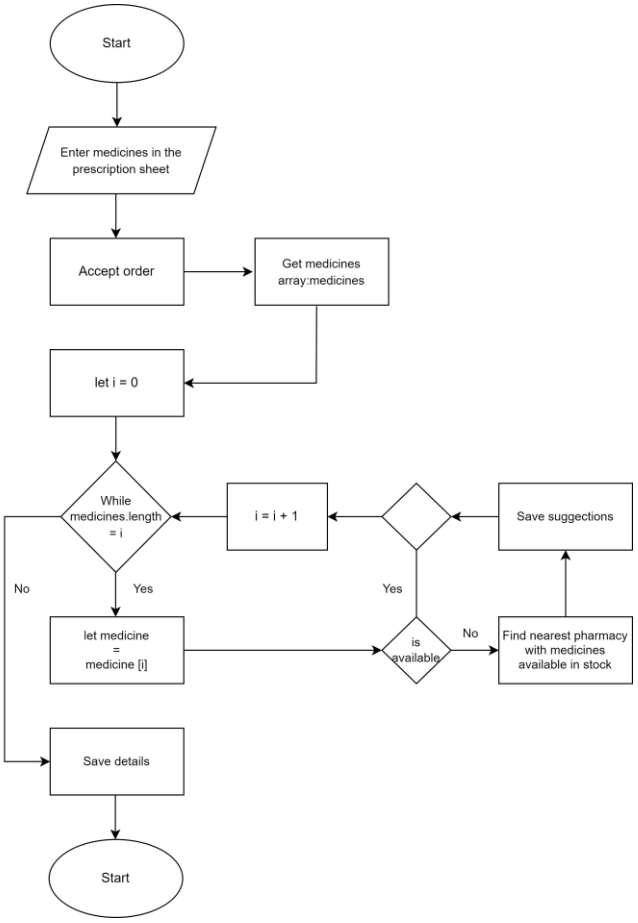

Figure 3: Flow chart - Accept order

The pharmacy employee who is processing order should read the prescription sheet mark the medicines available in the prescription disregarding the fact that the medicine is available in stock or not. For all the medicines that are available, an order will be created by the backend with status accepted. For all the unavailable medicines, the backend will find closest pharmacies nearest to the delivery location and append them to the created order with the distance to the pharmacy from the delivery location as suggestions.

The algorithm uses the Haversine formula [9] for this calculation. If none of the medicines are available, the order will be cancelled but even then, pharmacy suggestions will be appended to the order. After that process is complete, the owner of the order can then review the order to decide whether to approve the order or cancel it. Pharmacy suggestions could be used to order unavailable medicines from suggested pharmacies.

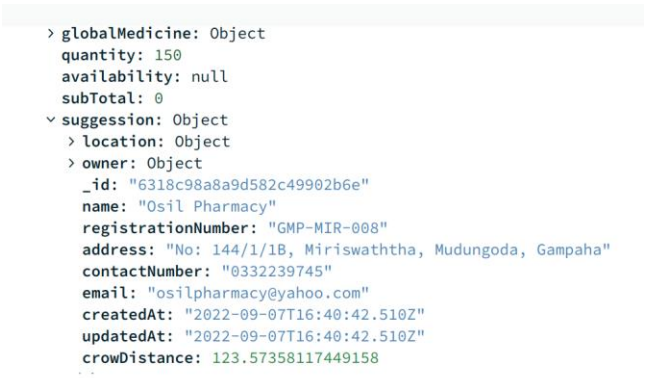

Figure 4: Pharmacy suggested through the algorithm

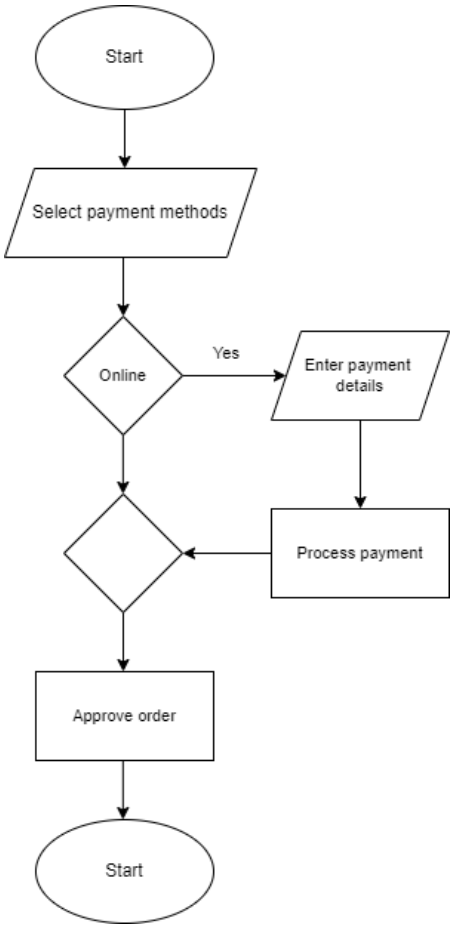

Figure 5: Flow chart - Approve order.

To approve the accepted order, the owner must select the payment method and process further. This solves the hassle of patients having to go through to find rare medicines. In addition to just solving the issue, the system facilities user with required information to know from which pharmacies they can get the medicine as fast as possible.

A. Global Medicines

Pharmacy suggestion algorithm requires all the pharmacies in the system to store medicines under a global identifier. If a medicine is not available in a pharmacy, algorithm uses this global medicine identifier referenced in each medicine document to find pharmacies with that medicine available.

B. Pharmacy

Pharmacy owner should register their pharmacies in the system to receive orders. It is also crucial to add the location of the pharmacy using the Google map provided. Pharmacy suggestion algorithm uses this location to map pharmacies nearest to the delivery location of the owner of the order. In addition, Only the pharmacy owners of the pharmacy will be given with access to mutate resources related to the pharmacy.

C. Medicine

Each pharmacy should record medicines available in their stock with reference to global medicine of each medicine with stock level & unit price. Pharmacy suggestion algorithm users this data to find if the medicine is available in the pharmacy or not.

D. Orders

Orders are initially placed by customers by uploading their prescription sheets. Pharmacy suggestion algorithm is initialized only if there is at least one medicine unavailable in the selected pharmacy after the pharmacy employee accepts the order by adding medicines in the prescription sheet to the order.

V. DISCUSSION

The main outcome of this research is to find a proper solution to assist patients to find exactly where to buy medicines which are rarer to find. Managing medicines across all the pharmacies with a global identifier supports the system to find medicine availability in each pharmacy. In addition to that, the system uses Haversine formula [9] with quicksort as the sorting algorithm to sort the pharmacies by the delivery location which is crucial in giving user the most relevant and efficient results.

The proposed solution supports the research work done by J.K.T.S. Perera [5] and in addition to that, the main challenge in finding medicines is addressed. The research done by Ganeshan Subramanian, et al. [4] highlights the use of IOT devices to assure the quality of the medicines and further research is required regarding this. In addition to methodologies provided in research done by D. D. Udugampola [6], this research focuses more on the main research problem. Although, the current research supports the functionality for inventory control elaborated in the research done by Asan Baker Kanbar, et al. [7] and the research done by Madhavi Mali, et al. [8] , the proposed solution in this research does not provide a functionality to alert pharmacy owners when,

- Medicine batches reach the expiration date
- Medicines reach the defined stock threshold.

Further research is required regarding this matter.

In addition to that the authentication procedure should be upgraded to OAuth 2.0 to increase the security further in the near future. Furthermore, computer vision and artificial intelligence should be used in reading prescription sheets to allow system to analyze orders without requiring manual work.

Each module is thoroughly tested by applying automation testing scripts using Selenium IDE. For further testing, load and stability testing, performance testing, security testing, scalability testing could be used.

VI. CONCLUSION

As medicinal supplies are shortening [1] rapidly due to the financial crisis in Sri Lanka [2], patients are having difficulties in finding medications they require in most of the pharmacies. Although most of the e pharmacy platforms allow patients to order medicines online, they do not provide functionalities know if the medicine is available or not. Because of this, current e pharmacy platforms cannot directly address the problem. Getting the medicines to be ordered directly from the user is not practical as majority of the patients do not possess the ability to read prescription sheets. Even with the approach of uploading the prescription sheet, patients must wait until the pharmacy reviews the prescription sheet and report that some medicines are not available to try another platform. In addition to that the pharmacy could even be far away from the delivery location. The newly proposed solution solves majority of the issues existing in the current researches. The pharmacies are sorted by the patient's delivery location. Patients could use these sorted results to place orders by uploading prescription sheets. Orders will be processed by the pharmacy owner and the system will give suggestion on where to buy unavailable medicine by taking the user location into consideration. Future research must be put into using IOT devices to keep track of the medicines and in addition, it is also required to research on inventory alert systems as well to keep track of medicine expirations, etc. [7] [8] Furthermore, it is also required to research on the usage of computer vision and artificial intelligence in reading prescription sheets.

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