Vydhya

Software Design

CSCI-P465/565 (Software Engineering I)

Project Team

<Bhanu Prakash Reddy Gaddam>

<Jake Sturgill>

<Janmejay Purohit>

<Keerthana Sugasi>

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1. Introduction

We have implemented a object oriented design approach for this sprint, in which the sprint task works around the enitity and their characteristics. This design strategies focuses on entities and its characteristics, class, abstraction and encapsulation around those entities.
The system is divided into smaller working solutions or components. Each component is treated as sub-system and further decomposed. when all the components are put together, it forms the whole working ssystem or application.

1.1 System Description

Vydhya is a Patient and Health insurance Management system which acts as a one stop solution for all the needs of doctors, Patients and Insurance providers. This is an effort to bring together all the needs of the three stakeholders and provide services for easy and best management of healthcare systems.

The application serves three different types of users.

1. Doctors
2. Patients
3. Insurance Providers

Functionalities of the system includes:

- The patients should be able to search or filter doctors and book appointments.
- The patients should be able to select health insurance plans and the application helps in providing best recommendations based on patients medical history.
- The patients should able to update their health records and view insurance details
- The doctors should be able to view patient history and appointment schedules
- The insurance providers should be able to provide best plans based on patients health records

- The doctors should be able to extend Covid-19 support to the patients and help track the cases and bed availability
- All the three stakeholders should be able communicate among themselves through chat option

For the first sprint we will be developing the User Registration and Login

1.2 Design Evolution

1.2.1 Design Issues

No system design issues were encountered as the application is planned to built on open-source softwares and the application is divided into Backend and Frontend parts separating the User Interface and business logic. As we get into deeper implementation we might start facing issues when the needs and design evolve. The key considerations in this design is to remain open-source friendly and cloud-native.

1.2.2 Candidate Design Solutions

Below are few of the design solutions:

- One of the design solutions we had come up was to adapt **Monolith Architecture Design** where all the major functionalities or components are unified into a single application. So there would a single database and different view templates for each stakeholder. The application is deployed in a server where it is accessed using REST APIs and a frontend template is created which consumes these APIs.

- Another approach was to adapt **Microservice Architecture** design. Microservice Architecture is an method that relies on a series of independent deployable services.Our application can be divided into 3 major services or components, one for each stakeholder. These services have their own business logic and database with a specific goal. Updating, testing, deployment, and scaling occur within each service. Also secure communication through appropriate protocols among the microservices needs to be established.

1.2.3 Design Solution Rationale

Based on the requirements of the business and application, the team selected with following design solution for the following reasons:

- If the application can be divided into microservices then there is need to maintain different databases for each service. But it would be a costly affair to maintain the infratructure for 3 components and maintain same information in the three databases. Since same data needs to be used to communicate among the three services, using different databases would be expensive and unnescesary.
- We would be separating the application into backend and frontend layers since the application is going to be data heavy. Backend layers implement the business and provide REST api for

the frontend. Frontend layer is separately hosted on a server which serves the requests from the users and requests appropriate API for data.
- Monolith applications are easy to debug and maintain as it is deployed as single application.

Based on the business requirements and necessity for quick delivery, the team decided to go with monolithic application with components under the same umbrella. While keeping in mind the growing business needs and if future requirements might ask for individual component scaling. Hence we have decided to go with what we call as **Microservice Ready Architecture** in which each of the three components are modularized in a way that when business need arises, the application can be converted into a microservice architecture with very minimal changes.

1.3 Design Approach

1.3.1 Methods

The application is heavy object oriented in a way that it is divided into classes and objects. The principles of OOP such as abstraction and encapsulation is followed by grouping the related service and data together.This method also helped us integrate different functionalities in a simpler manner.

1.3.2 Standards

- Naming Convention: All the classnames are in snake case and filenames follow sentence All the database names are in lowercase separated by underscores.
- Component hierarchy:The component hierarchy focuses on the component's scope of responsibility, creates meaningful relationships between components, encourages composability, and provides balance between flexibility and structure in our component library.
- Dependency injection: The basic idea is that if an object depends upon having an instance of some other object then the needed object is "injected" into the dependent object; for example, being passed a database connection as an argument to the constructor instead of creating one internally.

1.3.3 Tools

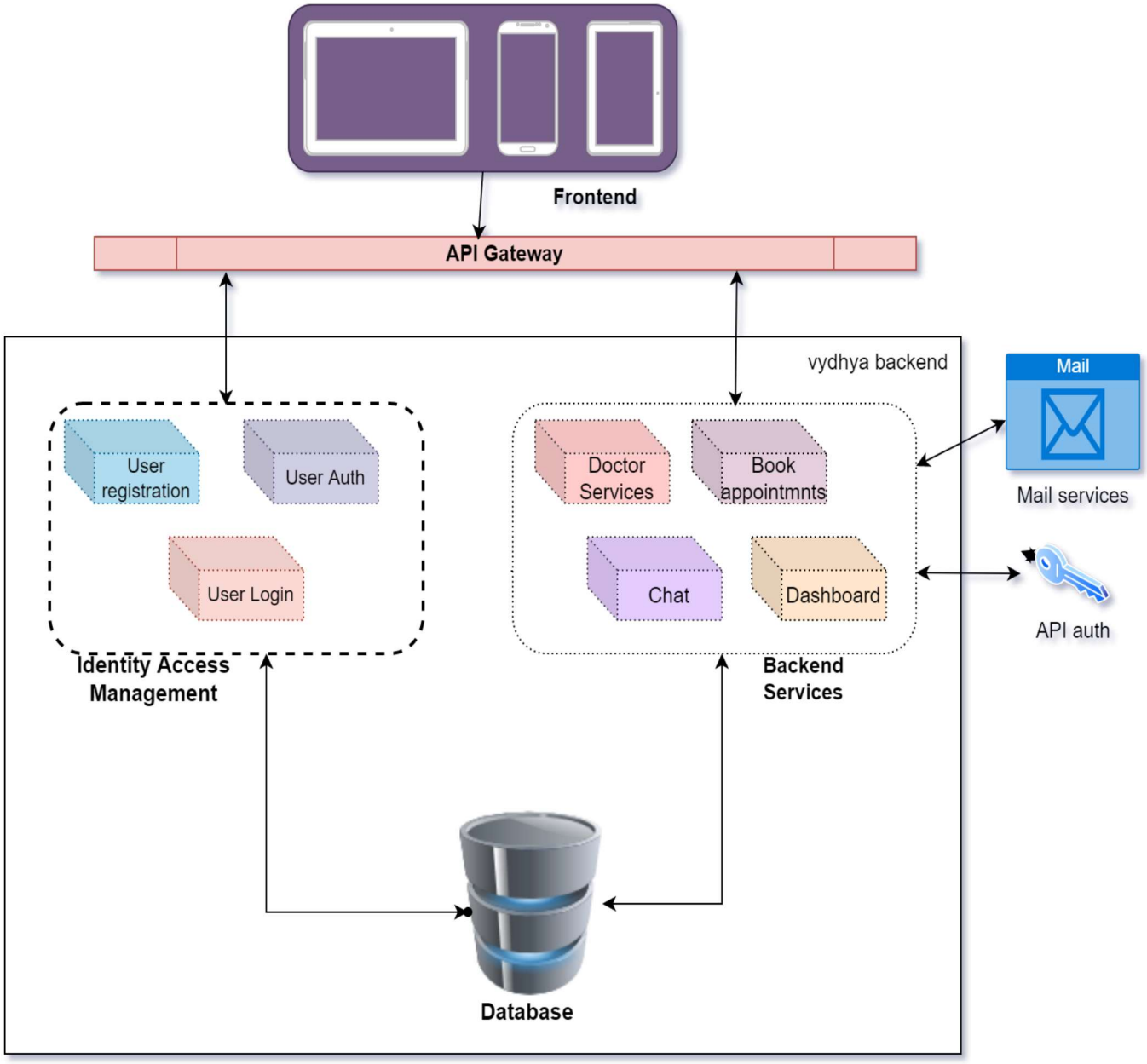
Tools that helped in design devlopment are tools like draw.io and wireframe designing tools which came in handy to visualize the workflows of the system.
Docker and Kuberenetes helped in autonomous development and delivery being enviroment agnostic and cloud agnostic.

2. System Architecture

2.1 System Design

The application follows object-oriented structure where the system is divided into components and developed separately as the sprint progresses.

High Level Design:



High Level data diagram

The high level diagram shows that there are three main components. Frontend, API Gateway and Backend. As shown in the image below the frontend serves requests from the users and passes it to API gateway wich authenticates the request and decides which component to route the user request.
The backend consists of the following components divided based on the business logic:

- Identity Access Management: This component includes the entities like User Registration, User Login after authentication, Reset Password and talks with database to insert and fetch the User Profile data.
- Database: A shared data for all the needs of the three stakeholders. It is important that the there is various inter-communication that happens between the services for each stakeholder.
- Backend Service: This includes a set of services and classes that part of the activities or flows for each stakeholders. these include Appointment Booking with Doctors, Search and filter doctors, book for insurance plans etc. All the activities are interlinked and developed in modular and extensible fashion such that future requirements can be added easily.

Going forward we might be adding more classes or components as the design evolves.

Technologies used:

- **Backend :**A python based framework FastAPI, Python
- **Frontend :**ReactJS, HTML, CSS
- **Databases :**Postgres
- **Hosting Environment :**Kubernetes hosted on Google Cloud Platform, Docker
- **External Integrations :**Google Oauth2, Chat, Github, JIRA, Confluence

2.2 External Interfaces

There are external systems that work in cooperation with our application.

1. **Google OAuth2 :** A external 2-step verfication for login is integrated with Google OAuth API which is a token based authentication based on the logged in user email. The Google API provides a JSON with JWT token which is used to autheticate the users as well as the APIs.
2. **Gmail Interface :** Interface with SMTP protocol to send auto generated system emails from the applicaton like password reset, reminder emails, appointment confirmation etc.
3. **Machine Learning healthcare recommendation engine:** A machine learning which suggests the best health care plans based on the patients medical history that is fetched from the database and the model performs a simple linear regression on the data to fetch the results.
4. **Docker :** Create docker image of the application and upload to DockerHub. Docker helps to encapsulate each of them in Docker containers. Docker containers are lightweight, resource isolated environments through which you can build, maintain, ship and deploy your application.
5. **Kubernetes :**Kuberenetes helps to orchestrate the docker containers and provide independent deployments that that automatically manages, scales, and deploys the containers. Though our application is not exactly microservice based architect, this was an attempt to make the application independent of the hosting platform and cloud agnostic.
6. **Google Cloud PLatform :** Cloud based hosting environment for the application. Appplication will be hosted on a linux engine with 16GB RAM and 8 core CPU.

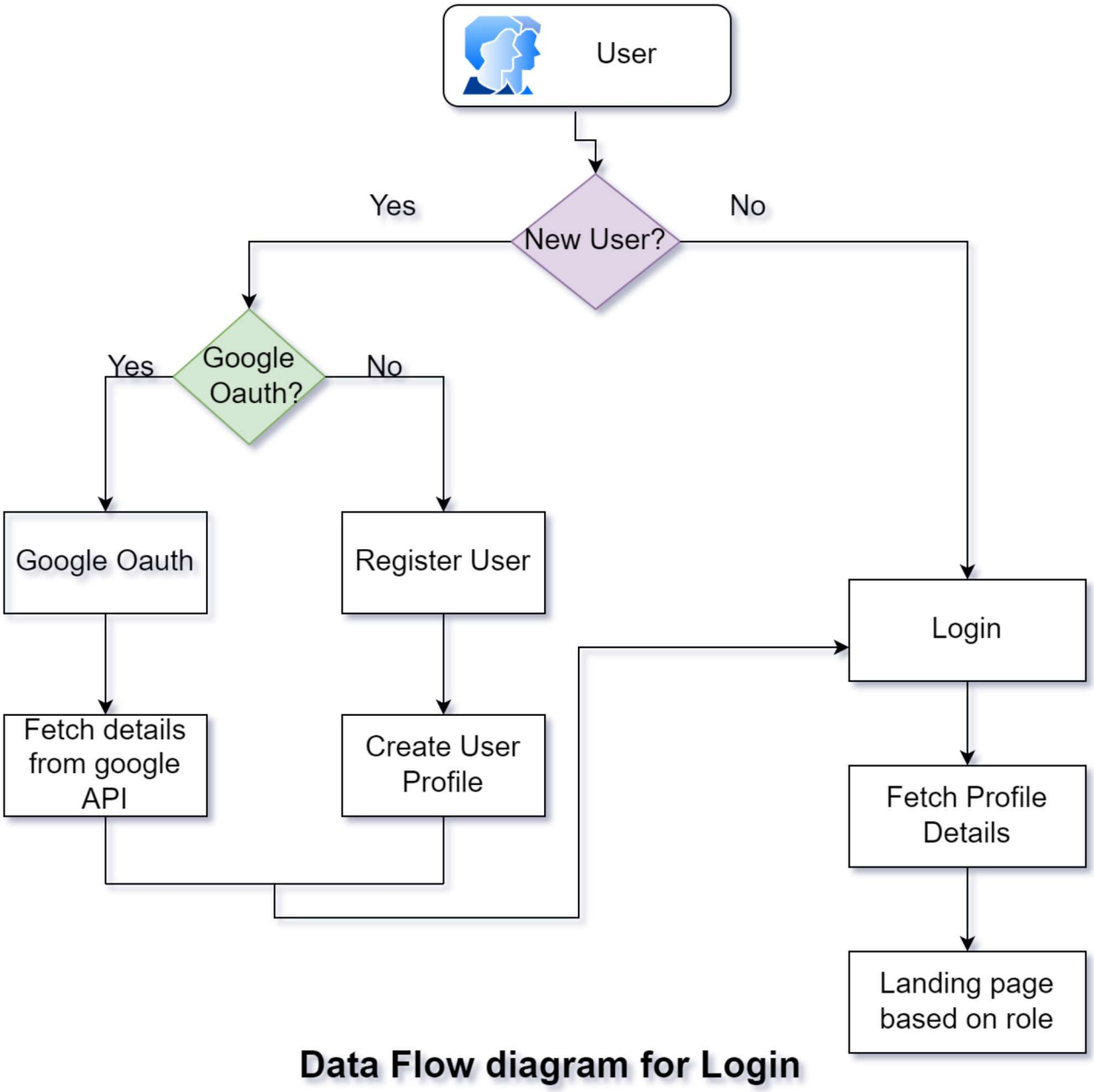
3. Component Design

- **Component Name**
  User Registration and Login
- **Component Description**
  There are two major components here:
  1. **User Registration:** The component is for new users. The registration page has a form which requests for details like username, password, Role and create an entry for that user in the database on clicking the submit button. In the backend, the username is an email id and is validated against Email Validation criteria. Also the password is stores as an hashed string in the database. Aftersuccesful registration user is redirected to login.
  2. **User Login:** This components allow authorized access to an registered user into the appli cation. The Login Page is a form which takes in Username and Password and compares it with the data in the database. If a matching user detail is found it logs the user into the system. Also user login maintains an authentication mechanism using JWT tokens to authenticate the user and API requests coming from frontend.

- **Responsible Development Team Member**

  Backend and Database : Keerthana and Bhanu Prakash
  Frontend : Jake and Janmejay

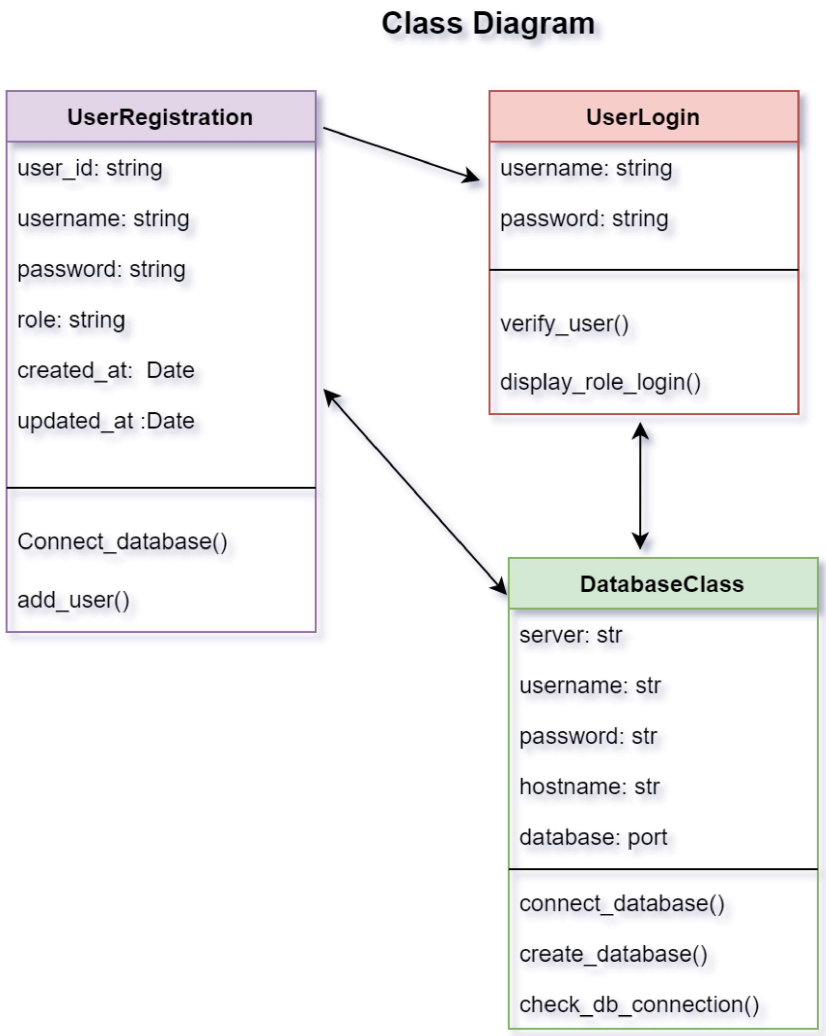
- **Component Diagram**



Data Flow diagram for Login

- **Component User Interface**
  The UI has 2 pages:
  - The UI is designed as a React component. User Registration page is opened when user click on New user option in the login. it directs to a form where certain details are collected and submitted to backend.
  - Another page is Login Page where the user enters the username and password. On authentication the user is permitted into the system. The landing page view is decided based on the role of the user.

- **Component Objects**

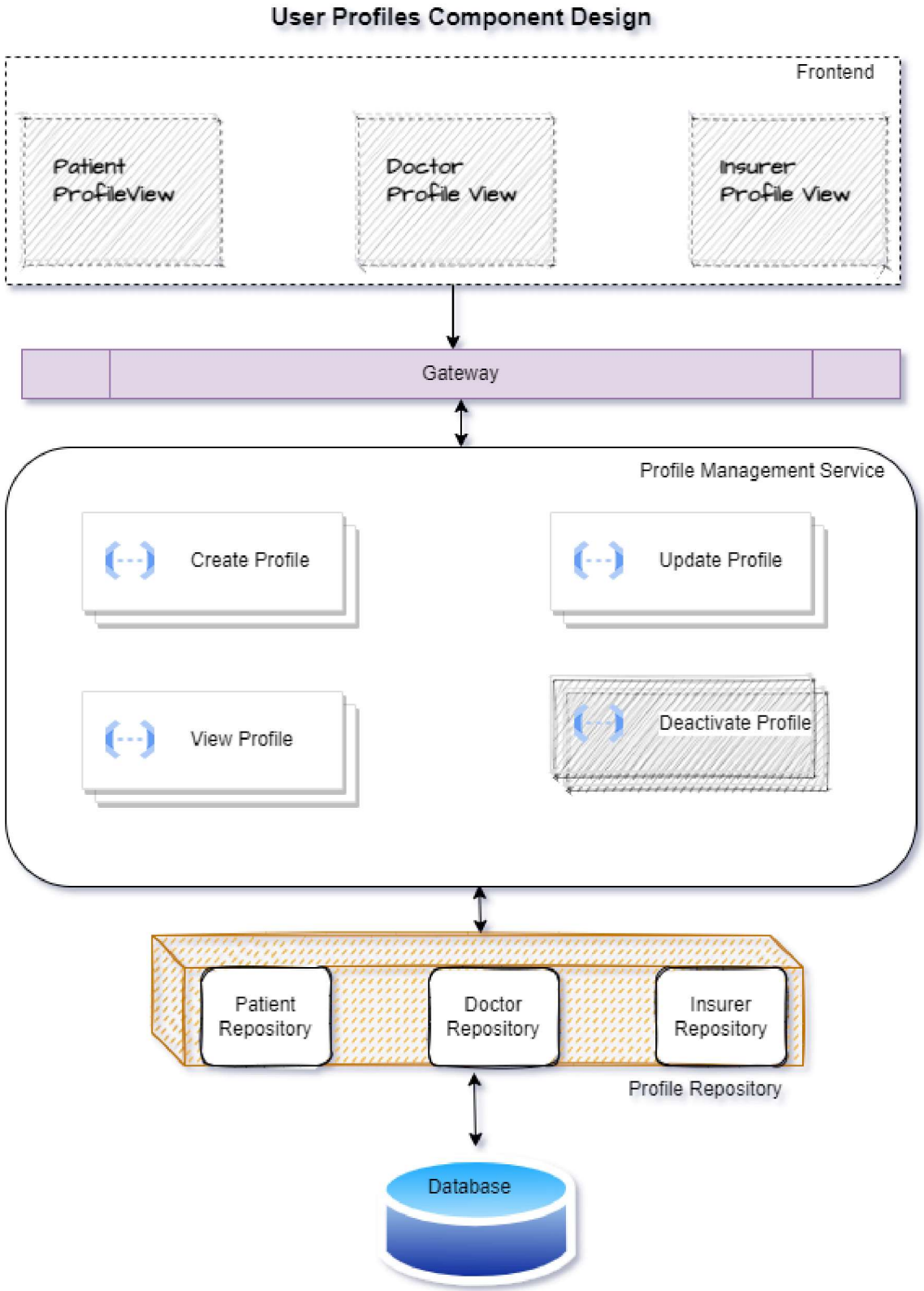


- **Component Interfaces (internal and external)**
  There is no external interfaces for this module as of now. Going forward we are planning on adding an OAuth2 login using Google OAuth2 APIs.
- **Component Error Handling**

  1. User Registration:
     - Error Case 1: User registration Failed: Missing data or values
     - Error Case 2: Invalid Email / username : Format of email is invalid
     - Error Case 3: User already exists: Creating duplicate username
     - Error Case 4: Empty field: Missing required data
  2. User Login:
     - Error Case 1: Login Failed : Invalid Username or password
     - Error Case 2: Login Failed : User doesnt exist
     - Error Case 4: Empty field: Missing required data

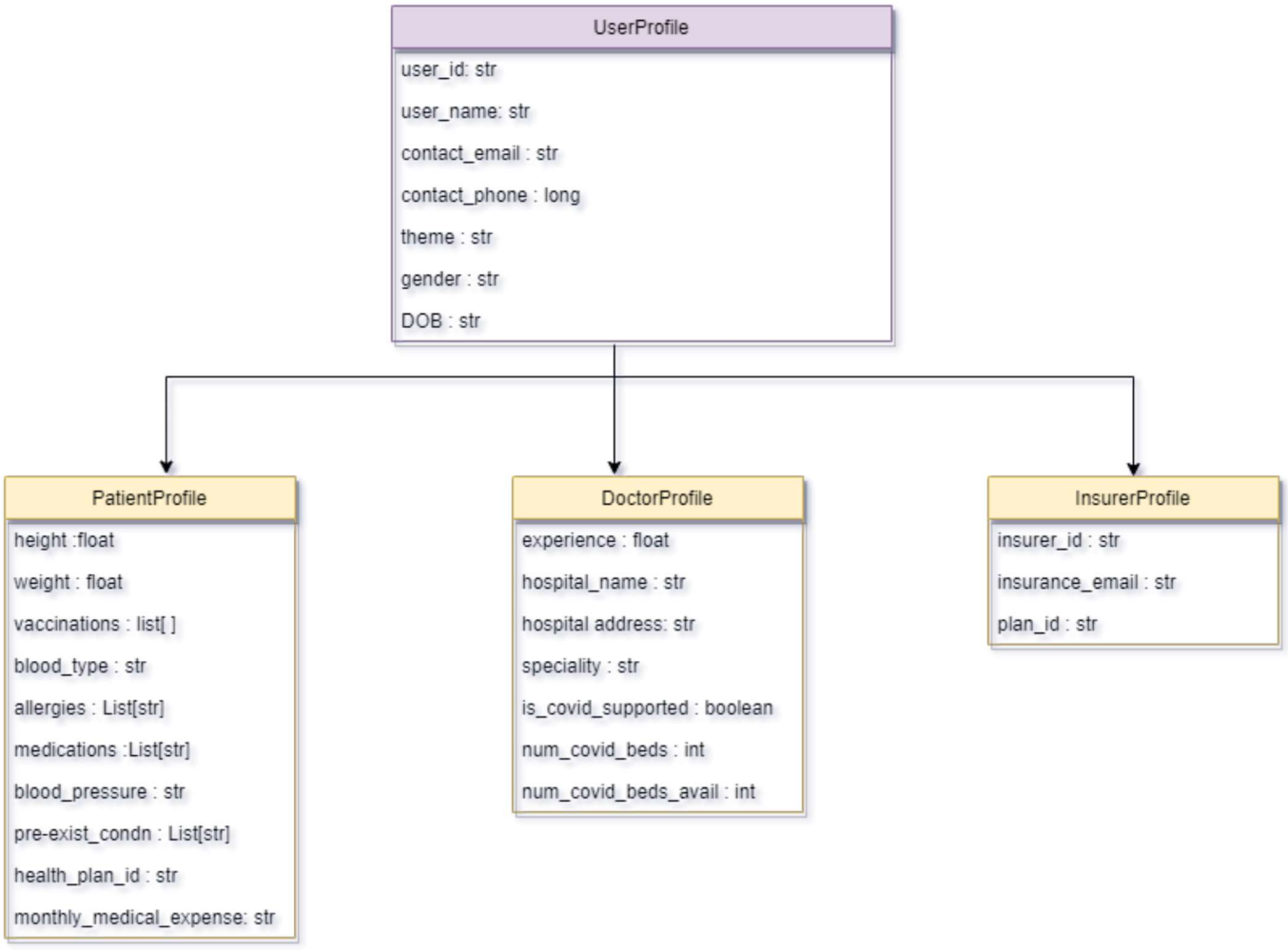
- **Component Name**
  User Profiles Management
- **Component Description**
  This component is supposed to do the following functionalities:
  1. Create user profiles based on user_roles -> update the user profiles based on the user_id and user_role using user registration and login.
  2. View the user profiles requested using user_id and profile
  3. Update the user profiles based on role.

- **Responsible Development Team Member**
  Frontend : Jake Strugill Backend : Keerthana Sugasi
- **Component Diagram**



- **Component User Interface**
  This component has a user interface which has option to view user profile in modal. Also an edit option is provided which is a form which allows the fields to be edited. Also this existed as a common interface for all 3 user dashboards.

- **Component Objects**
  Class Diagram:



Profile Class Diagram

Tasks for create profile:

- Created a model to update the common details using details obtained from login registration
- Implemented a funcion to insert into appropriate user tables based on the role provided in the user registration service.

Tasks for View Profile:

- created necessary data models for 3 user roles: doctor, patient and insurer.
- created a data repository for the above models to interact with the database tables for respective roles.
- created a profile service which retrieves the profile data based on userid and user role
- Return the results in the decided response format

Request URL:
https://vydhya-api.herokuapp.com/profile?user_id=patient_1&user_role=patient
Response Body:


```
{
  "status": 200,
  "error": null,
  "data": {
    "patient": {
      "user_id": "patient_1",
      "contact_email": "user@example.com",
      "theme": "primary",
      "gender": null,
```

```
        "dob": null,
        "height": null,
        "weight": null,
        "vaccinations": null,
        "blood_type": null,
        "allergies": null,
        "medications": null,
        "blood_pressure": null,
        "preexist_conditions": null,
        "health_plan_id": null,
        "monthly_medical_expense": null
      },
      "doctor": null,
      "insurer": null
    }
}
```

Tasks for Update Profile:

- created necessary data models for 3 user roles: doctor, patient and insurer.
- created a data repository for the above models to interact with the database tables for respective roles.
- created a profile service which parses the request body and updates the data with the new or modified information only. It filters out the empty data from the request body.
- Make a POST call to the function above.
- Return the results in the decided response format

Sample Request URL:
POST: https://vydhya-api.herokuapp.com/profile?user_id=patient_1&user_role=patient
Sample Request Body:

```
{
  "patient": {
    "contact_email": "string",
    "theme": "string",
    "gender": "string",
    "dob": "string",
    "height": 0,
    "weight": 0,
    "vaccinations": [
      "string"
    ],
    "blood_type": "string",
    "allergies": [
      "string"
    ],
    "medications": [
      "string"
    ],
    "blood_pressure": "string",
    "preexist_conditions": [
      "string"
    ],
    "health_plan_id": "string",
    "monthly_medical_expense": "string"
  }
}
```

Sample Response Body:

```
{
  "status": 200,
  "error": null,
  "data": {
    "patient": {
      "user_id": "patient_1",
      "contact_email": "string",
      "theme": "string",
      "gender": "string",
      "dob": "string",
      "height": 0,
      "weight": 0,
      "vaccinations": [
        "string"
      ],
      "blood_type": "string",
      "allergies": [
        "string"
      ],
      "medications": [
        "string"
      ],
      "blood_pressure": "string",
      "preexist_conditions": [
        "string"
      ],
      "health_plan_id": "string",
      "monthly_medical_expense": "string"
    },
    "doctor": null,
    "insurer": null
  }
}
```


- **Component Interfaces (internal and external)**
  This component is interfaced with the following services:
  - Database Postgres running on Kunbernetes in Google Cloud Platform
  - Swagger UI for API documentation
  - Heroku for hosting
    This component is in-house built and does not use any external 3rd party functionality or integrations.
- **Component Error Handling**
  The services in the component will raise appropriate HTTP error responses if any unnatural behavior is encountered.
  1. **Error 1: Invalid User_id**
     The error response format:


     ```
     {
         "status": 500,
         "error": "error while authenticating user patient_: unable to find user patient_",
         "data": null
     }
     ```


  2. **Error 2 : Invalid User Role**

     The error response format:


     ```
     {
         "status": 500,
         "error": "unsupported user_role: patient_123",
     ```


```
    "data": null
}
```

3. **Error 3: Wrong fields in the Request Body**

   The error response format:

```
{
  "status": 500,
  "error": "field doesnt exists in request body : field_name",
  "data": null
}
```

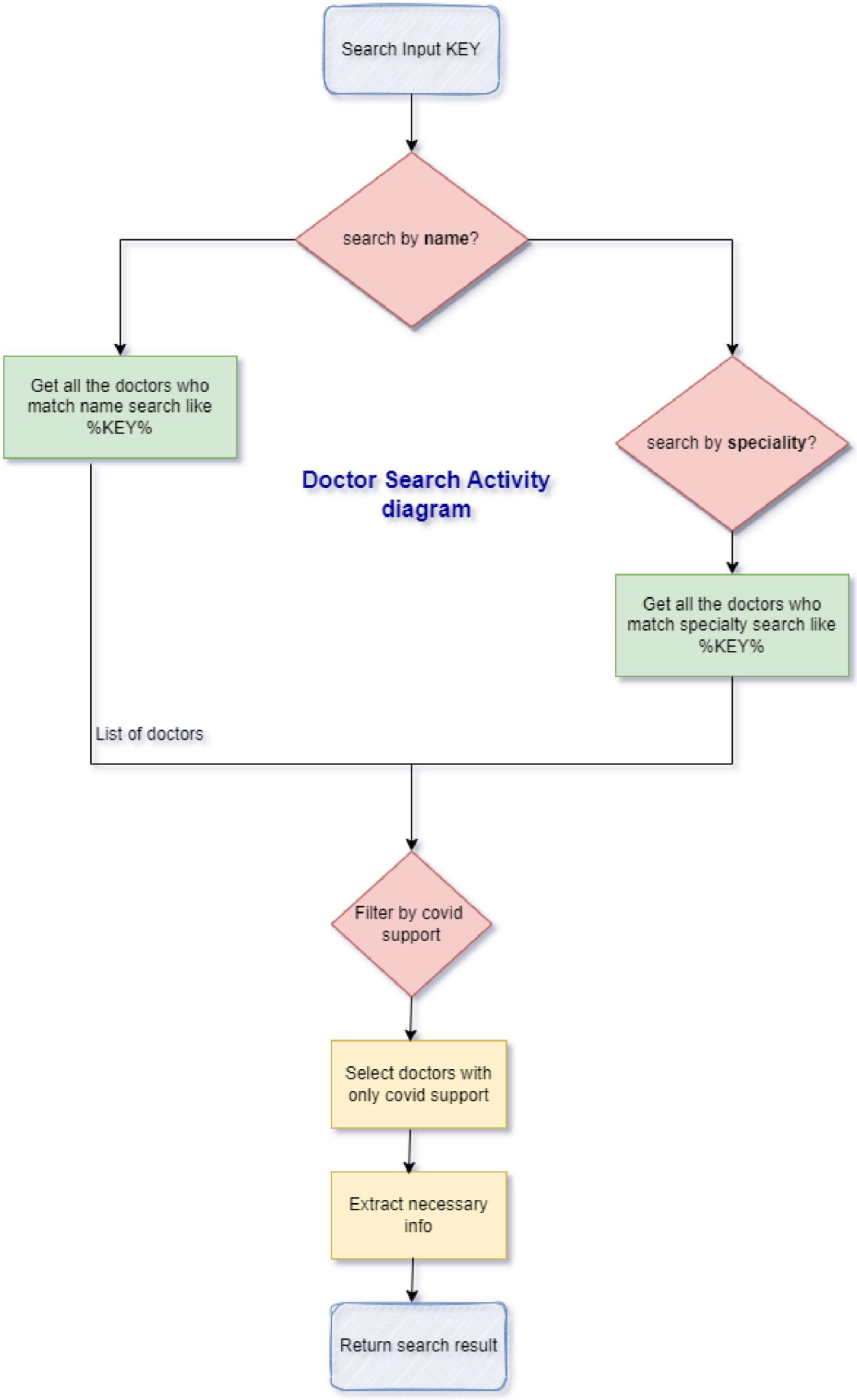
4. **Error 4: Datatype mismatch for updation of Profile**

   The error response format:

```
{
  "status": 500,
  "error": "Datatype mismatch for updation of Profile : field_name",
  "data": null
}
```

- **Component Name**
  Doctor Search and Filter
- **Component Description**
  Doctor Search API
  1. Implemented search for doctors based on speciality and doctor name criteria
  2. Filters the result of the above search with covid support
  3. Return list of doctors' profiles and number of doctor profiles returned as a response
- **Responsible Development Team Member**
  Frontend: Janmejay Purohit
  Backend: Keerthana Sugasi

- **Component Diagram**



- **Component User Interface**
  This component has an User Interface which is a react hook. In the UI there will be a search bar alongside a dropdown search criteria which is by default searches by name. Currently only 2 search criterias : Doctor name and speciality is supported. On selecting the criteria, and entering the search keyword we get a list of doctors whether they are covid supported or not. If the covid support is checked then the result is filtered only with doctors working in covid supported hospitals.
- **Component Objects**
  Tasks for Doctor search:
  - Created data models for doctorSearchRequest and DoctorSearchResponse
  - Make a POST call with request body of search_by, search_criteria and covid_support.
  - Created a function for searching doctors based on search criteria which retrives the data using LIKE behaviour in database.
  - Return the response in predicided format which is a list of doctor profiles and total number of doctors

  Sample Request URL:
  POST: https://vydhya-api.herokuapp.com/doctor/search
  Sample Request Body:

```
{
  "search_by": "speciality",
  "search_string": "cardio",
  "covid_support": false
}
```

  Sample Response Body:

```
{
  "status": 200,
  "error": null,
  "data": {
    "doctor_details": [
      {
        "name": "Doctor2",
        "is_hosp_covid_supported": "0",
        "contact_email": "doctor2@iu.edu",
        "contact_phone": "435654",
        "experience": 5,
        "hospital_name": "abc hospitals",
        "hospital_address": "Bloomington Indiana",
        "speciality": "Cardiology",
        "insurance_accepted": "0",
        "gender": "Male"
      },
      {
        "name": "Doctor4",
        "is_hosp_covid_supported": "0",
        "contact_email": "doctor4@gmail.com",
        "contact_phone": "4356005413",
        "experience": 15,
        "hospital_name": "San Jose hospitals",
        "hospital_address": "San Jose, California",
        "speciality": "Interventional Cardiology",
        "insurance_accepted": "0",
        "gender": "Male"
      }
    ],
    "num_doctors": 2
  }
}
```

- **Component Interfaces (internal and external)**
  This component is interfaced with the following services:
  - Database Postgres running on Kunbernetes in Google Cloud Platform
  - Swagger UI for API documentation
  - Heroku for hosting

  This component is in-house built and does not use any external 3rd party functionality or integrations.
- **Component Error Handling**
  The services in the component will raise appropriate HTTP error responses if any unnatural behavior is encountered.
  1. **Error 1: Invalid Search Criteria**
     The error response format:

     ```
     {
             "status": 500,
             "error": "error while searching doctors: unsupported search filter: ame",
             "data": null
     }
     ```

  2. **Error 2: Wrong Search word/ query**
     The return response format:

     ```
     {
             "status": 200,
             "error": null,
             "data": {
               "doctor_details": [],
               "num_doctors": 0
     }
     ```

     Returns a empty list of doctors when any doctors profiles doesnt satisfy search criteria.

- **Component Name**
  Custom Dashboards
- **Component Description**
  1. The patients should have access to the doctorâ€™s profile and feedback that the doctor has received from other patients, so they can make an informed decision.
  2. Feedback can be rated in terms of stars or numbers and personal opinions i.e. written reviews.Users should have the option to provide feedback to the doctors whom they visited.
  3. Doctors that work in hospitals supporting COVID-19 patient care should have the provision to see if there are beds available to admit a patient who has tested positive for COVID-19 and is in a critical condition

  This section will be updated in the upcoming sprints

- **Component Name**
  Recommendation and Statistics
- **Component Description**
  1. The insurance providers should have the option to provide various insurance packages to the patients
  2. A default package for general patients. More advanced packages for patients spending more than usual on medical expenses.
  3. Machine learning can be used to provide recommendations to the users based on their past data.
  4. Patients should be able to subscribe to an insurance provider that would inform the patient about new/discounted insurance packages as the insurance provider publishes.

  This section will be updated in the upcoming sprints

- **Component Name**
  Chat
- **Component Description**
  1. The patients can chat with any insurance provider to get details about the insurance plan.
  2. There should be an option for group chat between all doctors.
  3. The chat should have the following features:
     i. Private chat feature
     ii. Online/offline status.
     iii. Message status, delivered/undelivered.
     iv. Display â€œtypingâ€ when the other user is typing

  This section will be updated in the upcoming sprints

Revision History

Revision	Date	Change Description
User Login Component	10/18/2022	Added Reset Password functionality
Profile Management	10/18/2022	Added create, view and update user profiles for all 3 user roles
Doctor Search	10/18/2022	Feature to search the doctors based on speciality and name. Filtered out based on Covid support by doctor and hospital.

Page Author/Creator: Keerthana Sugasi

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