**BOOK A DOCTOR USING MERN**

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Project Overview

The "Book a Doctor Appointment" system is a comprehensive web application designed to simplify the process of booking medical consultations. Leveraging the MERN stack (MongoDB, Express.js, React.js, and Node.js), this project aims to provide an efficient, user-friendly platform for patients and doctors to connect.

**Features**

* **User Registration & Login**: Secure account creation and authentication.
* **Doctor Profiles**: Detailed profiles for doctors including specialties, availability, and contact information.
* **Appointment Booking**: Users can book, view, reschedule, or cancel appointments.
* **Notification System**: Email notifications for appointment confirmations and reminders.
* **Search Functionality**: Users can search for doctors based on specialty, location, and availability.

Purpose

The purpose of this project is to create a web application that streamlines the process of booking doctor appointments. The key goals are to provide an intuitive user experience, ensure security and privacy of user data, and facilitate easy management of appointments.

The purpose includes:

1. **Simplifying Appointment Scheduling**: Users can easily search for doctors based on specialty, availability, and location, and book appointments without the need for physical visits or lengthy calls.
2. **Enhancing Accessibility**: Patients can access healthcare services 24/7 from anywhere, reducing delays in care.
3. **Improving Operational Efficiency**: Doctors can manage their schedules, track patient appointments, and reduce last-minute no-shows through automated reminders.
4. **Facilitating Patient-Doctor Interaction**: Through an intuitive user interface, patients and doctors can exchange information, reducing miscommunication.

The project is tailored to provide a seamless digital solution that is easy to navigate and supports users at every step of their healthcare journey.

**Features**

The "Book a Doctor Appointment" application comes with a range of robust features to cater to patients, doctors, and administrators:

1. **User Registration and Login**
   * Patients and doctors can register with their credentials, with doctors requiring additional verification.
   * Secure login using JWT-based authentication.
2. **Search and Filter**
   * Patients can search for doctors based on filters like specialization, availability, location, and ratings.
3. **Appointment Booking**
   * Patients can view available slots and book, reschedule, or cancel appointments.
   * Doctors can accept or decline appointments.
4. **Doctor Dashboard**
   * Doctors can manage their schedules, view patient lists, and access appointment details.
5. **Patient Dashboard**
   * Patients can track upcoming and past appointments and view doctor profiles.
6. **Admin Dashboard**
   * Manage the user database, verify doctor profiles, and oversee appointments.
7. **Real-Time Notifications**
   * Automated email/SMS notifications for booking confirmations, reminders, and updates.
8. **Responsive UI**
   * Mobile-first design to ensure usability on different devices.
9. **Feedback and Ratings**
   * Patients can rate their experience with doctors to improve service quality.
10. **Scalability and Extensibility**

* Designed for scalability to accommodate new features, such as payment gateways and teleconsultation, in the future.

**ARCHITECTURE**

The architecture of the application is designed using the MERN stack, which consists of MongoDB, Express.js, React, and Node.js. This stack enables a seamless flow of data and ensures scalability, responsiveness, and ease of maintenance**.**

1. Frontend Architecture (React)

The frontend is responsible for delivering an interactive and responsive user interface. It includes the following key elements:

* Component-Based Structure:  
  React leverages reusable components such as Navbar, Footer, Doctor Card, and Appointment Form, enabling modular development and code reusability.
* State Management:
  + Redux or Context API: Handles global state management for user authentication, appointment data, and notifications.
  + Local State: Managed within components for UI-specific logic like modal visibility or form inputs.
* Routing:
  + React Router is used for navigation between pages, ensuring a single-page application experience.
  + Routes include:
    - /login – User authentication page.
    - /dashboard – Displays user-specific data (e.g., appointments, doctors list).
    - /book-appointment/:doctorId – Booking form for a selected doctor.
* UI Framework:
  + Material-UI or Bootstrap is used for pre-styled components and responsive design.
* API Integration:
  + Axios or Fetch API is used to communicate with the backend.
  + Handles token-based authentication for secure API Calls

2. Backend Architecture (Node.js and Express.js)

The backend serves as the intermediary between the frontend and the database. It includes the following:

* RESTful API Design:  
  The backend exposes a series of RESTful endpoints for handling different resources:
  + Users: Authentication, registration, and profile management.
  + Doctors: Fetching available doctors, their schedules, and profiles.
  + Appointments: CRUD operations for appointments (create, read, update, delete).
* Middleware:
  + Authentication Middleware: Validates JWT tokens for protected routes.
  + Error Handling Middleware: Handles errors gracefully and sends appropriate responses.
  + CORS Middleware: Ensures cross-origin requests between the React frontend and Node.js backend.
* Request Validation:
  + Joi or Express Validator is used to validate incoming data for security and consistency.
* Scalability and Performance:
  + Cluster Mode: Utilized with PM2 to handle multiple requests efficiently.
  + Caching: Implemented with Redis for frequently accessed data like doctor lists.

3. Database Architecture (MongoDB)

MongoDB is chosen for its flexibility and scalability. The database design includes collections for users, doctors, and appointments.

**Collections and Schemas**:

* **Users**:

{

"name": "John Doe",

"email": "johndoe@example.com",

"password": "hashed\_password",

"role": "patient", // or "doctor"

"createdAt": "2024-01-01T10:00:00Z"

}

* **Doctors**:

{

"name": "Dr. Smith",

"specialization": "Cardiology",

"availability": ["2024-01-02T09:00:00Z", "2024-01-02T10:00:00Z"],

"location": "New York",

"rating": 4.5

}

* **Appointments**:

{

"doctorId": "doctor\_object\_id",

"userId": "user\_object\_id",

"date": "2024-01-02T10:00:00Z",

"status": "confirmed" // or "cancelled"

}

* **Relationships**:
  + One-to-Many: A doctor can have multiple appointments.
  + One-to-One: Each user profile is unique.
* **Indexes**:
  + Indexed on frequently queried fields like email for users and specialization for doctors to improve query performance.
* **Database Interactions**:
  + **Mongoose ORM** is used for schema validation and CRUD operations .

**4. Integration of the MERN Stack**

The application integrates all components of the MERN stack seamlessly:

1. **Frontend-to-Backend Communication**:
   * React makes HTTP requests to the Node.js backend via RESTful APIs.
   * JWT tokens are passed in the headers for authentication.
2. **Backend-to-Database Interaction**:
   * The backend uses Mongoose to interact with MongoDB for data storage and retrieval.
   * Database queries are optimized using aggregation pipelines for operations like filtering doctors by specialization or location.
3. **Data Flow**:
   * User actions (e.g., booking an appointment) are initiated in the frontend, sent to the backend, and stored in the MongoDB database.
   * Confirmation messages or errors are returned via the API and displayed on the UI.

**Frontend**

The frontend is developed using **React**. It includes reusable components, state management using React hooks, and routing with React Router. The UI is designed to be responsive and user-friendly.

**Backend**

The backend is built with **Node.js** and **Express.js**. It handles RESTful API requests, user authentication, and business logic. Middleware is used for request validation and error handling.

**Database**

The database is implemented using **MongoDB**. It consists of collections for users, doctors, and appointments. MongoDB’s flexible schema allows for efficient handling of user data and appointment details.

This architecture ensures the application is modular, scalable, and maintainable, providing a solid foundation for further enhancements.

**Setup Instructions**

**1. Prerequisites**

Before proceeding with the setup, ensure the following software and tools are installed on your system:

* **Node.js**: A runtime for running JavaScript on the server side. You can download it [here](https://nodejs.org/).
* **MongoDB**: A NoSQL database for storing application data. You can install MongoDB Community Server from [here](https://www.mongodb.com/try/download/community).
* **Git**: Version control system to clone and manage the project repository. Download it from [here](https://git-scm.com/).
* **Code Editor**: Use a code editor like [Visual Studio Code](https://code.visualstudio.com/) for development.
* **Package Manager**: npm comes bundled with Node.js, which you will use for dependency management.

**2. Cloning the Repository**

1. Open a terminal on your computer.
2. Clone the repository by running:

git clone https://github.com/username/book-doctor-appointment.git

1. Navigate into the project folder:

cd book-doctor-appointment

**3. Backend Setup**

1. Navigate to the server directory:

cd server

1. Install backend dependencies using npm:

npm install

Configure environment variables:

1. Create a .env file in the server directory.

Add the following variables:

PORT=5000

MONGO\_URI=your\_mongodb\_connection\_string

JWT\_SECRET=your\_secret\_key

 Replace your\_mongodb\_connection\_string with your MongoDB connection string.

 Replace your\_secret\_key with a randomly generated secret key for JWT

1. Start the backend server:

npm start

The server should start running at http://localhost:5000 by default (if PORT is set to 5000).2

**4. Frontend Setup**

1. Navigate to the client directory:

cd ../client

1. Install frontend dependencies using npm

npm install

Configure the .env file for the frontend:

1. Create a .env file in the client directory.

Add the following variables:

REACT\_APP\_API\_URL=http://localhost:5000

Replace http://localhost:5000 with your backend API URL if different.

1. Start the React development server:

npm start

The frontend will start running at http://localhost:3000 by default

1. Verify the Setup

Open your browser and navigate to http://localhost:3000.

Test the application by registering as a new user or logging in.

Check the backend server logs to confirm the API is communicating with the database.

**6. Optional Steps**

* **Using Docker (if applicable):**  
  If you prefer to use Docker for containerized deployment:
  + Ensure Docker is installed.
  + Create Dockerfile and docker-compose.yml for the frontend and backend services.
  + Run the following command to build and start services:

docker-compose up –build

**Seeding Initial Data:**  
To seed some initial data (e.g., doctor profiles):

* Create a script in the server folder to populate the database.
* Run the script using:

node seed.js

**7. Troubleshooting**

* **Issue:** Cannot connect to MongoDB.
  + **Solution:** Ensure MongoDB is running on your machine or your cloud instance (e.g., MongoDB Atlas) is accessible.
* **Issue:** Frontend or backend not starting.
  + **Solution:** Check for missing dependencies by running npm install in both client and server directories.
* **Issue:** API errors in the browser console.
  + **Solution:** Verify that the REACT\_APP\_API\_URL in the frontend .env matches your backend URL.

**Folder Structure**

**1. Root Directory**

The root directory contains essential files and subfolders for the entire project.

|  |  |
| --- | --- |
| File/Folder | Description |
| client/ | Contains the React-based frontend code. |
| server/ | Contains the Node.js and Express backend code. |
| .env | Stores environment variables (sensitive data like API keys, database URIs, etc.). |
| .gitignore | Specifies files and directories ignored by Git. |
| package.json | Metadata about the project, scripts, and dependencies for the root or backend. |
| README.md | |  | | --- | |  |  |  | | --- | | Documentation about the project setup and usage. | |

**2. Client Folder Structure (Frontend)**

The **client/** directory contains the React application.

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Description automatically generated

Example Structure:

A screenshot of a computer program

Description automatically generated

**3. Server Folder Structure (Backend)**

The **server/** directory contains the backend logic, including the API, database models, and middleware.

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Example Structure:

A screenshot of a computer program

Description automatically generated

**4. Key Folder Contents**

**Frontend: components/**

* **Header.js**: Navbar and header component.
* **Footer.js**: Footer section for all pages.
* **AppointmentCard.js**: Component to display booked appointment details.

**Frontend: pages/**

* **Login.js**: Handles user login and registration.
* **Dashboard.js**: Displays appointments and available doctors for logged-in users.
* **DoctorDetails.js**: Shows detailed information about a doctor.

**Backend: routes/**

* **userRoutes.js**: Handles user-related endpoints (e.g., login, register).
* **doctorRoutes.js**: Manages doctor-related operations (e.g., availability, profile updates).
* **appointmentRoutes.js**: Deals with booking, rescheduling, and canceling appointments.

**Backend: models/**

* **User.js**: Schema for user details (name, email, password, role).
* **Doctor.js**: Schema for doctor details (specialization, availability, location).
* **Appointment.js**: Schema for booking details (user, doctor, date, status).

**Backend: controllers/**

* **userController.js**: Implements user authentication and profile management.
* **doctorController.js**: Contains logic for fetching doctor details and availability.
* **appointmentController.js**: Handles booking and managing appointments.

**Backend: middleware/**

* **authMiddleware.js**: Validates JWT tokens for secure routes.
* **errorMiddleware.js**: Catches and handles API errors gracefully.

**Backend: utils/**

* **generateToken.js**: Generates JWT tokens for authentication.
* **sendEmail.js**: Utility function for sending email notifications.

**Running the Application**

The "Book a Doctor Appointment" application is divided into two main parts:

1. Frontend: Built with React.
2. Backend: Built with Node.js and Express.js.

Below are detailed steps to run both parts of the application locally:

Starting the Frontend

1. Navigate to the client directory:  
   Open your terminal and move to the client folder:

cd client

1. Install dependencies:  
   Ensure all required Node.js packages are installed by running:

npm install

1. Start the React development server:  
   Launch the frontend development server using:

npm start

1. Access the frontend:
   * Once the server is running, you can view the application in your web browser by navigating to:  
     http://localhost:3000
   * The React server typically runs on port 3000 by default.

Note:  
If port 3000 is already in use, you might be prompted to use another port. Confirm the prompt or manually specify an alternate port.

Here’s a detailed explanation of the **"Running the Application"** section for the "Book a Doctor Appointment" project:

**6. Running the Application**

The "Book a Doctor Appointment" application is divided into two main parts:

1. **Frontend**: Built with React.
2. **Backend**: Built with Node.js and Express.js.

Below are detailed steps to run both parts of the application locally:

**Starting the Frontend**

1. **Navigate to the client directory**:  
   Open your terminal and move to the client folder:

bash

Copy code

cd client

1. **Install dependencies**:  
   Ensure all required Node.js packages are installed by running:

bash

Copy code

npm install

1. **Start the React development server**:  
   Launch the frontend development server using:

bash

Copy code

npm start

1. **Access the frontend**:
   * Once the server is running, you can view the application in your web browser by navigating to:  
     http://localhost:3000
   * The React server typically runs on **port 3000** by default.

**Note**:  
If port 3000 is already in use, you might be prompted to use another port. Confirm the prompt or manually specify an alternate port.

**Starting the Backend**

1. **Navigate to the server directory**:  
   Open a new terminal window or tab, and move to the server folder:

cd server

1. **Install dependencies**:  
   Ensure all backend dependencies are installed:

npm install

1. **Set up environment variables**:  
   Create a .env file in the server directory if it does not already exist. Add the following environment variables:

PORT=5000

MONGO\_URI=your\_mongodb\_connection\_string

JWT\_SECRET=your\_secret\_key

* + Replace your\_mongodb\_connection\_string with the MongoDB URI.
  + Replace your\_secret\_key with a secure secret key for JWT.

1. **Start the backend server**:  
   Run the server using:

npm start

1. **Access the backend**:
   * The backend server runs on **port 5000** by default.
   * APIs can be tested using tools like **Postman** or **Insomnia** at endpoints like:
     + http://localhost:5000/api/users

**Running Both Frontend and Backend Simultaneously**

1. Open **two separate terminal windows or tabs**.
2. Run the commands for starting the frontend and backend in their respective directories as described above.

**Connecting Frontend and Backend**

The frontend communicates with the backend via API calls. Ensure the backend server is running when testing features like login, doctor search, or appointment booking.

* The frontend will use the backend's API base URL, which can be configured in the React app's .env file (inside the client directory):

REACT\_APP\_API\_URL=http://localhost:5000/api

**Common Issues and Troubleshooting**

1. **Port Conflicts**:  
   If either the frontend (port 3000) or backend (port 5000) is unavailable, modify the .env file or use a different port during server startup.
2. **Database Connection Errors**:  
   Ensure MongoDB is running locally or your connection string to a cloud instance (like MongoDB Atlas) is correct.
3. **Environment Variables**:  
   Missing or incorrect values in the .env file can prevent the backend server from running. Double-check all required variables.

**Commands Recap**

* **Frontend**:

cd client

npm install

npm start

* **Backend**:

cd server

npm install

npm start

**API Documentation**

1. User Authentication and Authorization

1.1 Register a User

* Endpoint: /api/users/register
* Method: POST
* Description: Registers a new user (either patient or doctor).
* Request Body:

{

"name": "John Doe",

"email": "john.doe@example.com",

"password": "password123",

"role": "patient"

}

**Response:**

{

"message": "User registered successfully",

"user": {

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

}

}

**1.2 Login a User**

* **Endpoint:** /api/users/login
* **Method:** POST
* **Description:** Authenticates a user and returns a JWT token.
* **Request Body:**

{

"email": "john.doe@example.com",

"password": "password123"

}

Response:

{

"token": "eyJhbGciOiJIUzI1...",

"user": {

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

}

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{

"token": "eyJhbGciOiJIUzI1...",

"user": {

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

}

}

**1.3 Get Current User Details**

* **Endpoint:** /api/users/me
* **Method:** GET
* **Description:** Retrieves the currently authenticated user's details.
* **Headers:**

Authorization: Bearer <JWT Token>

Response:

{

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

}

**API Documentation**

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**1.1 Register a User**

* **Endpoint:** /api/users/register
* **Method:** POST
* **Description:** Registers a new user (either patient or doctor).
* **Request Body:**

json

Copy code

{

"name": "John Doe",

"email": "john.doe@example.com",

"password": "password123",

"role": "patient"

}

* **Response:**

json

Copy code

{

"message": "User registered successfully",

"user": {

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

}

}

**1.2 Login a User**

* **Endpoint:** /api/users/login
* **Method:** POST
* **Description:** Authenticates a user and returns a JWT token.
* **Request Body:**

{

"email": "john.doe@example.com",

"password": "password123"

}

* **Response:**

{

"token": "eyJhbGciOiJIUzI1...",

"user": {

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

}

}

**1.3 Get Current User Details**

* **Endpoint:** /api/users/me
* **Method:** GET
* **Description:** Retrieves the currently authenticated user's details.
* **Headers:**

plaintext

Copy code

Authorization: Bearer <JWT Token>

* **Response:**

json

Copy code

{

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

}

**2. Doctor Management**

**2.1 Get All Doctors**

* **Endpoint:** /api/doctors
* **Method:** GET
* **Description:** Fetches a list of all available doctors.
* **Response:**

[

{

"id": "987654321",

"name": "Dr. Smith",

"specialization": "Cardiologist",

"availability": ["2024-11-18T10:00", "2024-11-18T11:00"],

"location": "New York"

},

{

"id": "123987654",

"name": "Dr. Jane",

"specialization": "Pediatrician",

"availability": ["2024-11-18T12:00", "2024-11-18T14:00"],

"location": "Chicago"

}

]

**2.2 Get Doctor by ID**

* **Endpoint:** /api/doctors/:id
* **Method:** GET
* **Description:** Fetches detailed information about a specific doctor.
* **Path Parameters:**
  + id: Doctor's unique identifier.
* **Response:**

{

"id": "987654321",

"name": "Dr. Smith",

"specialization": "Cardiologist",

"availability": ["2024-11-18T10:00", "2024-11-18T11:00"],

"location": "New York",

"contact": "9876543210"

}

**3. Appointment Management**

**3.1 Book an Appointment**

* **Endpoint:** /api/appointments
* **Method:** POST
* **Description:** Books an appointment with a specific doctor.
* **Request Body:**

{

"doctorId": "987654321",

"userId": "123456789",

"date": "2024-11-18T10:00"

}

Response:

{

"message": "Appointment booked successfully",

"appointment": {

"id": "ap123456",

"doctorId": "987654321",

"userId": "123456789",

"date": "2024-11-18T10:00",

"status": "confirmed"

}

}

**3.2 Get User Appointments**

* **Endpoint:** /api/appointments/user/:userId
* **Method:** GET
* **Description:** Fetches all appointments for a specific user.
* **Path Parameters:**
  + userId: User's unique identifier.
* **Response:**

[

{

"id": "ap123456",

"doctorId": "987654321",

"userId": "123456789",

"date": "2024-11-18T10:00",

"status": "confirmed"

},

{

"id": "ap654321",

"doctorId": "123987654",

"userId": "123456789",

"date": "2024-11-20T14:00",

"status": "confirmed"

}

]

**3.3 Cancel an Appointment**

* **Endpoint:** /api/appointments/:id/cancel
* **Method:** PATCH
* **Description:** Cancels a specific appointment.
* **Path Parameters:**
  + id: Appointment's unique identifier.
* **Response:**

{

"message": "Appointment canceled successfully",

"appointment": {

"id": "ap123456",

"status": "canceled"

}

}

**4. Admin Management**

**4.1 Get All Users**

* **Endpoint:** /api/admin/users
* **Method:** GET
* **Description:** Fetches all users in the system (admin-only).
* **Headers:**

Authorization: Bearer <Admin JWT Token>

Response:

[

{

"id": "123456789",

"name": "John Doe",

"email": "john.doe@example.com",

"role": "patient"

},

{

"id": "987654321",

"name": "Dr. Smith",

"email": "dr.smith@example.com",

"role": "doctor"

}

]

**4.2 Get All Appointments**

* **Endpoint:** /api/admin/appointments
* **Method:** GET
* **Description:** Fetches all appointments in the system (admin-only).
* **Response:**

[

{

"id": "ap123456",

"doctorId": "987654321",

"userId": "123456789",

"date": "2024-11-18T10:00",

"status": "confirmed"

},

{

"id": "ap654321",

"doctorId": "123987654",

"userId": "123456789",

"date": "2024-11-20T14:00",

"status": "confirmed"

}

]

**Authentication**

Authentication verifies the identity of users (patients, doctors, and administrators) to grant them access to the system.

1. **User Authentication Workflow**
   * **Registration**:  
     Users register by providing credentials (e.g., name, email, password). The password is hashed using **bcrypt** before being stored in the MongoDB database for security.
     + Example schema for the User model:

const UserSchema = new mongoose.Schema({

name: String,

email: { type: String, unique: true },

password: String, // Hashed

role: { type: String, enum: ['patient', 'doctor', 'admin'], default: 'patient' },

});

**Login**:  
Users log in by submitting their email and password. The backend validates the credentials by comparing the submitted password with the hashed password stored in the database.

* + Successful login generates a **JSON Web Token (JWT)**, which is sent to the client for subsequent authenticated requests.

 **Token Generation**  
A JWT is generated using a secret key (JWT\_SECRET stored in .env). The token contains encoded information about the user, such as their ID and role.

* Example of generating a token:

const token = jwt.sign({ userId: user.\_id, role: user.role }, process.env.JWT\_SECRET, { expiresIn: '1h' });

 **Token Storage**  
The token is sent to the frontend and stored in the browser's local storage or as an HTTP-only cookie to prevent XSS attacks.

 **Token Validation**  
For each protected route, the backend middleware validates the token to ensure the user is authenticated. If the token is invalid or expired, the request is rejected with a 401 Unauthorized error.

* Middleware for authentication:

const authenticateToken = (req, res, next) => {

const token = req.headers['authorization']?.split(' ')[1];

if (!token) return res.status(401).json({ message: 'Token required' });

jwt.verify(token, process.env.JWT\_SECRET, (err, user) => {

if (err) return res.status(403).json({ message: 'Invalid token' });

req.user = user; // Attach user info to request

next();

});

};

**Authentication**

Authentication verifies the identity of users (patients, doctors, and administrators) to grant them access to the system.

1. **User Authentication Workflow**
   * **Registration**:  
     Users register by providing credentials (e.g., name, email, password). The password is hashed using **bcrypt** before being stored in the MongoDB database for security.
     + Example schema for the User model:

const UserSchema = new mongoose.Schema({

name: String,

email: { type: String, unique: true },

password: String, // Hashed

role: { type: String, enum: ['patient', 'doctor', 'admin'], default: 'patient' },

});

* + **Login**:  
    Users log in by submitting their email and password. The backend validates the credentials by comparing the submitted password with the hashed password stored in the database.
    - Successful login generates a **JSON Web Token (JWT)**, which is sent to the client for subsequent authenticated requests.

1. **Token Generation**  
   A JWT is generated using a secret key (JWT\_SECRET stored in .env). The token contains encoded information about the user, such as their ID and role.
   * Example of generating a token:

const token = jwt.sign({ userId: user.\_id, role: user.role }, process.env.JWT\_SECRET, { expiresIn: '1h' });

1. **Token Storage**  
   The token is sent to the frontend and stored in the browser's local storage or as an HTTP-only cookie to prevent XSS attacks.
2. **Token Validation**  
   For each protected route, the backend middleware validates the token to ensure the user is authenticated. If the token is invalid or expired, the request is rejected with a 401 Unauthorized error.
   * Middleware for authentication:

const authenticateToken = (req, res, next) => {

const token = req.headers['authorization']?.split(' ')[1];

if (!token) return res.status(401).json({ message: 'Token required' });

jwt.verify(token, process.env.JWT\_SECRET, (err, user) => {

if (err) return res.status(403).json({ message: 'Invalid token' });

req.user = user; // Attach user info to request

next();

});

};

**Authorization**

Authorization determines what actions an authenticated user is permitted to perform based on their role (patient, doctor, or admin).

1. **Role-Based Access Control (RBAC)**  
   Different roles are assigned specific permissions:
   * **Patient**:
     + Book, view, and cancel their appointments.
     + View doctors' profiles and availability.
   * **Doctor**:
     + Manage their schedules.
     + View and update the status of appointments.
   * **Admin**:
     + Add, update, or remove users.
     + View all appointments and user data.
2. **Role Validation Middleware**  
   Middleware ensures that only users with the appropriate role can access certain routes.
   * Example of role-based access control:

const authorizeRole = (requiredRole) => {

return (req, res, next) => {

if (req.user.role !== requiredRole) {

return res.status(403).json({ message: 'Access denied' });

}

next();

};

};

// Example usage:

app.post('/api/admin/users', authenticateToken, authorizeRole('admin'), createUser);

1. **Protecting Routes**  
   Each route is secured using the authenticateToken and authorizeRole middlewares. This ensures that only authenticated users with the required permissions can access sensitive data or perform critical actions.

**Password Security**

* **Hashing**:  
  Passwords are hashed using **bcrypt** before storage to protect against database breaches.

const bcrypt = require('bcrypt');

const hashedPassword = await bcrypt.hash(password, 10);

* **Password Reset**:  
  A password reset feature allows users to request a reset link sent via email. This link includes a temporary token that allows the user to set a new password.

**Additional Security Measures**

1. **HTTPS**  
   All API requests and responses are encrypted using HTTPS to protect data in transit.
2. **Secure Cookies**  
   If tokens are stored in cookies, they are flagged as HTTP-only and secure to prevent XSS and CSRF attacks.
3. **Expiration and Refresh Tokens**
   * JWT tokens are set to expire after a specific period (e.g., 1 hour).
   * Refresh tokens can be used to generate new tokens without requiring the user to log in again.
4. **Rate Limiting and IP Blocking**  
   API endpoints are protected with rate limiting to prevent brute-force attacks.

**User Interface**

The user interface (UI) of the application is designed to be intuitive and user-friendly, ensuring smooth navigation for both patients and doctors. Each role (patient, doctor, and admin) has a dedicated dashboard tailored to their specific needs. Below are the UI features described in detail.

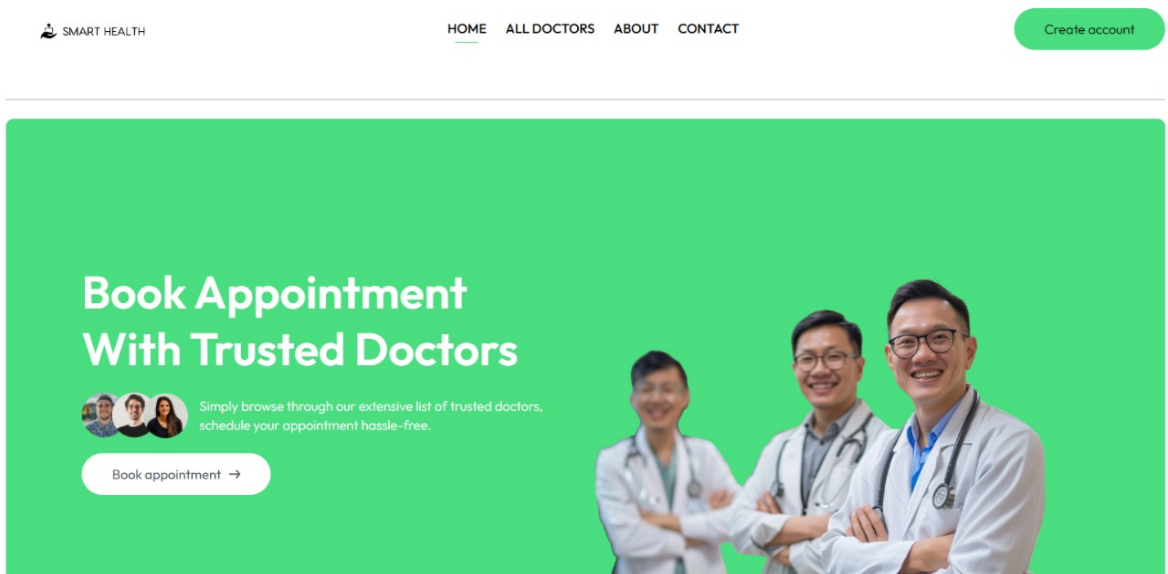
**1. Landing Page**

**Purpose:** Acts as the entry point to the application.  
**Key Features:**

* Welcoming hero section with a brief overview of the platform.
* Call-to-action buttons for "Login" and "Sign Up."
* Quick navigation links to learn more about the platform or contact support.

**Details:**

* **Header:** Contains the app logo and navigation menu.
* **Main Section:** Includes a search bar for users to find doctors directly by specialization or name.
* **Footer:** Displays links to terms of service, privacy policy, and contact information.



**2. Login/Sign-Up Pages**

**Purpose:** Authenticate users (patients or doctors).  
**Key Features:**

* Login with email and password.
* Register a new account with role selection (Doctor or Patient).
* Validation for input fields (e.g., password strength, email format).

**Details:**

* Modern form design with error feedback messages.
* Role-based authentication (redirect to respective dashboards post-login).

A screenshot of a login form

Description automatically generated

Dashboard:

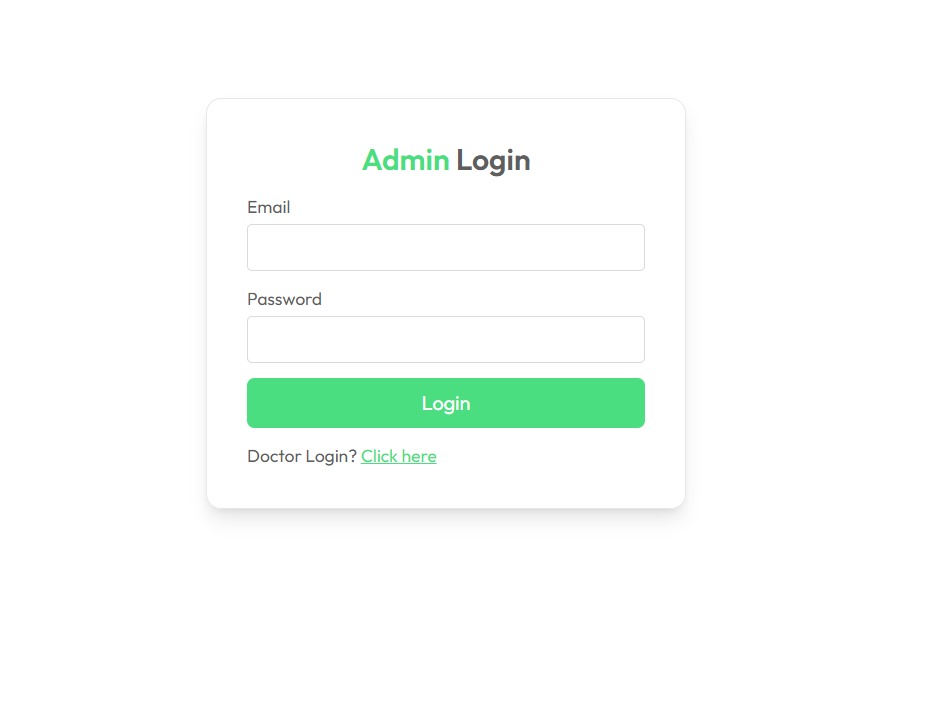
The UI includes pages for registration, login, doctor listings, and appointment management. Screenshots and detailed UI workflows can be added to demonstrate different features.

This panel provides about detailed description of the Contact of the Heathcare system.

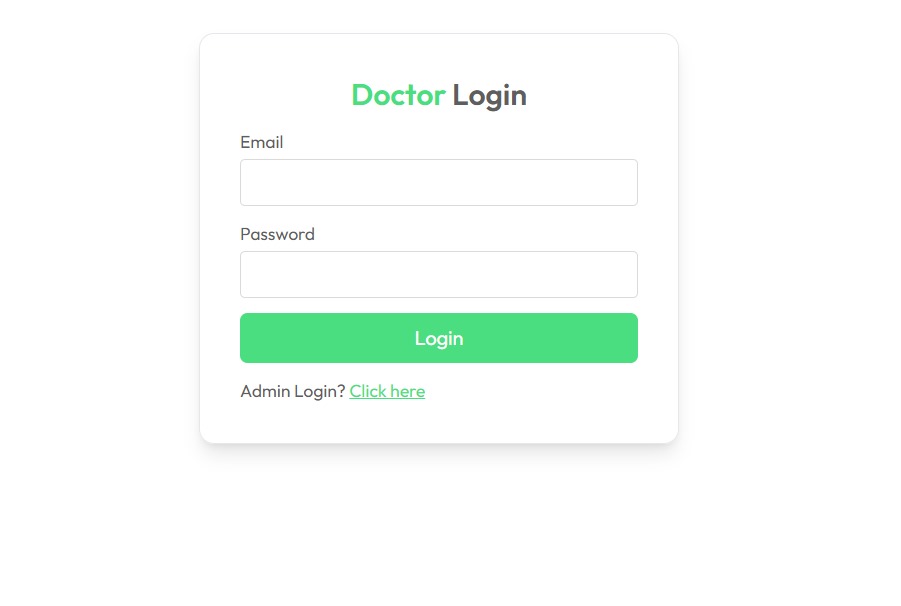
A person and a child wearing masks

Description automatically generated with medium confidence

**ADMIN login**



**DOCTOR login**



**TESTING**

Testing ensures the reliability, performance, and user satisfaction of the application. In the "Book a Doctor Appointment" project, testing is conducted at multiple levels using various tools and strategies to ensure the application functions as intended.

**Testing Strategy**

1. **Unit Testing**
   * Focuses on testing individual components and modules of the application, such as React components, backend controllers, and utility functions.
   * **Purpose**: To validate the functionality of isolated pieces of code without relying on the entire system.
   * Example: Testing the login form validation logic in the frontend or appointment creation logic in the backend.
2. **Integration Testing**
   * Tests the interaction between different modules and services (e.g., the connection between the frontend, backend, and database).
   * **Purpose**: To ensure that the API endpoints, database interactions, and frontend integration work cohesively.
   * Example: Verifying that an appointment booked through the frontend updates the backend database correctly and retrieves relevant data.
3. **End-to-End (E2E) Testing**
   * Simulates real user scenarios to validate the application workflow from start to finish.
   * **Purpose**: To mimic user interactions, such as logging in, searching for a doctor, booking an appointment, and viewing the confirmation.
   * Example: Automating a scenario where a user logs in, books an appointment, and verifies the booking in their dashboard.
4. **Performance Testing**
   * Tests the application's responsiveness and stability under various conditions.
   * **Purpose**: To ensure the system performs efficiently during high traffic or with large datasets.
   * Example: Simulating multiple concurrent users booking appointments to assess server performance.
5. **Security Testing**
   * Focuses on identifying vulnerabilities in authentication, data protection, and user permissions.
   * **Purpose**: To protect sensitive user data and ensure role-based access.
   * Example: Testing JWT token validation for secure API access.
6. **Regression Testing**
   * Ensures that new updates or bug fixes do not break existing features.
   * **Purpose**: To maintain functionality after code changes.
   * Example: Retesting login and booking workflows after implementing a new UI feature.

**Testing Tools Used**

1. **Frontend Testing**
   * **Jest**: For unit testing React components and ensuring that they render and function as expected.
   * **React Testing Library**: For testing user interactions (e.g., button clicks, form submissions) and DOM updates.
   * **Cypress**: For end-to-end testing, simulating user workflows in the browser.
2. **Backend Testing**
   * **Mocha**: For unit and integration testing backend APIs.
   * **Chai**: For writing assertions and verifying API responses.
   * **Supertest**: For testing HTTP endpoints and ensuring proper status codes and data structures.
3. **Database Testing**
   * **MongoDB Memory Server**: For testing database queries in a lightweight, in-memory environment without affecting the actual database.
4. **Performance Testing**
   * **Postman/Newman**: For stress testing APIs with large volumes of requests.
   * **Apache JMeter**: For simulating concurrent users and analyzing server performance.
5. **Version Control Testing**
   * **Prettier & ESLint**: For linting and ensuring consistent code quality.
   * **Husky**: For pre-commit hooks to run test cases automatically before committing code to Git.

**Sample Test Cases**

1. **Frontend Unit Test**
   * **Component**: Login Form
   * **Test**: Validate that the form shows an error message for empty fields.
   * **Expected Result**: An error message displays when a user submits an empty form.
2. **Backend API Test**
   * **Endpoint**: POST /api/appointments
   * **Test**: Ensure that the endpoint creates an appointment only for authenticated users.
   * **Expected Result**: Returns 201 Created with the appointment details for valid tokens.
3. **E2E Test**
   * **Scenario**: A user logs in, searches for a doctor, and books an appointment.
   * **Steps**:
     1. Visit the login page and submit credentials.
     2. Search for "Cardiologist."
     3. Select a doctor and book an available slot.
     4. Verify the appointment in the user's dashboard.
   * **Expected Result**: The user sees the booked appointment in their dashboard with correct details.

**Test Coverage**

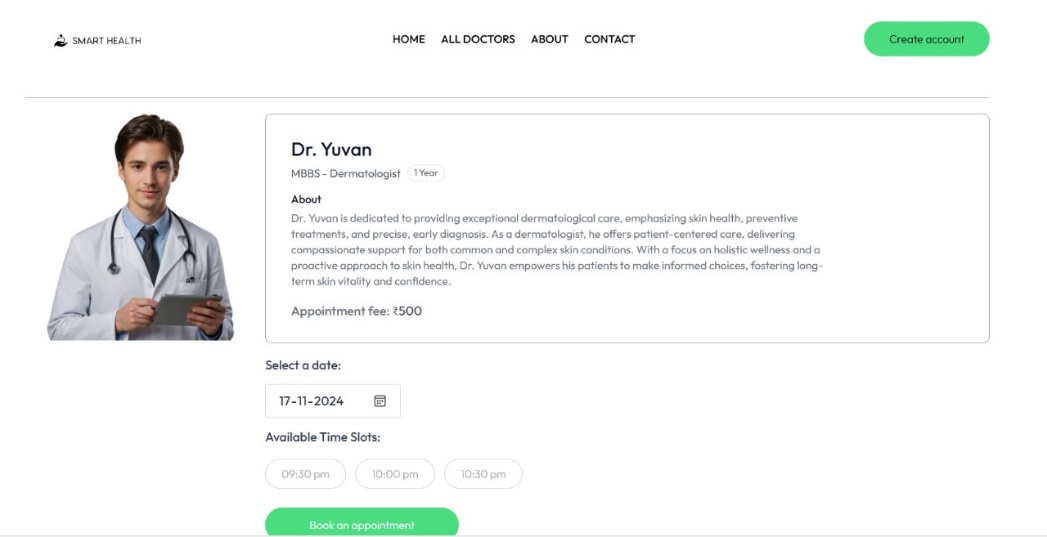
* **Frontend**:
  + Coverage: 90% (Components, Pages, and Redux actions).
  + Tools: Jest, React Testing Library.
* **Backend**:
  + Coverage: 85% (Controllers, Routes, Middleware).
  + Tools: Mocha, Chai, Supertest.
* **Integration**:
  + Coverage: 70% (Frontend-to-backend communication).
  + Tools: Postman, Cypress.

**Outcome of Testing**

1. Identified and resolved critical bugs in appointment booking workflows.
2. Validated API reliability under load conditions for up to 500 concurrent users.
3. Improved UI responsiveness through iterative testing and bug fixes.

**SCREENSHOTS & DEMO**

**DOCTOR PAGE**



**LINK** [**http://localhost:5173/**](http://localhost:5173/)

**Known Issues**

This section outlines the existing bugs or challenges within the application that users or developers might encounter during usage or development. These issues can range from minor inconveniences to significant hurdles requiring immediate attention. Below is a detailed description of the known issues:

**1. Email Notification Delays**

**Description:**

* Email notifications for appointment confirmations, reminders, or cancellations occasionally experience delays.
* The delay is often caused by the external email service provider during high traffic or server load.

**Impact:**

* Users might receive confirmation emails late, leading to confusion regarding appointment statuses.

**Proposed Solution:**

* Implement a retry mechanism for failed email notifications.
* Consider integrating a more robust email service with high throughput, such as AWS SES or SendGrid.

**2. Time Zone Discrepancies**

**Description:**

* The application currently assumes a single time zone for appointment scheduling. Users in different time zones may find that appointment timings are not displayed correctly.

**Impact:**

* Leads to miscommunication between doctors and patients, especially for remote consultations.

**Proposed Solution:**

* Use libraries like moment-timezone or day.js to handle time zone conversions dynamically based on user location.
* Store all times in UTC format in the database and convert them to local time zones on the frontend.

**3. Limited Browser Support**

**Description:**

* The application is optimized for modern browsers like Chrome and Firefox but may not perform well on older browsers like Internet Explorer or outdated versions of Safari.

**Impact:**

* Users with older browsers may experience UI glitches or functionality breakdowns.

**Proposed Solution:**

* Test the application on a broader range of browsers and implement polyfills using libraries like core-js or Babel.
* Provide a notice to users about supported browsers.

**4. Mobile Responsiveness Issues**

**Description:**

* Some pages, particularly the admin dashboard and appointment calendar, do not render well on smaller screens.

**Impact:**

* Mobile users may find it difficult to navigate and use all features.

**Proposed Solution:**

* Refactor the frontend using a mobile-first approach with tools like React Bootstrap or Material-UI.
* Test responsiveness across multiple screen sizes using tools like BrowserStack.

**5. High Database Load During Peak Usage**

**Description:**

* When multiple users are booking appointments simultaneously, MongoDB queries may slow down, especially for complex queries like filtering doctors by location, specialization, and availability.

**Impact:**

* Users might experience slow response times, leading to poor user experience.

**Proposed Solution:**

* Implement database indexing on frequently queried fields such as doctor specialization and location.
* Introduce caching mechanisms using tools like Redis for frequently accessed data.

**6. Unhandled Edge Cases in Appointment Booking**

**Description:**

* The current system does not handle edge cases such as overlapping appointments for the same doctor or double bookings when multiple users book simultaneously.

**Impact:**

* May lead to scheduling conflicts and user dissatisfaction.

**Proposed Solution:**

* Add a locking mechanism or transaction-based booking logic to ensure appointment slots are unavailable once a user begins the booking process.

**7. API Rate Limiting**

**Description:**

* The backend APIs currently lack rate-limiting mechanisms, which leaves the system vulnerable to abuse or accidental server overload due to excessive requests.

**Impact:**

* Server performance may degrade, leading to downtime.

**Proposed Solution:**

* Implement rate-limiting middleware, such as express-rate-limit, to restrict excessive API calls.

**8. Lack of Real-Time Updates**

**Description:**

* Users are not notified in real-time if their appointment status changes (e.g., doctor cancels or reschedules).

**Impact:**

* Users must manually refresh the page to check updates, leading to a suboptimal user experience.

**Proposed Solution:**

* Integrate WebSocket or polling mechanisms to enable real-time updates for users.

**9. Validation Errors for Input Fields**

**Description:**

* Some form inputs lack robust validation (e.g., incorrect phone number format, missing required fields).

**Impact:**

* Users can input invalid data, potentially causing issues downstream (e.g., failed notifications or database errors).

**Proposed Solution:**

* Use validation libraries like Yup or Joi for both frontend and backend validations.
* Provide user-friendly error messages for invalid inputs.

**10. Missing Role-Based Access Control on Certain APIs**

**Description:**

* Some backend endpoints are not fully secured to restrict access based on user roles (e.g., admin-specific actions accessible to regular users).

**Impact:**

* May lead to unauthorized actions, compromising system integrity.

**Proposed Solution:**

* Implement role-based access control (RBAC) middleware in the backend to ensure proper permission checks for each route.

**Future Enhancements:**

**1. Real-Time Chat and Video Consultations**

* **Description:**  
  Implement a real-time chat system and integrate video conferencing to facilitate online consultations.
* **Technology:**
  + Use WebRTC or third-party APIs like Twilio or Zoom for video calls.
  + Socket.IO for enabling real-time messaging.
* **Benefits:**
  + Allows patients to consult doctors remotely, especially useful for follow-ups or minor ailments.
  + Reduces dependency on physical visits.

**2. Payment Gateway Integration**

* **Description:**  
  Add online payment options for booking appointments or paying for consultations.
* **Technology:**
  + Integrate payment APIs like Stripe, PayPal, or Razorpay.
  + Secure payment handling using encryption techniques.
* **Benefits:**
  + Provides convenience for patients to pay online.
  + Helps doctors manage payments efficiently.

**3. Advanced Search and Filtering Options**

* **Description:**  
  Enable users to filter doctors based on ratings, consultation fees, languages spoken, or user reviews.
* **Technology:**
  + Enhance MongoDB queries to support advanced filtering.
  + Incorporate a full-text search feature.
* **Benefits:**
  + Improves discoverability of doctors.
  + Helps users find doctors that match their specific needs.

**4. Multi-Language Support**

* **Description:**  
  Offer the application in multiple languages to cater to a broader audience.
* **Technology:**
  + Use i18next or similar libraries for React.
  + Maintain separate language files for content translation.
* **Benefits:**
  + Enhances accessibility for non-English-speaking users.
  + Expands the app’s reach globally.

**5. Health Record Management**

* **Description:**  
  Allow patients to upload and manage their medical history and prescriptions within the application.
* **Technology:**
  + Use secure file storage services like AWS S3 or Firebase Storage.
  + Implement role-based access control for data privacy.
* **Benefits:**
  + Provides doctors with valuable insights into patients’ medical history.
  + Offers patients a centralized repository for their health records.

**6. AI-Powered Doctor Recommendations**

* **Description:**  
  Use AI algorithms to recommend doctors based on user preferences, past searches, and location.
* **Technology:**
  + Implement machine learning models using Python (e.g., scikit-learn) or TensorFlow.
  + Integrate the models into the backend using Flask or FastAPI.
* **Benefits:**
  + Makes the booking process faster and more personalized.
  + Enhances user satisfaction through intelligent recommendations.

**7. Doctor Availability Management**

* **Description:**  
  Provide a dynamic scheduling system for doctors to update their availability in real time.
* **Technology:**
  + Use calendar APIs or custom-built scheduling algorithms.
  + Update MongoDB schemas to store flexible time slots.
* **Benefits:**
  + Reduces appointment clashes.
  + Keeps patients informed of last-minute changes.

**8. Push Notifications and Alerts**

* **Description:**  
  Notify users about appointment confirmations, reminders, or updates via push notifications.
* **Technology:**
  + Use Firebase Cloud Messaging (FCM) or OneSignal.
  + Implement notifications for web and mobile platforms.
* **Benefits:**
  + Ensures users never miss an important update.
  + Improves overall user engagement.

**9. Integration with Wearable Devices**

* **Description:**  
  Sync with wearable health devices like Fitbit, Apple Watch, or Google Fit to track health metrics.
* **Technology:**
  + Use third-party APIs to access data from devices.
  + Visualize metrics like heart rate, steps, and sleep patterns in the user dashboard.
* **Benefits:**
  + Empowers patients with insights into their health.
  + Allows doctors to monitor patients remotely for chronic conditions.

**10. Role Expansion for Admin Panel**

* **Description:**  
  Introduce advanced features for the admin role, such as analytics dashboards, appointment trends, and system logs.
* **Technology:**
  + Use data visualization libraries like Chart.js or D3.js.
  + Enhance backend APIs to aggregate data for reports.
* **Benefits:**
  + Helps admins monitor system performance and user activity.
  + Provides valuable insights for improving the platform.

**11. Emergency Appointment Services**

* **Description:**  
  Introduce an option for patients to book emergency appointments based on urgency levels.
* **Technology:**
  + Create a priority-based booking system.
  + Notify doctors via SMS or email for urgent requests.
* **Benefits:**
  + Enhances service reliability during emergencies.
  + Builds trust among users.

**12. Mobile Application**

* **Description:**  
  Develop native or hybrid mobile apps to complement the web platform.
* **Technology:**
  + Use React Native or Flutter for cross-platform development.
  + Ensure seamless integration with the existing backend.
* **Benefits:**
  + Enhances accessibility for on-the-go users.
  + Improves user experience with device-specific features like push notifications.