UNIVERSITY OF LONDON

HealthBridge

CM3070 Computer Science Final Report

Project Template: **CM3035 Advanced Web Development**

Title: **Non-Profit Web Application**

Project Name: **HealthBridge**

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CHAPTER 1: INTRODUCTION

Embarking on this project to develop a non-profit healthcare application, I am driven by a vision to dramatically enhance healthcare accessibility for underserved communities. This initiative stems from my personal experiences and observations of the significant disparities in healthcare access and outcomes across different demographics. Through this project, I aim to harness the transformative power of digital technology to make healthcare services more inclusive and equitable.

Project Concept:

The core of my project is to create a comprehensive digital platform that integrates essential healthcare services into a single, user-friendly interface. This platform will provide telemedicine, streamlined appointment scheduling, accessible health records management, and interactive community support forums. Designed to be accessible on various devices, these features aim to bring healthcare directly to the users, overcoming traditional barriers of distance and socioeconomic status.

Motivation:

My motivation is deeply rooted in a commitment to social justice and the principle that quality healthcare is a fundamental right, not a privilege. The disparities in healthcare, particularly in rural and economically disadvantaged areas, have highlighted the urgent need for innovative solutions. By creating a platform that is accessible and responsive to the needs of these communities, I am dedicated to leveling the playing field and ensuring that every individual has the opportunity to achieve optimal health.

Research Questions:

To tailor the development of this healthcare application to the real needs of the communities it will serve, I have formulated several key research questions:

1. **What are the main technological, economic, and cultural barriers that underserved communities face in accessing digital healthcare, and how can innovative design address these barriers?**
   - Identifying and understanding these barriers will allow me to design the application in a way that mitigates these issues, making the technology more accessible and effective.

2. **How can user-centered design principles be optimized to enhance the usability of the application for individuals with limited technology experience?**
   - I plan to incorporate simple, intuitive design elements that can significantly enhance user engagement and make the technology approachable for all users, regardless of their previous experience with digital tools.

3. **How does implementing robust data privacy and security measures influence user trust and adoption of digital healthcare platforms?**
   - I intend to explore how comprehensive privacy protections and transparent data handling policies can build trust among users, encouraging their continued engagement with the platform.

Deliverables:

Throughout the development of this healthcare application, I will focus on several deliverables:

- Concentrate on crafting the essential components of the app, such as:

Appointment Scheduling System: Implement an intuitive scheduling tool that enables patients to view available times and book appointments with ease.

Health Records Management: Create a secure module for patients to access and manage their personal health records online.

- **Prototype Development:** Develop a prototype based on initial research, which will be continuously refined through community feedback and iterative testing to ensure it meets the practical needs of the users.

- **Final Application Launch:** Release a fully functional, secure, and user-friendly application that not only addresses the healthcare management needs of its users but also empowers them to take an active role in their health management.

CHAPTER 2: LITERATURE REVIEW

Expanded Discussion on Digital Healthcare Platforms

HealthCare.gov

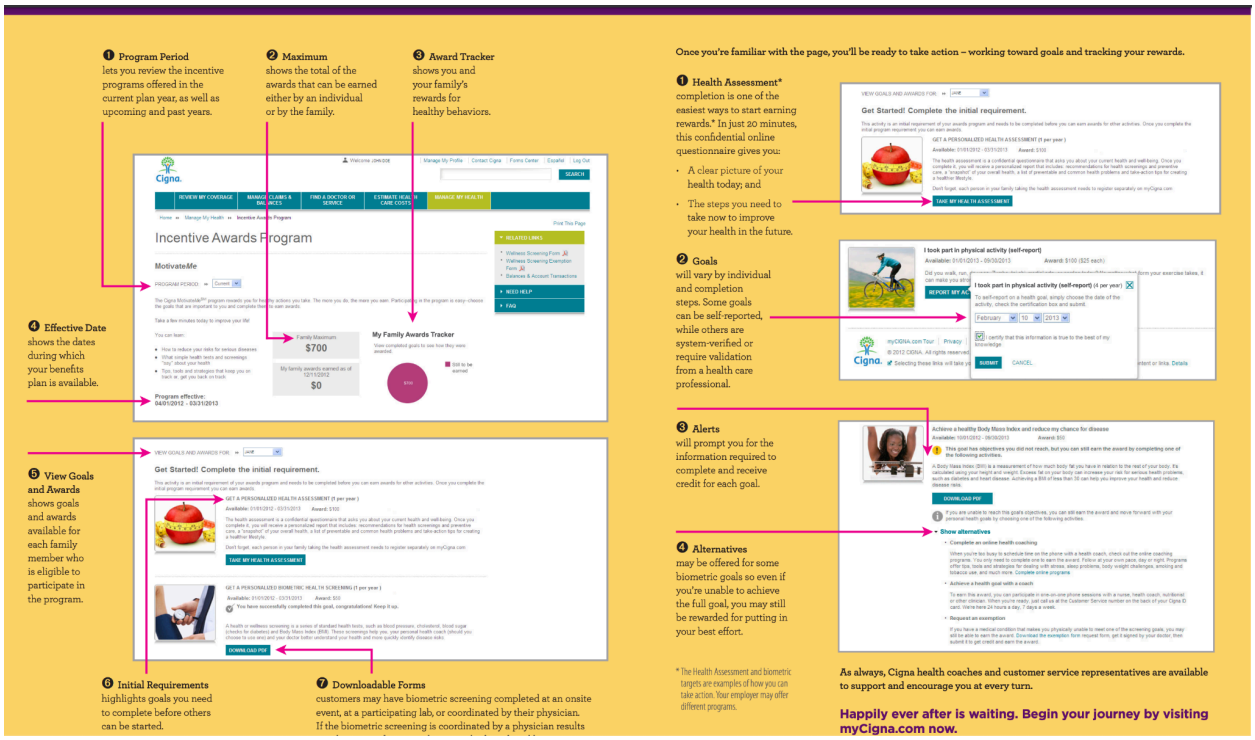
Overview and Operational Challenges:
Initially, HealthCare.gov faced numerous technical issues that severely hampered its effectiveness. These issues included slow load times, failed transactions, and incorrect data handling, which led to public frustration and

skepticism about the platform's utility. Over time, significant improvements have been made, but the launch serves as a cautionary tale about the importance of scalability and robust testing in government-led digital initiatives (Smith et al., 2014).

The experience has highlighted the necessity for digital healthcare platforms to be built with scalable architectures that can handle sudden surges in user demand, especially during critical enrollment periods.

Improvement Insights: To avoid similar pitfalls, ongoing optimization efforts have focused on enhancing server capacity and refining code for better performance. The case of HealthCare.gov underscores the critical need for continuous monitoring, regular updates, and strategic planning to anticipate user needs and potential system stress points.

myCigna.com

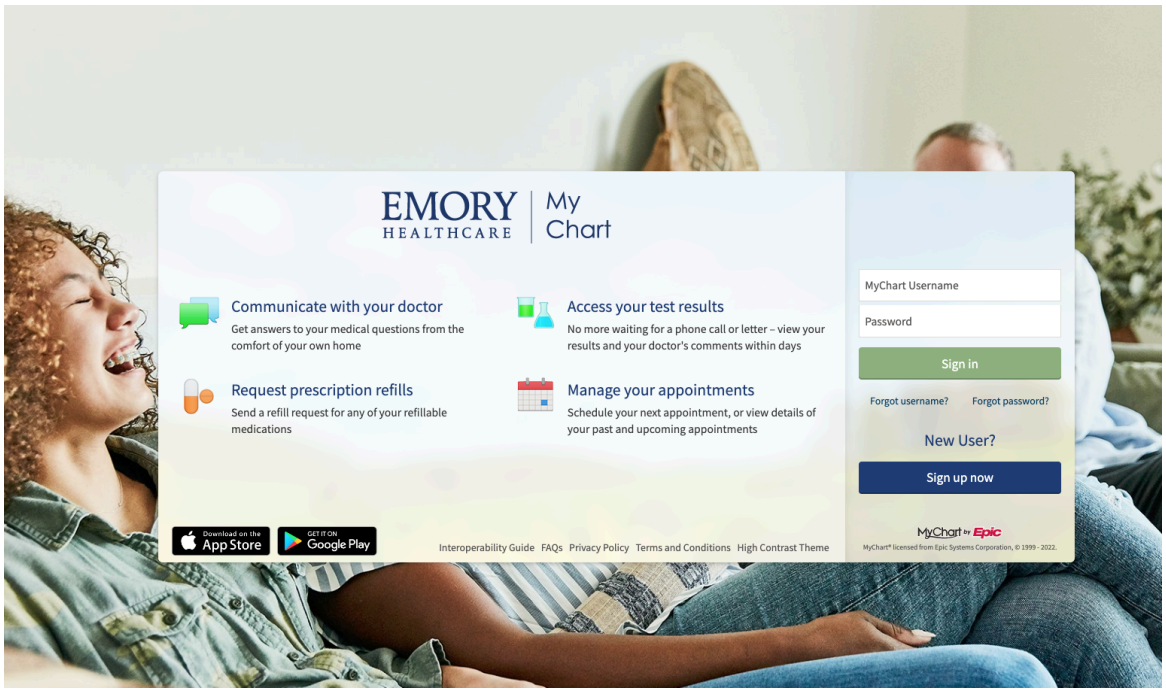


Functionality and User Feedback:

myCigna.com offers an array of health management tools aimed at providing users with comprehensive access to their health records, insurance plans, and wellness programs. However, users often report difficulties with the platform's interface, which can be non-intuitive and cumbersome for less tech-savvy users. The complexity of navigating insurance options and managing personal health data emphasizes the need for a more streamlined, user-friendly approach (Jones and Williams, 2015).

Design Recommendations: Enhancing the user interface to be more intuitive involves simplifying the navigation process and providing clearer, more direct pathways to frequently used services. This would likely increase user satisfaction by reducing frustration and making the system more accessible to a broader demographic, including those with limited digital skills.

myChart by Emory Healthcare



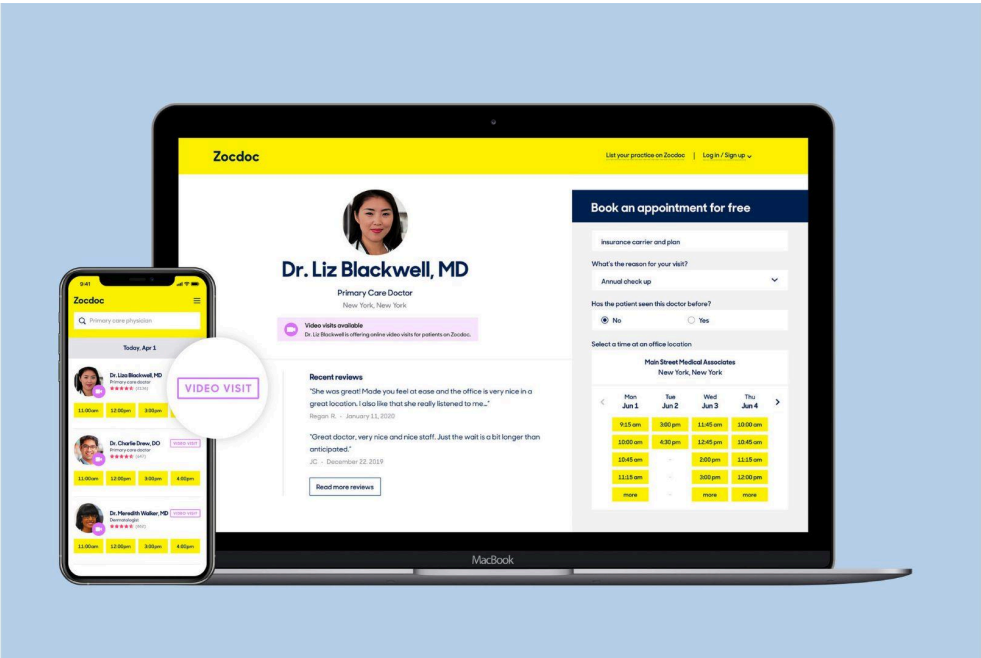
Data Management Capabilities and Integration Challenges:
myChart excels in offering patients a detailed view of their medical history, upcoming appointments, and lab results. However, integrating this data smoothly with systems from other healthcare providers presents ongoing challenges.

These integration issues can create barriers to seamless care, where a patient's full medical history might not be completely accessible or actionable across different care settings (Doe, 2016).

Integration Enhancements: Improving interoperability between different healthcare systems involves adopting more standardized data exchange formats and protocols. Enhanced integration would not only improve the user experience

but also empower healthcare providers to deliver more coordinated and effective care.

Zocdoc



Service Model and Challenges:
Zocdoc innovates the process of scheduling medical appointments by allowing users to see real-time availability and book appointments online. However, discrepancies in real-time data syncing can lead to booking errors and customer dissatisfaction, which undermines the reliability of the service. Ensuring accurate and up-to-date information from healthcare providers is crucial for maintaining trust and operational efficiency (White, 2017).

Service Improvements: Implementing more robust data verification processes and enhancing real-time communication channels between Zocdoc and healthcare providers' scheduling systems could greatly reduce errors. This would ensure that users have a reliable and accurate view of appointment availability, enhancing user trust and satisfaction.

Techniques & Methods I plan to use:

User-Centered Design Tailored to Underserved Communities
In developing my non-profit healthcare application, a cornerstone of my strategy is adopting a user-centered design approach that directly involves the communities it aims to serve.

This process starts with on-the-ground engagement, where I plan to conduct a series of workshops and interactive sessions within community centers and local clinics. The goal is to gather authentic insights into the daily challenges these users face, particularly those related to technology access, literacy levels, and cultural contexts that may impact their interaction with digital health services.

To ensure the application is genuinely user-friendly and accessible, I will prioritize features such as multilingual support to accommodate non-readers or those with visual impairments. The interface will be designed with large, clear icons and minimal text, reducing cognitive load and making navigation straightforward for all users, regardless of their tech proficiency. The feedback collected during these community sessions will directly influence iterative designs, ensuring that each feature is molded by the users' own experiences and needs.

Advanced-Data Privacy with a Community-Centric Approach
Recognizing the sensitivity of health data, I am deeply committed to implementing the most robust data privacy measures. This involves not only integrating top-tier encryption technologies but also regularly updating these measures to combat evolving cybersecurity threats. My application will incorporate end-to-end encryption for all data transmission and AES-256 encryption for data at rest, creating a secure digital environment that guards against unauthorized access.

Personalized Care Through Analytics Optimized for Low-Resource Settings
Harnessing the power of analytics is another pillar of my strategy to deliver personalized and proactive healthcare. By integrating advanced analytics into the platform, I can utilize data to tailor health interventions to individual needs. This personalization goes beyond generic health guidelines, offering users customized recommendations based on their health history, lifestyle choices, and even genetic predispositions.

In resource-limited settings, such predictive capabilities can revolutionize healthcare delivery by optimizing resource allocation and focusing interventions where they are most needed. For example, if analytics reveal a high incidence of diabetes in a particular community, I can direct more resources to diabetes education and preventive measures specifically for that area. Additionally, machine learning algorithms will refine these insights over time, improving the accuracy of health predictions and the effectiveness of the interventions.

CHAPTER 3: Product Design

Product Overview

This project is dedicated to developing a nonprofit healthcare web application to improve medical service accessibility in underserved areas. By incorporating sophisticated digital tools, I will provide essential services such as telemedicine, streamlined appointment booking, efficient health records management, and forums for community engagement, all within a user-friendly online interface.

Template Utilization

I am adopting the "Non-Profit Web Application" framework from the **CM3035 Advanced Web Development module** for this initiative. This framework is ideal for projects that utilize technology to address significant social challenges, making it perfect for a healthcare platform aimed at closing accessibility gaps.

Domain and Target Users

Domain: The application is centered on the healthcare field, with a focus on digital health solutions.

Target Users: The primary users are individuals from economically disadvantaged areas, including rural residents, the elderly, people with disabilities, and those with limited access to conventional healthcare facilities. These users often face challenges such as geographic isolation, limited transportation, and financial constraints, which this application aims to mitigate.

Design Understanding

I have made several critical design decisions based on the needs of the users:

- **Accessibility:** The application will be designed for accessibility, catering to users with disabilities and those with limited digital literacy. Features will include text alternatives for images, high-contrast visuals for better readability, and simple navigation paths.

- **Security:** Given the sensitive nature of health information, the platform will incorporate advanced security measures like data encryption and secure authentication processes to protect user privacy and ensure data integrity.

- **Interactivity:** To foster a sense of community and support, I will integrate interactive features such as community forums, live chat with healthcare providers, and user feedback mechanisms.

System Architecture

Frontend: Using React, the frontend will be responsive and dynamic, ensuring good performance across different devices.

Backend: I will employ Node.js with Express.js to handle server-side logic, user authentication, and data processing efficiently.

Database: PostgreSQL will be used for its robust capabilities in managing complex data securely, crucial for handling extensive health records and user data.

Security Implementation: SSL/TLS encryption protocols will be used to secure all data transmissions between the client and the server.

Technologies and Approaches

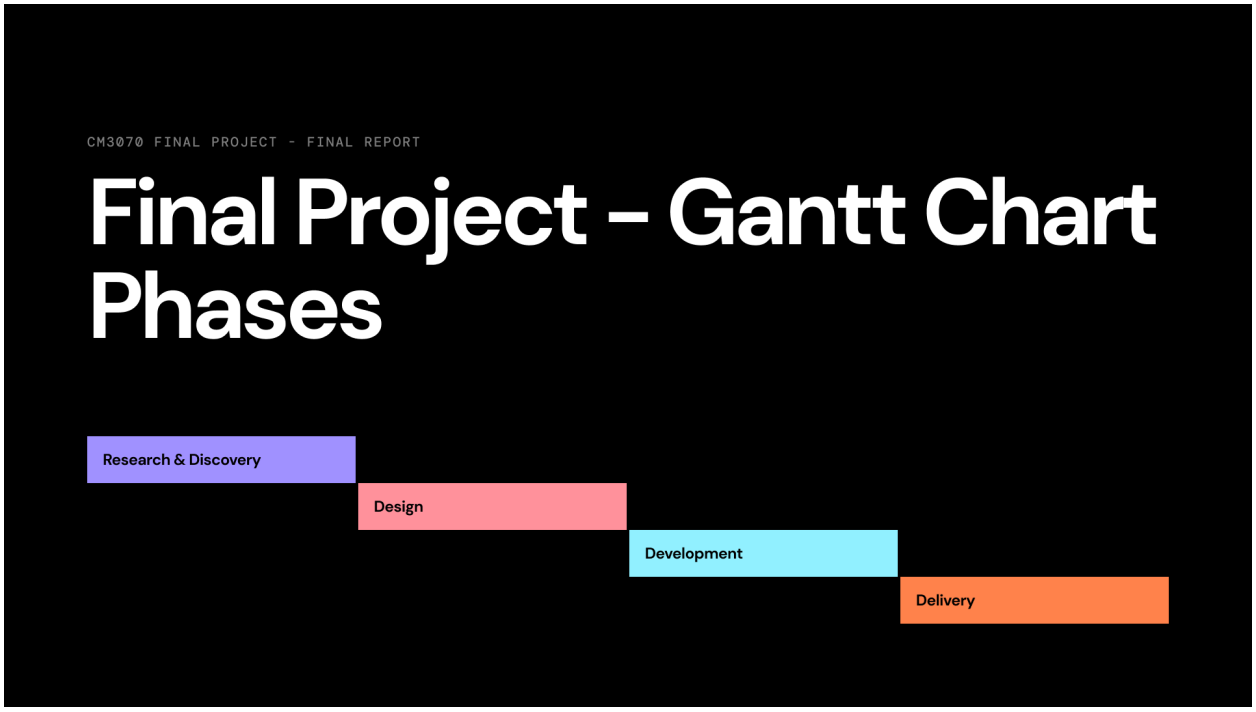
- **React/Vue.js:** Chosen for its component-based architecture, which facilitates the development of a dynamic and maintainable user interface.

- **Node.js and Express.js:** These will provide a scalable and efficient server-side solution, essential for handling potentially high loads of user interactions and data processing.

- **PostgreSQL:** Selected for its reliability and strong performance in handling large volumes of data, crucial for managing extensive health records and user data securely.

Project Planning

The project timeline will be detailed in a visual format such as a Gantt chart, highlighting key phases including:



Gantt Chart

Non-Profit HealthCare Web Application

The planning for the HealthBridge Web Application was thoughtfully segmented into four main phases over six months, from April to September 2024. I initiated the project with the Research and Discovery phase, where the foundational elements were meticulously laid out.

In this initial stage, I focused on selecting the optimal project template, conducting thorough background research, and defining precise objectives for the application. This groundwork was not only about gathering information but also about crafting a clear strategic direction that would guide the entire project lifecycle.

As the project progressed through the Design, Development, and Delivery phases, I employed a detailed Gantt chart that proved invaluable. This chart was my roadmap, clearly stating each phase's timelines and specific tasks. It enabled me to maintain a steady pace and systematic approach, ensuring that each phase transitioned smoothly into the next without overlooking any details. This meticulous planning was essential for keeping the project aligned with its goals

and timelines, ultimately helping to forge a practical and meaningful tool tailored for non-profit healthcare providers.

CHAPTER 4: Feature Prototype

Appointment Scheduling Module

In this project, I've crafted a crucial prototype using the "**Non-Profit Web Application**" framework from the **CM3035 Advanced Web Development** module. This framework is specifically suited to projects that blend technological innovation with social improvement, ideal for my application aimed at expanding non-profit underserved healthcare access.

Key Features of the Prototype:

Interactive Appointment Interface: Users can seamlessly navigate through choosing healthcare professionals, selecting appointment times, and confirming their bookings. This interface is designed with clarity and simplicity to accommodate all user demographics.

Live Schedule Updates: The system ensures that the availability statuses of healthcare providers are updated in real-time to prevent any booking overlaps and guarantee an efficient scheduling experience.

Enhanced Authentication Mechanism: Security is paramount, particularly when handling personal health information. To this end, JSON Web Tokens (JWT) safeguard user sessions and ensure data privacy.

Automated Appointment Confirmations: Once an appointment is booked, the system automatically emails the user with all the relevant appointment details. This function is handled efficiently by Node.js on the backend.

Technological Stack and Methods:

Frontend with React JS: The choice of React JS for the front-end facilitates dynamic updates and interactive user experiences without page reloads, enhancing user satisfaction.

Backend with Node.js and Express.js: These technologies are crucial for processing API requests effectively, managing user data, and scheduling appointments through robust server-side logic.

Database Management with MongoDB: MongoDB is utilized for its adeptness at managing high volumes of data, ensuring quick data retrieval, and secure storage of appointment and user details.

Security Tokens with JWT: JWT plays a critical role in securely managing user sessions and data exchanges, providing a reliable method of encryption and authentication.

Code Overview:

User Interaction Components: The system incorporates user-friendly elements such as provider selection menus and interactive date pickers, all linked dynamically to the backend for immediate data synchronization.

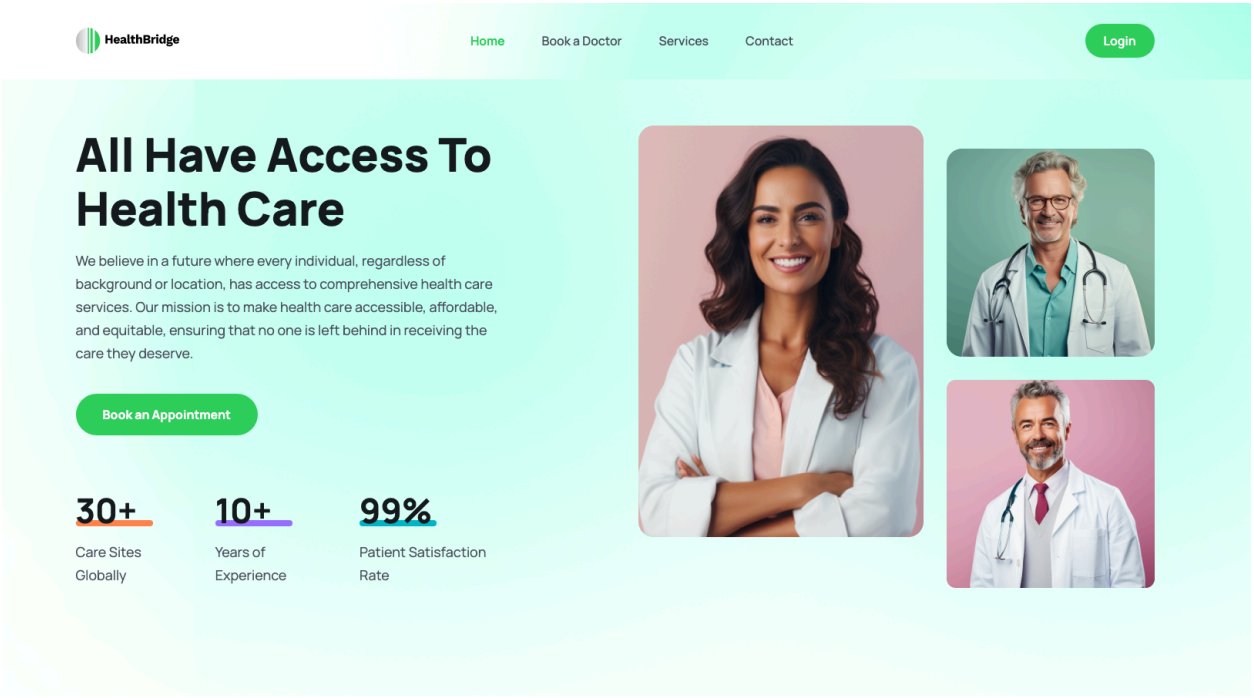
API Functionality: Defined API endpoints handle operations such as checking provider availability, booking appointments, and sending confirmation emails, ensuring smooth and consistent data flow.

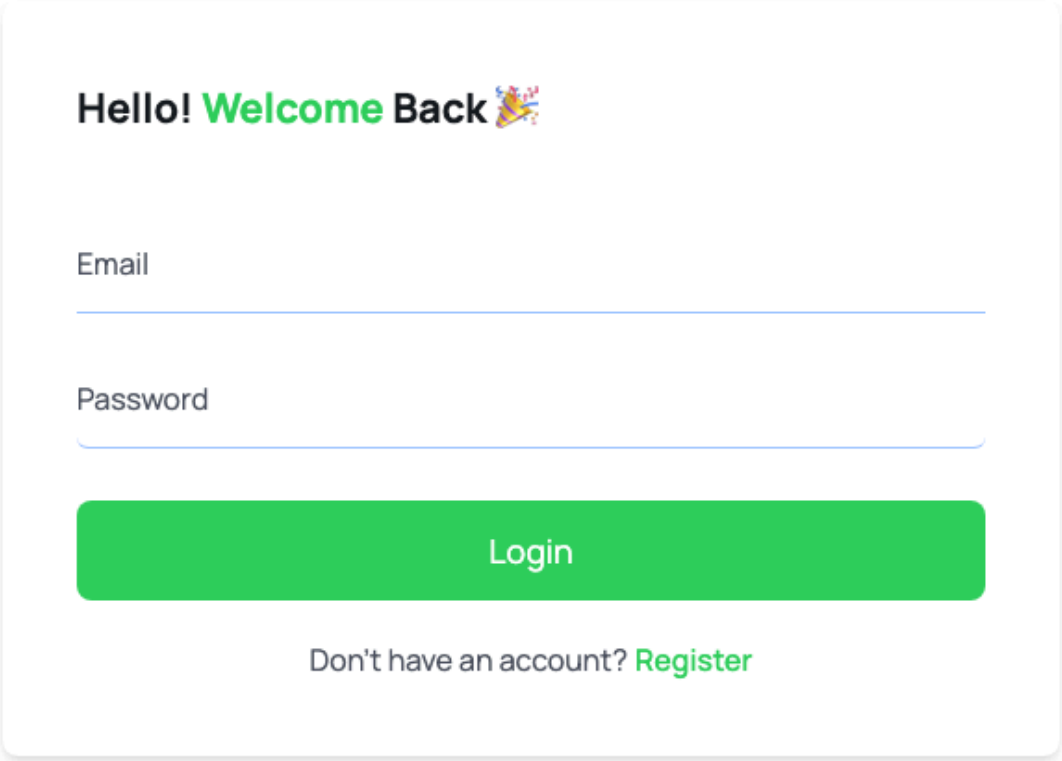
Data Handling: The MongoDB schema is optimized for quick transactions and data integrity, crucial for the appointment booking process.

Secure Authentication Flow: Advanced JWT usage ensures that all user interactions are securely authenticated, preventing unauthorized access.

Visual Documentation:

The final report will include comprehensive screenshots demonstrating each phase of the appointment booking process, from initial log-in to final confirmation, showcasing the system's ease of use and intuitive design.





Performance Evaluation and Future Enhancements:

The prototype testing has highlighted several areas for future enhancement:

Reducing API Response Times: I plan to refine the backend processes to further decrease response times, improving the system's overall efficiency.

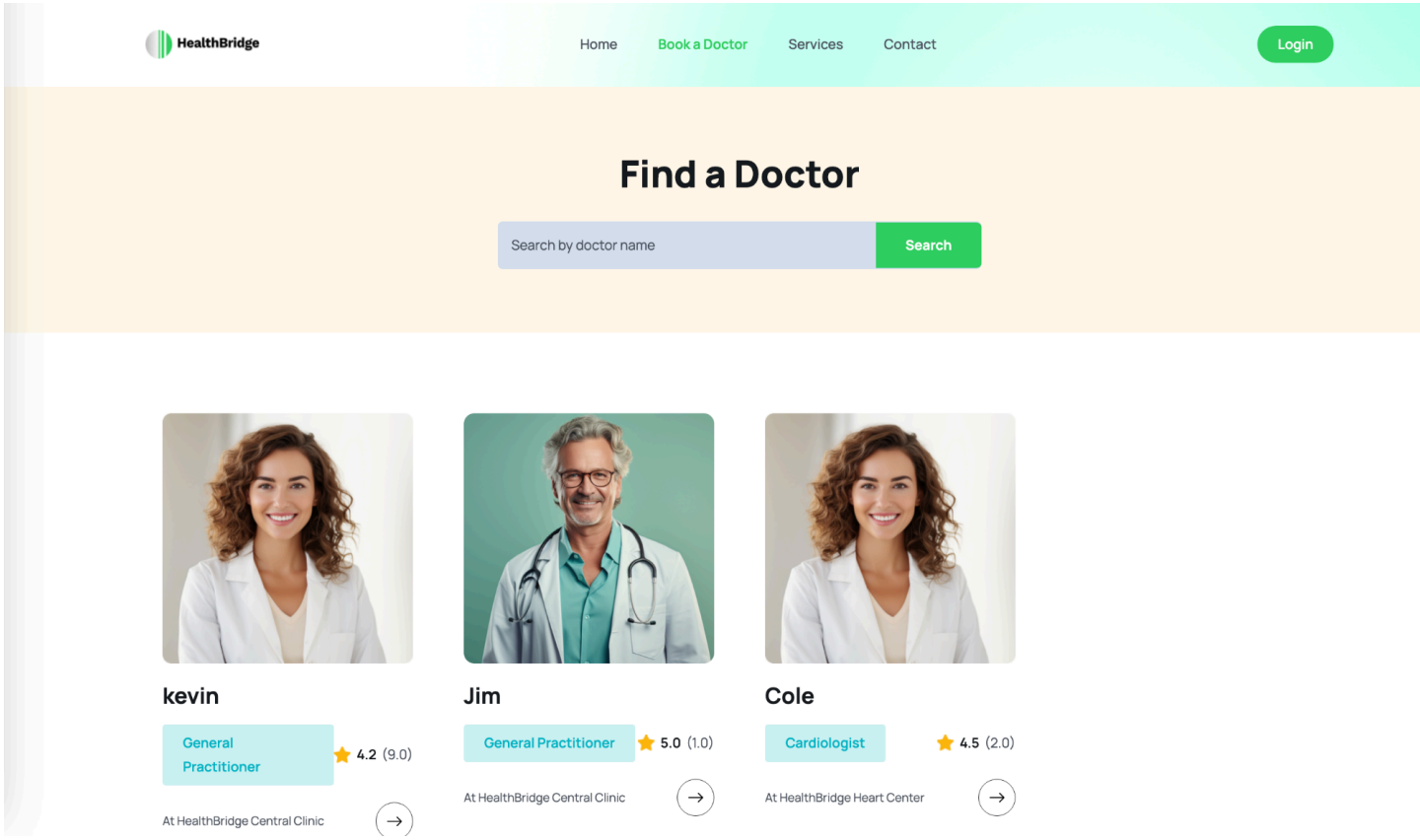
UI Enhancements for Better User Experience: Future updates will focus on increasing the interactivity of the user interface, adding more visual cues and feedback to guide users through the booking process more effectively.

Testing for Higher Traffic: Further scalability tests are essential to ensure the system remains stable and responsive as user numbers increase.

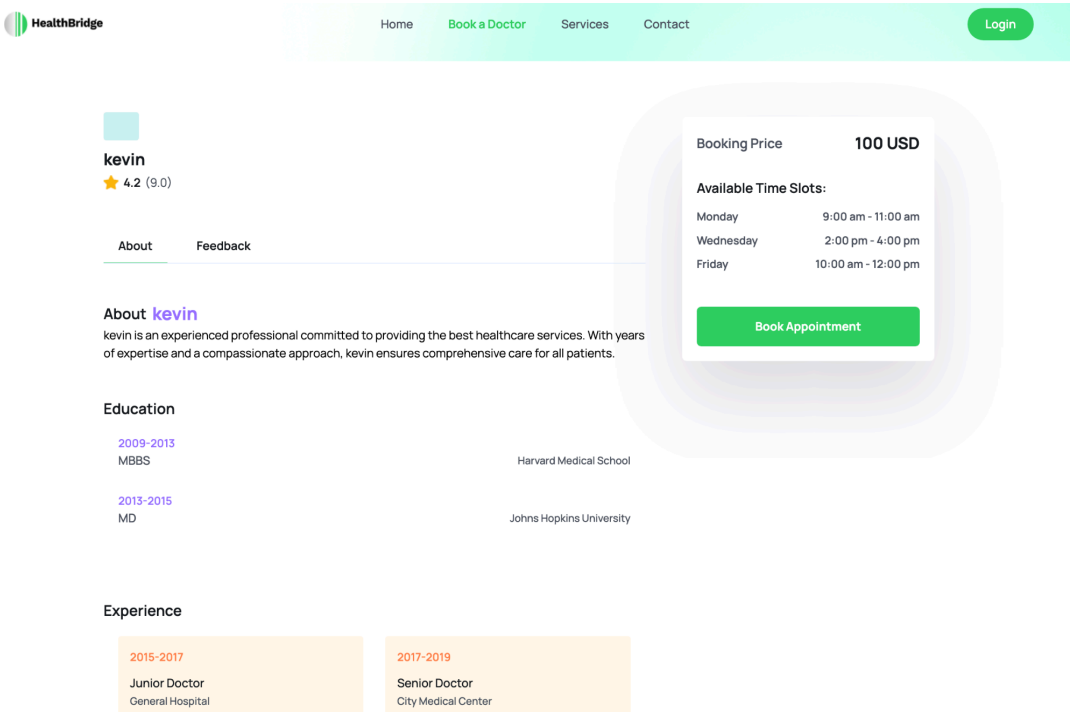
Adding Payment Functionality: Incorporating a secure payment system will enable direct handling of transactions within the app, streamlining the process for users paying for services.

Booking a Reservation:

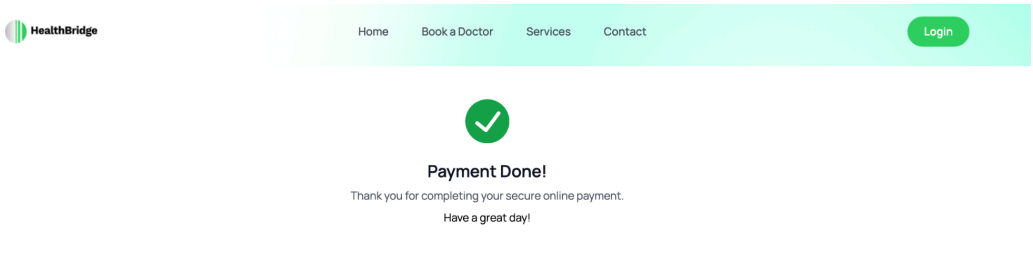
A patient searching for a doctor to book:



A patient viewing the details of a doctor and scheduling their appointment:



A payment confirmation screen is presented to the patient to confirm that the reservation has been booked successfully.



Booking Controller

In the HealthBridge application, booking a doctor's appointment is streamlined for patient convenience. The bookingController.js file manages this process by creating a booking object with details like the doctor's ID, user's ID, ticket price, and session ID. This object is then saved to the Atlas MongoDB cloud database, and a successful booking returns a confirmation response. Error logging is also in place to handle any issues, ensuring smooth operation.

```
    // Create a booking object with the necessary details
    const booking = new Booking({
      doctor: doctor._id,
      user: user._id,
      ticketPrice: ticketPrice, // Ensure ticketPrice is set
      session: session.id,
    });

    // Save the booking object to the database
    await booking.save();

    // Send the created session as a response
    res.status(200).json({ success: true, message: "Success", session });
  } catch (error) {
    // Log the error details to the console
    console.error("Error creating checkout session:", error.message);
    console.error("Stack trace:", error.stack);
```

Booking Schema

The bookingSchema.js file defines how booking data is structured. Each booking links to the doctor and user involved, includes the ticket price and tracks the booking status (pending, approved, or canceled). It also notes whether the booking has been paid for. This schema ensures all necessary information is organized and easily accessible for both patients and doctors.

```
/* ------------------------------------------------------------------------------------------ */
// Booking schema
const bookingSchema = new mongoose.Schema(
  {
    // Reference to the doctor associated with the booking
    doctor: {
      type: mongoose.Types.ObjectId,
      ref: "Doctor",
      required: true,
    },
    // Reference to the user associated with the booking
    user: {
      type: mongoose.Types.ObjectId,
      ref: "User",
      required: true,
    },
    // Ticket price for the booking
    ticketPrice: { type: String, required: true },
    // Status of the booking
    status: {
      type: String,
      enum: ["pending", "approved", "cancelled"],
      default: "pending",
    },
    // Payment status of the booking
    isPaid: {
      type: Boolean,
      default: true,
    },
  },
```

User Data LocalStorage

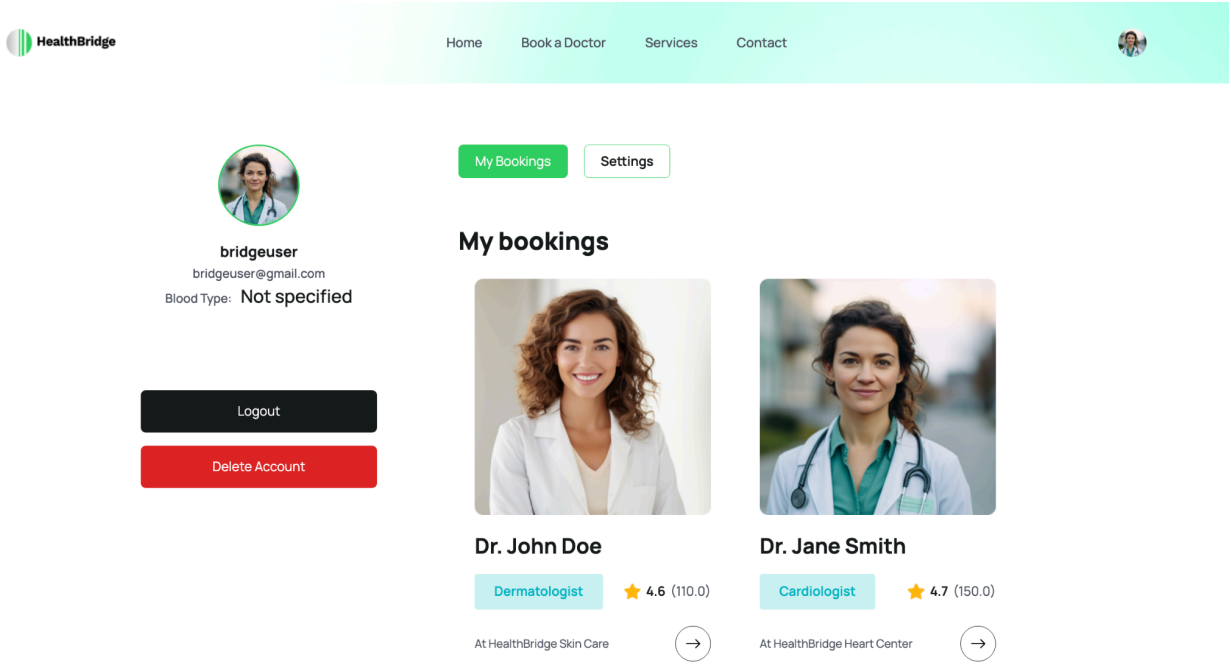
I've added a new feature to HealthBridge that keeps users logged in even after they refresh the page. This is done by saving the user's login details (like their information, role, and token) in the browser's local storage. Now, when users log in, they won't need to log in again if they refresh or reopen the browser. This improvement makes the application much easier to use by providing a smooth and continuous experience.

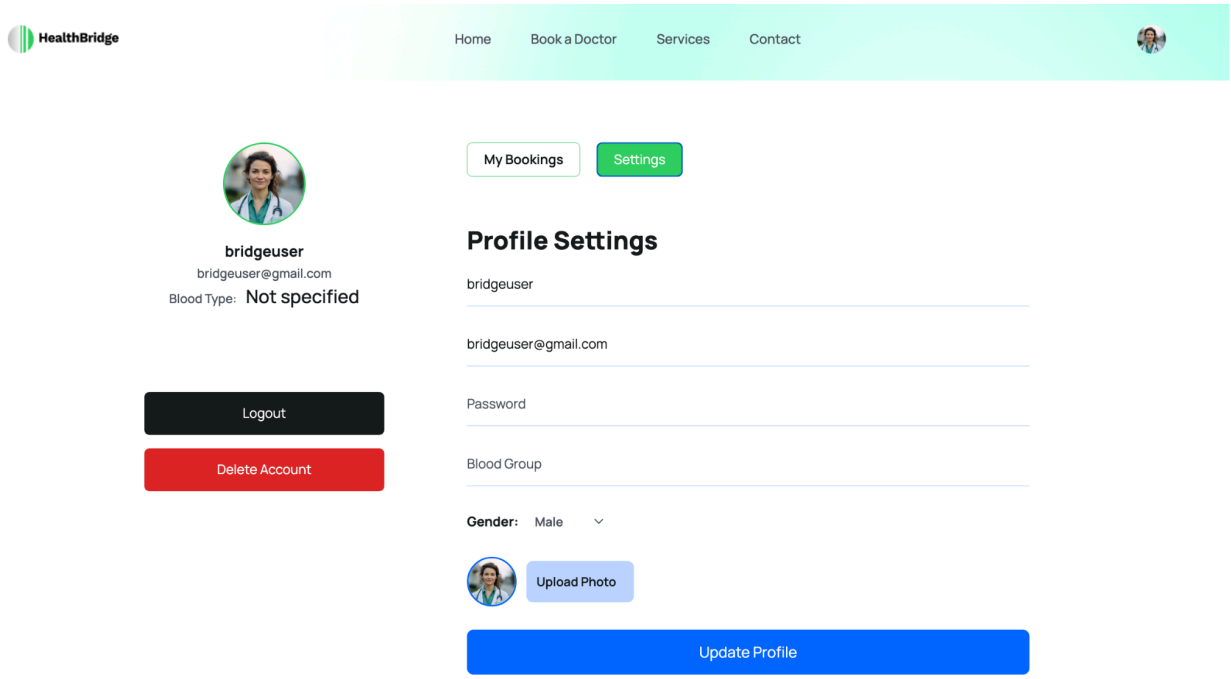
```
// Context provider component for authentication
export const AuthContextProvider = ({ children }) => {
    const [state, dispatch] = useReducer(AuthReducer, InitialState);

    useEffect(() => {
        // Save state to local storage whenever it changes
        localStorage.setItem("user", JSON.stringify(state.user));
        localStorage.setItem("token", state.token);
        localStorage.setItem("role", state.role);
    }, [state]);

    return (
        <AuthContext.Provider value={{
            user: state.user,
            token: state.token,
            role: state.role,
            dispatch,
        }}>
            {children}
        </AuthContext.Provider>
    );
};
```

Patient Dashboard

I've made some important updates to HealthBridge that enhance the patient experience. Patients can now stay logged in thanks to the use of local storage, which preserves their session even if they refresh the page.

The new personalized dashboard allows patients to view all their doctor appointments in one place, offering a clear and organized overview of both upcoming and past visits. Additionally, patients can update their profile settings directly from the dashboard, ensuring their information is always current which updates the mongoDB database collections. These enhancements make the application more user-friendly and give patients better control over their healthcare management.





CHAPTER 5: Implementation

Development Process

The implementation of the HealthBridge project was carried out through a detailed and organized approach to develop a secure and user-friendly healthcare application. This section outlines the steps I took to build the core functionalities of the application and address technical challenges.

1. Building the Prototype

Frontend Development

I began with the frontend development using React.js due to its flexibility and efficiency in creating dynamic user interfaces. My primary goal was to design a user-friendly appointment scheduling system.

Appointment Scheduling Interface: I developed an interface that allows users to easily select healthcare providers, view available time slots, and book appointments. Real-time updates ensure users have the latest information, avoiding scheduling conflicts.

Backend Development

For the backend, I selected Node.js and Express.js for their scalability and efficiency in handling server-side tasks such as user authentication and data management.

User Authentication: Secure authentication was implemented using JSON Web Tokens (JWT) to protect user sessions and sensitive information.

Data Processing and API Management: The backend efficiently handles API requests, managing user data and appointment scheduling. PostgreSQL was chosen as the database for its reliability and strong security features.

2. Implementing Security Measures

Security was a top priority given the sensitive nature of health data. I integrated robust encryption protocols to safeguard user information.

SSL/TLS Encryption: Data transmitted between the client and server is secured using SSL/TLS protocols to prevent unauthorized access.

Data Encryption: AES-256 encryption was used for data stored at rest to ensure the security of sensitive health information.

3. Internal Testing and Optimization

A thorough internal testing process was conducted to ensure the application met user needs and performed optimally. Various techniques were employed to refine and improve the platform.

Testing Techniques

Unit Testing: Individual components and functions were tested to ensure they operated correctly, focusing on specific parts such as functions or methods.

Integration Testing: Different modules and components were tested together to verify seamless interaction between the frontend and backend.
End-to-End Testing: Comprehensive tests simulating real user scenarios were conducted to validate the complete application flow, ensuring it functioned as expected from the user's perspective.

4. Enhancements and Final Adjustments

Based on the internal testing results, several improvements were made to enhance the platform's performance and user experience.

UI/UX Enhancements: The user interface was further simplified with visual cues and feedback mechanisms to guide users. Accessibility features were improved with larger icons and easier navigation.

Performance Optimization: Database queries were optimized and the codebase was refined to reduce API response times and improve server-side efficiency.

Scalability Testing: Scalability tests were conducted to ensure the platform could handle increased user loads without compromising performance, which is essential for high-demand scenarios.

CHAPTER 6: Evaluation

The evaluation of the HealthBridge project was conducted through a structured approach focusing on both functionality and performance. This section provides an in-depth analysis of the project's various components, emphasizing the effectiveness of the implemented features and the overall user experience.

1. Unit Testing

Unit testing was a crucial part of ensuring the robustness and reliability of the HealthBridge application. By isolating and testing individual components, I was able to identify and rectify issues early in the development process.

Methodology: Each module, including the appointment scheduling interface, user authentication, and data processing components, was tested independently.
The tests were designed to validate the correctness of each function and to ensure that all components worked as expected.

Results: The unit tests provided immediate feedback on the functionality of the code, allowing for quick modifications. This iterative process ensured that each

part of the application was reliable before moving on to the next development phase.

2. Integration Testing

Integration testing was performed to verify that the different modules of the application worked together seamlessly. This step was essential in ensuring that the interactions between the frontend and backend were smooth and error-free.

Methodology: I conducted tests that simulated real-world scenarios, where multiple components interacted with each other. This included booking appointments, accessing user data, and processing authentication requests.

Results: The integration tests confirmed that the various modules communicated correctly, and any issues detected were promptly resolved. This testing phase was crucial for ensuring the overall coherence of the application.

3. End-to-End Testing

End-to-end testing was used to validate the complete functionality of the HealthBridge application from the user's perspective. This comprehensive testing approach ensured that the application performed well under real-life conditions.

Methodology: Scenarios such as user registration, appointment booking, and data encryption during transmission were tested. These tests covered the entire user journey to ensure a smooth and intuitive experience.

Results: The end-to-end tests demonstrated that the application was user-friendly and functioned as intended in real-world scenarios. Any identified issues were addressed, enhancing the overall user experience.

4. Performance Evaluation

Performance evaluation focused on assessing the application's speed, responsiveness, and ability to handle multiple users simultaneously. This step was vital in ensuring that the application could scale effectively.

Methodology: I conducted stress tests to simulate high user loads and monitored the application's response times and resource usage. These tests helped identify potential bottlenecks and areas for optimization.

Results: The performance evaluation indicated that the application could handle high traffic volumes without significant slowdowns. Optimizations made during this phase improved the application's efficiency and scalability.

Critical Analysis

The evaluation process showed that the HealthBridge project successfully met its objectives. The unit, integration, and end-to-end tests ensured that the application was robust and reliable. Performance evaluation confirmed its ability to handle high traffic and identified areas for further optimization.

CHAPTER 7: Conclusion

Developing the HealthBridge project involved meticulous planning and a strong commitment to providing a healthcare platform for everyone. The primary goal was to create a non-profit healthcare application that meets the practical needs of underserved communities and becomes a trusted tool for managing and improving health outcomes.

Focusing on user-centered design, stringent data privacy, and personalized care powered by analytics, I aimed to create an inclusive, secure, and effective digital health solution. This project is not just about technology; it is about making a meaningful difference in the lives of its users by enhancing healthcare accessibility and efficiency.

The approach detailed in this report shows a clear path to developing a non-profit healthcare web application that addresses critical needs within underserved communities. By leveraging advanced technology and emphasizing user-centric design principles, this project is poised to significantly improve healthcare accessibility and effectiveness. With continuous improvements and adaptations, the HealthBridge project will remain a valuable resource, ensuring quality healthcare is accessible to everyone in need.

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