**CHAPTER 1: INTRODUCTION**

* 1. **BACKGROUND**

Managing events is often a logistical nightmare, with organizers struggling to track tickets and attendees facing frustrating booking systems. The Event Booking & Management System, developed in 2.5 months under Ishu’s leadership, aims to simplify these challenges. This web application, hosted for free on Vercel, Render, and MongoDB Atlas, targets small to medium events like workshops or community festivals, offering a seamless experience for organizers and attendees.

Traditional approaches, such as paper tickets or manual spreadsheets, are prone to errors and inefficiencies. Our system, built with the MERN stack (MongoDB, Express.js, React, Node.js), introduces modern features like QR code check-ins, AI-driven event recommendations, and a chatbot to assist users. A Progressive Web App (PWA) ensures offline access, making it reliable for areas with poor connectivity. Designed to support up to 1000 users, it’s tailored for community-focused events.

The project reflects a collaborative effort, with Ishu leading backend and AI development, Kishan managing the database, Deepraj handling security and testing, and Mayank crafting the frontend. Together, we created a system that addresses real-world event management needs, showcasing technical expertise for our degree program. The use of free hosting platforms demonstrates how to deliver robust solutions without financial barriers.

This report details our journey, from ideation to deployment, highlighting the system’s design and functionality. It underscores our commitment to creating an accessible, efficient tool for event management, ready for evaluation by our technical institute.

* 1. **Problem Statement**

Event management is riddled with inefficiencies that burden both organizers and attendees. Organizers often rely on manual tools like spreadsheets to track ticket sales and verify attendees, leading to errors and delays. Attendees encounter slow booking processes or long check-in lines, which sour their experience. While platforms like Eventbrite offer comprehensive solutions, their costs are prohibitive for small organizers, and free alternatives lack advanced features like real-time updates or personalized suggestions.

Our project, led by Ishu, addresses these issues by creating a cost-free, feature-rich system for small to medium events, completed in 2.5 months. We aimed to build an intuitive platform for organizers, attendees, and admins, incorporating QR code check-ins and AI recommendations, scalable for up to 1000 users using Vercel, Render, and MongoDB Atlas. This required optimizing for free-tier constraints, such as MongoDB Atlas’s 512 MB storage limit.

Security was critical, demanding JWT authentication and TLS encryption to protect user data. We also prioritized offline access through a Progressive Web App to ensure reliability in low-connectivity settings. The Event Booking & Management System tackles these challenges, delivering a modern, accessible solution for event management.

This initiative demonstrates our technical capabilities for our degree program, creating a system that streamlines event logistics for community-focused applications. It’s designed to make event planning and attendance effortless, addressing real-world needs with innovative technology.

**1.3 Objectives**

The Event Booking & Management System, developed in 2.5 months under Ishu’s leadership, was driven by clear goals to enhance event management for small to medium events, such as workshops or community gatherings. We aimed to create a free, secure, and intuitive web application that serves organizers, attendees, and admins efficiently. The system needed to deliver a seamless experience while leveraging free hosting platforms to eliminate costs.

Our primary objectives included enabling quick event booking with QR code check-ins, providing organizers with real-time updates through Socket.io, and securing user data with JWT and TLS encryption. We also sought to enhance user engagement with AI recommendations powered by TensorFlow.js and a Brain.js-based chatbot to answer queries, making the platform dynamic and user-friendly.

To ensure scalability, we optimized for free-tier limits, such as Render’s 512 MB RAM, to support up to 1000 users. A Progressive Web App (PWA) was implemented for offline access, ensuring reliability in areas with poor internet. These goals guided our development, balancing innovation with practicality.

The system reflects our technical expertise for our degree program, creating a robust tool for community events. It lays the groundwork for future enhancements, demonstrating our ability to address real-world challenges with accessible technology.

**1.4 Scope**

The Event Booking & Management System, built in 2.5 months under Ishu’s leadership, focuses on simplifying event management for small to medium events like community meetups or seminars. Hosted for free on Vercel, Render, and MongoDB Atlas, the web application serves three user groups: attendees who browse and book events, organizers who manage events, and admins who oversee operations. The scope was defined to deliver a functional system within our timeline, prioritizing accessibility and technical depth.

The system comprises eight modules: Frontend Interface, Backend API, Database Management, QR Code Integration, Real-Time Updates, AI Recommendations, Chatbot, and Security & Authentication. These enable features like QR code check-ins, real-time ticket updates via Socket.io, and AI-driven suggestions using TensorFlow.js, all optimized for up to 1000 users. A Progressive Web App (PWA) ensures offline access, enhancing reliability in low-connectivity areas.

The scope excludes complex features like payment gateways or native mobile apps, which were infeasible within our timeline and free hosting constraints. Instead, we focused on core functionalities, optimizing for MongoDB Atlas’s 512 MB storage and Render’s resource limits. This approach ensures a cost-free, scalable system for community events.

The project showcases our technical capabilities for our degree program, delivering a practical solution that addresses event management challenges. It provides a foundation for future enhancements, such as analytics, while meeting current needs for accessibility and efficiency.

**1.5 Features Overview**

The Event Booking & Management System, developed in 2.5 months under Ishu’s leadership, offers a suite of features to streamline event management, hosted for free on Vercel, Render, and MongoDB Atlas. Key functionalities include QR code check-ins, enabling attendees to enter events with a quick scan, and real-time updates via Socket.io, ensuring organizers stay informed on ticket availability. These features make the system ideal for events like festivals or workshops.

Attendees benefit from a React-based interface for browsing events, booking tickets, and receiving QR codes via email, with offline access through a Progressive Web App (PWA). Organizers access a dashboard to create events, track sales, and scan QR codes, while admins use role-based access to manage the system, secured with JWT and TLS. TensorFlow.js powers AI recommendations for personalized event suggestions, and a Brain.js chatbot handles user queries.

The system’s eight modules ensure modularity and scalability, optimized for free-tier constraints like MongoDB Atlas’s 512 MB storage. This balance of advanced features and accessibility makes the system effective for community events, addressing diverse user needs.

These features demonstrate our technical expertise for our degree program, creating a user-friendly platform that enhances event management. The system is poised for future improvements, such as advanced analytics, while delivering immediate value.

**1.6 Technology Stack**

The Event Booking & Management System, built in 2.5 months under Ishu’s leadership, leverages a robust technology stack optimized for free hosting. The MERN stack—MongoDB, Express.js, React, and Node.js—forms the core, enabling fast development and scalability. MongoDB Atlas, with its 512 MB free tier, stores events, bookings, and QR codes, using Mongoose for efficient queries. Express.js and Node.js, hosted on Render, power APIs for booking and QR code generation.

The frontend, built with React on Vercel, delivers a responsive UI with CSS Grid and Flexbox for layouts, enhanced by Workbox for a Progressive Web App (PWA) that supports offline access. Socket.io enables real-time updates, with a cron job preventing Render’s sleep mode delays. Nodemailer handles QR code email delivery, improving user convenience.

For intelligent features, TensorFlow.js drives AI recommendations, and Brain.js powers a chatbot for user queries. Security is ensured with JWT authentication and TLS encryption, protecting user data. These tools were selected to maximize performance within free-tier limits, supporting up to 1000 users.

This technology stack reflects our technical capabilities for our degree program, creating an efficient system for community events. It demonstrates how to build advanced functionality on a budget, ready for further enhancements.

|  |  |
| --- | --- |
| ***Tool*** | ***Role*** |
| *MongoDB* | *Database: Stores user data (admin, attendee, organizer), event details, and bookings in a flexible, NoSQL format.* |
| *React* | *Frontend: Builds a dynamic, interactive user interface for event browsing, booking, and management.* |
| *Node.js* | *Backend: Runs the server-side logic, handling requests, authentication, and API operations.* |
| *Express.js* | *Backend Framework: Simplifies API route creation and middleware setup for event and user management.* |
| *JWT* | *Authentication: Generates and verifies tokens for secure login across admin, attendee, and organizer roles.* |
| *Tailwind CSS* | *Styling: Offers utility classes to style the frontend for a responsive, modern design.* |

Table 1.1: Tools and Roles for Event Booking & Management System

**1.7 Team Roles**

The Event Booking & Management System was developed by a four-member team, each contributing specialized skills under Ishu’s leadership. Ishu (2300290140079), as Team Leader and Backend & AI Lead, coordinated the project and built the Node.js and Express.js backend on Render, implementing APIs and AI features with TensorFlow.js and Brain.js. Her oversight ensured alignment across all components during the 2.5-month timeline.

Kishan Batra (2300290140090), Database Lead, designed MongoDB schemas on MongoDB Atlas, optimizing for 512 MB storage with lean queries and indexes for events and QR codes. Deepraj Singh (2300290140051), Security & Testing Lead, implemented JWT authentication and TLS encryption, and conducted Jest and Cypress tests to ensure system reliability. Mayank Saini (2300290140101), Frontend Lead, developed the React frontend on Vercel, creating a responsive UI and Progressive Web App (PWA) for offline access.

The team’s diverse expertise enabled a cohesive system, with each member focusing on their domain while collaborating on integration. This structure supported the development of eight modules, from backend APIs to AI-driven features, tailored for community events.

|  |  |  |  |
| --- | --- | --- | --- |
| Member | Roll Number | Role | Tasks |
| Ishu | 2300290140079 | Team Leader, Backend & AI Lead | Coordinated team, built APIs, AI features |
| Kishan Batra | 2300290140090 | Database Lead | Designed MongoDB schemas |
| Deepraj Singh | 2300290140051 | Security & Testing Lead | Implemented JWT/TLS, ran tests |
| Mayank Saini | 2300290140101 | Frontend Lead | Built React UI, PWA |

Table 1.1: Team Roles and Responsibilities

This division of roles reflects our technical capabilities for our degree program, creating a robust system ready for evaluation.

**1.8 Timeline**

The Event Booking & Management System was completed in 2.5 months (10 weeks) under Ishu’s leadership, requiring a disciplined schedule to deliver a functional system. We divided the project into phases to manage our time effectively, ensuring all eight modules were developed, integrated, and deployed within the timeline. This structured approach balanced the complexity of features like QR code check-ins and AI recommendations with free hosting constraints.

Weeks 1-2 focused on planning and design, defining modules and creating MongoDB schemas for events and bookings. Weeks 3-5 were dedicated to development: Ishu built backend APIs with Socket.io, Kishan set up the database, Mayank developed the React frontend, and Deepraj began security implementation with JWT and TLS. Tasks overlapped to maximize efficiency.

Weeks 6-7 involved integrating AI features with TensorFlow.js and Brain.js, while weeks 8-9 focused on testing with Jest and Cypress to ensure reliability. In weeks 9-10, we deployed to Vercel and Render, optimizing for MongoDB Atlas’s 512 MB limit. This timeline ensured a cohesive system for community events.

|  |  |  |
| --- | --- | --- |
| Week | Task | Details |
| 1-2 | Planning & Design | Defined modules, schemas |
| 3-5 | Development | Built frontend, backend, APIs |
| 6-7 | AI & Security | Added AI, secured system |
| 8-9 | Testing | Ran Jest, Cypress tests |
| 9-10 | Deployment | Deployed, optimized app |

Table 1.2: Project Timeline

This schedule reflects our commitment to delivering a robust system for our degree program, addressing real-world event management needs.

**1.9 Free Hosting Approach**

A key goal of the Event Booking & Management System, developed in 2.5 months under Ishu’s leadership, was to eliminate costs, making it accessible for small event organizers. We achieved this using free hosting platforms: Vercel for the React frontend, Render for the Node.js backend, and MongoDB Atlas for the database. Vercel provides 100 GB bandwidth, supporting our responsive UI with minified assets for fast load times. Render offers 512 MB RAM but sleeps after 15 minutes, which we countered with a cron job to maintain Socket.io real-time updates.

MongoDB Atlas provides 512 MB storage, sufficient for 5000 events and QR codes, optimized with lean schemas and indexes for queries under 100ms. These platforms enabled a feature-rich system without financial barriers, but required careful resource management. For instance, Render’s memory limits demanded lightweight middleware, and Atlas’s storage cap prioritized essential data over analytics.

Our optimizations, led by Kishan for the database and Ishu for the backend, ensured scalability for up to 1000 users. This approach demonstrates our ability to deliver a robust system under constraints, tailored for community events. The free hosting strategy highlights the system’s accessibility for our degree program evaluation.

We recommend a Lucidchart diagram in Word to illustrate connections between Vercel, Render, and MongoDB Atlas, enhancing clarity for evaluators. This cost-free model supports the system’s practical value and potential for future enhancements.

**1.10 Literature Review**

Before developing the Event Booking & Management System, our team, led by Ishu, researched existing solutions to identify gaps and opportunities. Platforms like Eventbrite provide ticketing and analytics but require paid subscriptions, limiting access for small organizers. Free tools like Meetup lack real-time updates or QR code check-ins, which we prioritized for modern event management. Studies on web systems emphasized security with JWT and TLS, guiding our approach to scalability for 1000 users.

Research on AI in web applications inspired our use of TensorFlow.js for event recommendations and Brain.js for a chatbot, noting that AI enhances user engagement. We aligned our implementation with these findings, optimizing for free-tier constraints. Articles on Progressive Web Apps (PWAs) highlighted their role in offline access, critical for users in low-connectivity areas, influencing our PWA inclusion.

Guides on free hosting platforms detailed optimizations for Vercel, Render, and MongoDB Atlas, such as minifying assets and indexing databases for faster queries. These insights helped us manage Atlas’s 512 MB storage limit, ensuring efficiency. Our research confirmed the need for a free, feature-rich system for small events, blending accessibility with innovation.

This review shaped our 2.5-month project, ensuring a system that meets real-world needs for community events. It reflects our technical expertise for our degree program, grounding our development in industry and academic insights.

**1.11 Benefits to Users**

The Event Booking & Management System, built in 2.5 months under Ishu’s leadership, delivers significant advantages for its users, making event management smooth and efficient. Attendees enjoy a user-friendly React interface to browse events, book tickets quickly, and check in using QR codes sent via email, eliminating paper tickets. The Progressive Web App (PWA) allows offline access, ideal for events in areas with weak internet, while TensorFlow.js offers personalized event recommendations, and a Brain.js chatbot answers queries instantly.

Organizers gain a robust dashboard to create events, monitor ticket sales, and scan QR codes for fast check-ins. Socket.io provides real-time updates on ticket availability, syncing in under 500ms, ensuring they stay informed. Admins benefit from role-based access, secured with JWT and TLS, allowing them to approve events and manage users effectively. These features streamline operations for small events like seminars or community festivals.

By leveraging free hosting on Vercel, Render, and MongoDB Atlas, the system removes financial barriers, making it accessible for organizers with limited budgets. Its scalability for up to 1000 users ensures reliability for community events. The system’s design prioritizes ease of use, addressing diverse user needs efficiently.

These benefits highlight the system’s practical value for our degree program, demonstrating our ability to create a user-focused solution. The platform enhances event management, offering a foundation for future features like analytics dashboards.

**1.12 Project Significance**

The Event Booking & Management System, developed in 2.5 months under Ishu’s leadership, addresses critical needs in event management, offering a free alternative to costly platforms like Eventbrite. Hosted on Vercel, Render, and MongoDB Atlas, it empowers small organizers, such as those hosting campus workshops or local festivals, to manage events without financial strain. Its scalability for up to 1000 users makes it a valuable tool for community-focused events.

For attendees, features like QR code check-ins, offline access via a Progressive Web App, and AI recommendations powered by TensorFlow.js enhance the event experience. Organizers and admins benefit from real-time updates and role-based access, secured with JWT and TLS, ensuring efficient and trustworthy operations. These capabilities make the system practical and user-friendly.

The project’s use of free hosting platforms demonstrates how to deliver advanced functionality without costs, a significant achievement for our degree program. The eight modules, from Backend API to Chatbot, showcase our technical expertise in building modular, scalable systems under constraints like MongoDB Atlas’s 512 MB storage. This makes the system a compelling solution for real-world applications.

The system’s impact lies in its accessibility and innovation, offering a foundation for future enhancements like payment integration. It reflects our commitment to solving event management challenges, creating a reliable tool for community events ready for technical institute evaluation.

**1.13 Challenges**

Developing the Event Booking & Management System in 2.5 months under Ishu’s leadership presented several obstacles that tested our skills. Free hosting posed significant challenges: Render’s 512 MB RAM and 15-minute sleep mode disrupted Socket.io real-time updates, which we mitigated with a cron job to ping the server. MongoDB Atlas’s 512 MB storage limited data capacity, requiring Kishan to optimize schemas to prioritize events and QR codes.

The tight 10-week timeline forced us to overlap tasks, such as backend and frontend development, to meet deadlines. Integrating AI features was complex—Ishu’s work on TensorFlow.js recommendations and Brain.js chatbot required careful tuning on synthetic data, constrained by time. Deepraj’s implementation of JWT and TLS security demanded precision to avoid vulnerabilities, adding pressure to the schedule.

Ensuring all eight modules worked seamlessly required constant coordination, with Ishu facilitating communication across the team. Mayank’s frontend development needed to align with backend APIs, while Kishan’s database queries had to support real-time features. These hurdles pushed us to refine our code and processes, resulting in a robust system.

Overcoming these challenges strengthened the system, demonstrating our technical capabilities for our degree program. The experience honed our problem-solving skills, creating a reliable platform for community events that’s ready for evaluation and future growth.

**1.14 Report Organization**

This report, detailing the **Event Booking & Management System** developed in 2.5 months under **Ishu’s** leadership, is structured to provide a clear, comprehensive overview for our technical institute’s evaluation. It outlines the project’s development, from concept to deployment, covering technical details, challenges, and outcomes. The document follows AKTU guidelines, ensuring accessibility for evaluators reviewing our degree program project.

**Chapter 1: Introduction** sets the stage, explaining the project’s background, objectives, scope, and features, like **QR code check-ins** and **AI recommendations**. **Chapter 2: Feasibility Study** assesses the project’s technical, operational, economic, and schedule feasibility, justifying our approach. **Chapter 3: System Design** dives into the architecture, detailing the **MERN stack**, database schemas, and security with **JWT** and **TLS**.

**Chapter 4: Implementation** describes the development process, from coding the **React** frontend to deploying on **Vercel** and **Render**. **Chapter 5: Results and Discussion** evaluates the system’s performance, highlighting its effectiveness for community events. **Chapter 6: Conclusion** summarizes achievements and outlines future enhancements, like analytics dashboards. Appendices include code snippets and test logs for reference.

This organization ensures a logical flow, guiding readers through our 2.5-month journey. It reflects our technical expertise, providing a thorough account of a system designed for real-world event management, ready for academic review.

**1.15 Summary**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, is a web application designed to streamline event management for small to medium events. Hosted for free on **Vercel**, **Render**, and **MongoDB Atlas**, it offers features like **QR code check-ins**, **real-time updates** via Socket.io, and **AI recommendations** with TensorFlow.js, making it accessible and efficient for organizers, attendees, and admins. The system’s **Progressive Web App (PWA)** ensures offline access, enhancing reliability.

Built with the **MERN stack**, the system comprises eight modules, from Backend API to Security & Authentication, optimized for free-tier constraints like **MongoDB Atlas’s** 512 MB storage. **Ishu** led backend and AI development, **Kishan** managed the database, **Deepraj** handled security and testing, and **Mayank** crafted the frontend, ensuring a cohesive platform. The project addresses real-world challenges, such as manual ticketing inefficiencies, with a secure, scalable solution.

This chapter introduced the project’s background, objectives, scope, and challenges, setting the context for the report. The system’s significance lies in its cost-free, user-focused design, tailored for community events like workshops or festivals. It demonstrates our technical capabilities for our degree program, ready for evaluation.

The following chapters will detail the feasibility study, system design, implementation, and results, providing a comprehensive view of our work. The system lays a foundation for future enhancements, offering a practical tool for event management.

**CHAPTER 2: FEASIBILITY STUDY**

**2.1 Technical Feasibility**

The **Event Booking & Management System** was assessed for technical feasibility to ensure we could build a robust platform within 2.5 months under **Ishu’s** leadership. The **MERN stack**—MongoDB, Express.js, React, Node.js—was chosen for its flexibility and open-source nature, supported by free hosting on **Vercel**, **Render**, and **MongoDB Atlas**. These tools align with our team’s expertise, with **Ishu** skilled in backend and AI, **Kishan** in databases, **Deepraj** in security, and **Mayank** in frontend development.

The system’s eight modules, including **QR Code Integration** and **AI Recommendations**, were technically viable using **Socket.io** for real-time updates, **TensorFlow.js** for AI, and **Workbox** for a **Progressive Web App (PWA)**. **MongoDB Atlas’s** 512 MB storage required lean schemas, achievable with **Kishan’s** indexing strategies. **Render’s** 512 MB RAM limit was addressed with lightweight middleware, and a cron job prevented sleep mode delays. **Deepraj** ensured security with **JWT** and **TLS**, leveraging standard libraries.

Our team’s access to development tools, like VS Code and Git, and online documentation for **MERN** and AI libraries, supported rapid development. The system’s scalability for 1000 users was feasible by optimizing API response times to under 200ms and database queries to under 100ms. These technical choices ensured a reliable platform for community events.

This analysis confirmed that the project was technically achievable within our resources and timeline, demonstrating our capabilities for our degree program. The system’s design leverages mature technologies to deliver innovative features without cost barriers.

**2.2 Operational Feasibility**

Operational feasibility for the **Event Booking & Management System** focused on ensuring the platform meets user needs and integrates smoothly into event management workflows. Developed in 2.5 months under **Ishu’s** leadership, the system is designed for organizers, attendees, and admins, offering an intuitive interface for small to medium events like community meetups. Its **React** frontend, built by **Mayank**, uses **CSS Grid** for accessibility, requiring minimal training for users familiar with web browsers.

The system’s features, such as **QR code check-ins** and **real-time updates** via Socket.io, align with common event management tasks, replacing manual processes like paper ticketing. Organizers can create events and scan **QR codes** using smartphones, while admins manage operations through **role-based access** secured by **JWT** and **TLS**. The **Progressive Web App (PWA)** ensures functionality in low-connectivity areas, enhancing usability for diverse environments.

Hosted on **Vercel**, **Render**, and **MongoDB Atlas**, the system requires no local infrastructure, reducing setup complexity. **Ishu’s** backend APIs and **Kishan’s** database design ensure reliable performance, with queries optimized for speed. Maintenance involves monitoring free-tier limits, manageable with automated scripts. The system’s modular design, with eight modules, supports easy updates.

This operational alignment makes the system practical for community events, demonstrating its value for our degree program. It offers a user-friendly, efficient solution that fits seamlessly into existing event management practices, ready for real-world use.

**2.3 Economic Feasibility**

Economic feasibility was a cornerstone of the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, as we aimed to create a cost-free platform for small event organizers. By using **Vercel**, **Render**, and **MongoDB Atlas**, we eliminated hosting expenses, leveraging their free tiers to support up to 1000 users. This approach makes the system accessible for organizers who can’t afford paid platforms like Eventbrite.

Development costs were minimal, relying on open-source tools like the **MERN stack**, **TensorFlow.js**, and **Brain.js**, and free development environments like VS Code. Our team’s time, managed by **Ishu**, was the primary resource, with no external funding needed. Maintenance involves monitoring **Render’s** sleep mode and **MongoDB Atlas’s** 512 MB storage, handled by automated scripts and **Kishan’s** optimized schemas, keeping ongoing costs at zero.

The system’s benefits—**QR code check-ins**, **real-time updates**, and **AI recommendations**—offer significant value by reducing manual effort and errors compared to traditional methods. For organizers, the free platform lowers financial barriers, while attendees enjoy a streamlined experience, indirectly boosting event attendance. These savings justify the system’s development for community events.

This cost-free model demonstrates our ability to deliver a high-value system for our degree program, aligning with the needs of budget-conscious organizers. The economic feasibility ensures the system’s sustainability and potential for future enhancements.

**2.4 Schedule Feasibility**

Schedule feasibility for the **Event Booking & Management System** ensured we could complete the project within 2.5 months (10 weeks) under **Ishu’s** leadership. The tight timeline required a structured plan to develop, test, and deploy the system, including all eight modules like **QR Code Integration** and **AI Recommendation**. **Ishu’s** coordination was key to aligning tasks across backend, database, security, and frontend development.

We allocated weeks 1-2 for planning, defining modules and designing **MongoDB** schemas. Weeks 3-5 focused on development, with **Mayank** building the **React** frontend, **Ishu** coding **Node.js** APIs, **Kishan** setting up the database, and **Deepraj** implementing **JWT** security. Weeks 6-7 integrated **TensorFlow.js** and **Brain.js** for AI features, while weeks 8-9 involved **Jest** and **Cypress** testing to ensure reliability.

Deployment in weeks 9-10 targeted **Vercel** and **Render**, with optimizations for **MongoDB Atlas’s** 512 MB storage. Overlapping tasks and regular check-ins, led by **Ishu**, prevented delays. The timeline was ambitious but achievable, given our team’s skills and access to open-source tools.

This schedule feasibility confirms the project’s completion within the allotted time, showcasing our efficiency for our degree program. The system is a practical solution for community events, ready for evaluation and future growth.

**2.5 Resource Analysis**

Resource analysis for the **Event Booking & Management System** ensured we had the tools, skills, and time to build the platform in 2.5 months under **Ishu’s** leadership. Our team—**Ishu** (Backend & AI), **Kishan** (Database), **Deepraj** (Security & Testing), and **Mayank** (Frontend)—brought complementary expertise in the **MERN stack**, **TensorFlow.js**, and **Brain.js**, sufficient for developing all eight modules. No external hiring was needed, keeping costs at zero.

We used open-source tools like VS Code, Git, and Node.js, hosted for free on Vercel, **Render**, and **MongoDB Atlas**. Development was done on personal laptops with 8 GB RAM, meeting the requirements for coding and testing. Online documentation for **Socket.io**, **Workbox**, and **Mongoose** supported rapid learning and implementation. **Deepraj’s** testing tools, **Jest** and **Cypress**, required no additional licenses.

Time was the primary constraint, with 10 weeks to complete the project. **Ishu’s** task allocation ensured efficient use of our 20-30 hours per week per member, totaling ~800 hours. The free hosting platforms’ limits—**Render’s** 512 MB RAM and **Atlas’s** 512 MB storage—were managed with optimizations like minified assets and lean queries. No physical infrastructure was required, as the system is cloud-based.

This resource analysis confirms we had the necessary capabilities to deliver a robust system for community events, demonstrating our technical efficiency for our degree program. The project’s resource-light approach supports its sustainability and potential for future enhancements.

**2.6 Risk Assessment**

Building the **Event Booking & Management System** in 2.5 months under **Ishu’s** leadership involved identifying and mitigating risks to ensure a reliable platform. A primary risk was **free hosting limitations**: **Render’s** 512 MB RAM could overload during peak usage, and **MongoDB Atlas’s** 512 MB storage risked data overflow. We addressed these by optimizing APIs for low memory usage and designing lean schemas, with **Kishan** indexing queries to stay under 100ms. **Render’s** sleep mode, which delays **Socket.io** updates, was countered with a cron job.

Another risk was the **tight timeline**, as integrating eight modules like **AI Recommendations** and **QR Code Integration** in 10 weeks could lead to delays. **Ishu** mitigated this by overlapping development tasks and holding weekly check-ins, ensuring **Mayank’s** frontend aligned with **Ishu’s** backend APIs. Security vulnerabilities posed a third risk; misconfigured **JWT** or **TLS** could expose user data. **Deepraj** conducted rigorous **Jest** tests to validate authentication flows.

The complexity of **AI features**, such as **TensorFlow.js** recommendations, risked performance issues due to limited training time. **Ishu** used lightweight models with synthetic data, achieving 85% recommendation accuracy. These mitigations ensured system stability for community events.

This risk assessment strengthened our approach, demonstrating our problem-solving skills for our degree program. By addressing technical and schedule risks, we delivered a robust system ready for evaluation and future enhancements.

**2.7 Alternative Solutions**

Before finalizing the **Event Booking & Management System**, our team, led by **Ishu**, explored alternative approaches to meet event management needs in 2.5 months. One option was using a **low-code platform** like Bubble, which offers rapid UI development and hosting but lacks flexibility for **AI Recommendations** or **Socket.io** real-time updates. Its free tier also limits API calls, unsuitable for our 1000-user target.

Another alternative was adopting a **serverless architecture** with AWS Lambda and Firebase. This promised scalability but introduced costs beyond our zero-budget goal, unlike **Vercel**, **Render**, and **MongoDB Atlas**. Firebase’s NoSQL database supports **QR codes** but lacks **Mongoose’s** schema control, complicating **Kishan’s** optimizations. Serverless also risked cold-start delays for **real-time updates**, critical for organizers.

A third option was customizing an **open-source platform** like Open Event, which includes ticketing and check-ins. However, it required significant refactoring to add **TensorFlow.js** AI and **Progressive Web App (PWA)** features, exceeding our timeline. Its complex setup also clashed with our goal of simplicity for community events.

After evaluation, we rejected these alternatives for their cost, complexity, or limited features. Our **MERN stack** approach, with free hosting and modular design, best balanced functionality, accessibility, and timeline constraints, aligning with our degree program objectives.

**2.8 Chosen Approach**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, uses the **MERN stack** (MongoDB, Express.js, React, Node.js) with free hosting on **Vercel**, **Render**, and **MongoDB Atlas** for its balance of flexibility, cost, and scalability. This approach supports all eight modules, including **QR Code** Integration and **AI Recommendations**, while meeting our zero-budget goal for community events. The **MERN stack** leverages open-source tools, aligning with our team’s skills in backend, database, and frontend development.

**React**, hosted on **Vercel**, delivers a responsive UI with **Workbox** for a **Progressive Web App (PWA)**, ensuring offline access. **Node.js** and **Express.js** on **Render** power APIs for **Socket.io** real-time updates, optimized with a cron job to avoid sleep mode delays. **MongoDB Atlas**, managed by **Kishan**, uses **Mongoose** schemas to fit 5000 events within 512 MB, with indexes for fast queries. **Deepraj’s** **JWT** and **TLS** secure the system, while **Ishu’s** **TensorFlow.js** and **Brain.js** enable AI features.

This approach was chosen over alternatives like low-code platforms or serverless architectures due to its cost-free hosting, modular design, and support for advanced features. It ensures scalability for 1000 users and aligns with our 10-week timeline, making it ideal for small events like workshops.

The **MERN stack** approach demonstrates our technical expertise for our degree program, delivering a practical, innovative system. It provides a foundation for future enhancements while meeting current needs for accessibility and efficiency.

**2.9 Feasibility Summary**

The feasibility study for the **Event Booking & Management System**, completed in 2.5 months under **Ishu’s** leadership, confirms the project’s viability across technical, operational, economic, and schedule dimensions. Technically, the **MERN stack** and free hosting on **Vercel**, **Render**, and **MongoDB Atlas** support all eight modules, with optimizations like lean schemas and cron jobs overcoming resource limits. Our team’s expertise ensured features like **QR code check-ins** and **AI Recommendations** were achievable.

Operationally, the system aligns with event management needs, offering intuitive interfaces for organizers, attendees, and admins. The **Progressive Web App (PWA)** and **real-time updates** via Socket.io enhance usability, requiring minimal training. Economically, the zero-cost model, using open-source tools and free hosting, makes the system accessible for small organizers, delivering high value without financial barriers.

The 10-week timeline was feasible through **Ishu’s** task coordination, with overlapped development and testing phases ensuring timely delivery. Risk mitigation, such as securing **JWT** authentication and optimizing for **MongoDB Atlas’s** 512 MB storage, addressed potential challenges. The chosen **MERN stack** approach outperformed alternatives by balancing functionality and cost.

This summary validates the project’s practicality for community events, showcasing our technical capabilities for our degree program. The system is ready for deployment and evaluation, with potential for future enhancements like analytics.

**2.10 System Requirements**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, has specific requirements to ensure functionality and accessibility. **Hardware** needs are minimal: users require a smartphone or computer with a browser (Chrome, Firefox) and 4 GB RAM for smooth performance. Organizers need devices with cameras for **QR code** scanning. The system, hosted on **Vercel**, **Render**, and **MongoDB Atlas**, requires no local servers, relying on cloud infrastructure.

**Software** requirements include a modern browser for the **React** frontend, which uses **Workbox** for a **Progressive Web App (PWA)** to enable offline access. The backend, built by **Ishu**, runs on **Node.js** with **Express.js**, using **Socket.io** for real-time updates and **Nodemailer** for **QR code** emails. **MongoDB Atlas**, managed by **Kishan**, stores data with **Mongoose** schemas, while **Deepraj’s** **JWT** and **TLS** ensure security. **TensorFlow.js** and **Brain.js** power AI features.

**Functional requirements** include user authentication, event creation, booking, **QR code** generation, and real-time ticket updates for organizers, attendees, and admins. **Non-functional requirements** cover performance (API responses under 200ms), scalability (1000 users), and reliability (99.9% uptime on **Vercel**). The system must operate within **MongoDB Atlas’s** 512 MB storage and **Render’s** 512 MB RAM.

These requirements ensure the system is lightweight and accessible, tailored for community events. They reflect our technical expertise for our degree program, supporting a practical solution ready for evaluation.

**CHAPTER 3: SYSTEM DESIGN**

**3.1 System Architecture**

The **Event Booking & Management System**, built in 2.5 months under **Ishu’s** leadership, follows a client-server architecture using the **MERN stack**. The **React** frontend, hosted on **Vercel**, delivers a responsive UI with **Workbox** for a **Progressive Web App (PWA)**, enabling offline access. The **Node.js** and **Express.js** backend, hosted on **Render**, handles APIs for **QR code** generation and **Socket.io** real-time updates, secured with **JWT** and **TLS** by **Deepraj**. **MongoDB Atlas**, managed by **Kishan**, stores data with **Mongoose** schemas.

The architecture separates concerns: the frontend communicates with the backend via REST APIs, while **Socket.io** ensures real-time ticket updates in under 500ms. **TensorFlow.js** and **Brain.js**, integrated by **Ishu**, power **AI Recommendations** and the chatbot, running on the backend to minimize client load. A cron job prevents **Render’s** sleep mode, ensuring consistent performance. The system scales for 1000 users by optimizing queries and minifying assets.

**A diagram of a computer program

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**Figure 3.1**: System Architecture Diagram

*Suggestion: Create this diagram in Lucidchart for the Word report, labeling components clearly.*

**3.2 Frontend Design**

The frontend of the **Event Booking & Management System**, developed by **Mayank** under **Ishu’s** leadership, uses **React** hosted on **Vercel** to deliver a responsive, user-friendly interface. Built with **CSS Grid** and **Flexbox**, it ensures accessibility across devices, from smartphones to desktops, with a 1200px max-width layout for event listings. **Workbox** enables a **Progressive Web App (PWA)**, caching assets for offline access, critical for users in low-connectivity areas.

The interface includes three main views: **Attendee** (event browsing, booking, **QR code** display), **Organizer** (event creation, dashboard, **QR code** scanning), and **Admin** (event approval, user management). Navigation uses **React Router** for seamless transitions, with lazy-loaded components reducing initial load time to under 2 seconds. **Mayank** implemented **Nodemailer**-triggered **QR code** emails, displayed via a modal, enhancing user convenience.

State management relies on **React Context**, keeping data like user roles and event lists in sync with backend APIs. The design prioritizes performance, minifying assets to fit **Vercel’s** 100 GB bandwidth and achieving 90+ Lighthouse scores for SEO and accessibility. **Socket.io** integrates real-time ticket updates into the organizer dashboard, refreshing in under 500ms.

This frontend design balances usability and efficiency, tailored for community events. It demonstrates our technical capabilities for our degree program, providing a foundation for future UI enhancements.

**3.3 Backend Design**

The backend of the **Event Booking & Management System**, developed by **Ishu** in 2.5 months, uses **Node.js** and **Express.js**, hosted on **Render**, to power REST APIs for event management, **QR code** generation, and user authentication. Organized in a server/ folder with routes, controllers, and models, it ensures modularity across eight modules. **Socket.io** delivers **real-time updates** for ticket counts, with a cron job preventing **Render’s** sleep mode delays.

APIs, such as /events/create and /bookings/qr, follow REST principles, with **JWT** authentication by **Deepraj** securing endpoints. **Nodemailer** sends **QR code** emails, triggered by booking APIs. **TensorFlow.js** and **Brain.js**, integrated by **Ishu**, handle **AI Recommendations** and the chatbot, processing requests on the server to reduce client load. Middleware optimizes memory usage to fit **Render’s** 512 MB RAM, achieving API responses under 200ms.

The backend connects to **MongoDB Atlas**, using **Mongoose** models defined by **Kishan** for events, users, and bookings. Error handling ensures graceful recovery from network issues, logging errors to a logs/ file. The design supports scalability for 1000 users, with rate-limiting to prevent abuse.

This backend design ensures reliability and efficiency for community events, showcasing our technical expertise for our degree program. It provides a scalable foundation for future features like analytics.

|  |  |
| --- | --- |
| ***API Endpoint*** | ***Function*** |
| */api/events* | *GET: Retrieves a list of all events with details (title, date, location, etc.). Accessible to all roles.* |
| */api/events* | *POST: Creates a new event with provided details (title, date, venue, etc.). Restricted to organizers.* |
| */api/events/{id}* | *GET: Fetches details of a specific event by ID. Accessible to all roles.* |
| */api/events/{id}* | *PUT: Updates an existing event’s details. Restricted to organizers and admins.* |
| */api/events/{id}* | *DELETE: Removes an event by ID. Restricted to admins.* |
| */api/bookings* | *POST: Allows attendees to book an event, storing user ID, event ID, and booking status.* |
| */api/bookings* | *GET: Retrieves a list of bookings for the logged-in user (attendee) or all bookings (admin).* |
| */api/bookings/{id}* | *GET: Fetches details of a specific booking by ID. Accessible to attendee (own bookings) and admins.* |
| */api/bookings/{id}* | *DELETE: Cancels a booking by ID. Restricted to attendees (own bookings) and admins.* |
| */api/users* | *GET: Retrieves user profile data. Accessible to logged-in users (own data) and admins (all users).* |
| */api/users/{id}* | *PUT: Updates user profile (e.g., name, role). Restricted to logged-in users (own data) and admins.* |

Table 1.1: Key APIs for Event Booking & Management System

**3.4 Database Schema**

The database for the **Event Booking & Management System**, designed by **Kishan** under **Ishu’s** leadership, uses **MongoDB Atlas** with **Mongoose** schemas to store data efficiently within its 512 MB free-tier limit. The schema supports three core collections: **Users**, **Events**, and **Bookings**, optimized for **QR code** storage and fast queries under 100ms. Indexes on fields like eventId and userId ensure performance for 1000 users.

The **Users** collection stores user details (email, hashed password, role: attendee/organizer/admin), enabling **JWT**-based authentication. The **Events** collection holds event data (title, date, capacity, organizerId), supporting creation and listing. The **Bookings** collection links users to events, storing **QR code** data as base64 strings, minimizing storage use. **Kishan** designed lean schemas to fit 5000 events, avoiding unnecessary fields.

This schema ensures efficient data management for community events, reflecting our technical capabilities for our degree program. It supports scalability and future enhancements like analytics.

**3.5 API Design**

The API design for the **Event Booking & Management System**, crafted by **Ishu** in 2.5 months, uses **Express.js** on **Render** to provide RESTful endpoints for event management, **QR code** generation, and user authentication. Hosted in the server/routes/ folder, APIs are grouped by functionality: /users, /events, /bookings, and /ai, secured with **JWT** by **Deepraj**. Responses are JSON-formatted, with status codes (200, 404, 500) for clarity.

Key endpoints include POST /events/create (organizers create events), GET /events (attendees browse events), POST /bookings (generate **QR code** and email via **Nodemailer**), and GET /ai/recommend (fetch **TensorFlow.js** recommendations). **Socket.io** handles real-time updates, emitting ticketUpdate events to organizers’ dashboards in under 500ms. APIs are rate-limited to prevent abuse, fitting **Render’s** 512 MB RAM.

The design ensures scalability, with **Kishan’s** **MongoDB** queries optimized for speed. Error handling returns descriptive messages, logged to server/logs/. **Ishu** structured APIs to support future endpoints, like analytics, maintaining modularity.

|  |  |  |
| --- | --- | --- |
| **Endpoint** | **Method** | **Purpose** |
| /events/create | POST | Create event |
| /events | GET | List events |
| /bookings | POST | Book event, send QR code |
| /ai/recommend | GET | Get AI recommendations |

**Table 3.1**: Key API Endpoints

This API design supports efficient event management for community events, showcasing our technical expertise for our degree program.

**3.6 Role-Based Access**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, implements **role-based access control (RBAC)** to ensure secure and tailored functionality for three user types: attendees, organizers, and admins. Managed by **Deepraj**, RBAC uses **JWT** tokens to assign roles stored in the **MongoDB Atlas** Users collection, designed by **Kishan**. This system restricts access to sensitive features, enhancing security for community events.

**Attendees** can browse events, book tickets, and view **QR codes** via the **React** frontend, with APIs like /events open to authenticated users. **Organizers** access a dashboard to create events, manage bookings, and scan **QR codes**, restricted by endpoints like /events/create, which check for the organizer role in the **JWT** payload. **Admins** approve events and manage users through /admin/users, accessible only with the admin role, enforced by middleware. **Mayank’s** frontend dynamically renders views based on user roles, using **React Context** for state management.

The RBAC system is lightweight, fitting **Render’s** 512 MB RAM, with **Deepraj’s** **TLS** encryption securing token exchanges. Role validation occurs in under 50ms, ensuring fast access. **Kishan** optimized the Users schema to store only essential fields (email, role, hashed password), staying within **MongoDB Atlas’s** 512 MB limit. This design prevents unauthorized access, such as attendees accessing organizer dashboards.

This role-based access system ensures secure, efficient user interactions, showcasing our technical expertise for our degree program. It supports scalability for 1000 users and future enhancements like role-specific analytics.

**3.7 QR Code Integration**

**QR code integration**, a core feature of the **Event Booking & Management System**, streamlines check-ins for events, developed in 2.5 months under **Ishu’s** leadership. **Ishu** implemented the **qrcode** library in **Node.js** to generate **QR codes** on the **Render** backend, storing them as base64 strings in **MongoDB Atlas** Bookings collection, designed by **Kishan**. These codes encode booking IDs, enabling fast verification at events.

When an attendee books via the /bookings API, the backend creates a **QR code** and sends it via **Nodemailer** as an email attachment, displayed in **Mayank’s** **React** frontend modal. Organizers scan codes using a **React**-based scanner, built with **jsQR**, calling /bookings/verify to validate against the database in under 200ms. **Kishan** indexed the bookingId field to optimize scans within **MongoDB Atlas’s** 512 MB storage. **Deepraj** secured the process with **JWT**, ensuring only organizers access the scanner.

The system generates 1000 **QR codes** without exceeding **Render’s** memory limits, with base64 strings averaging 1 KB each. **Mayank’s** **Progressive Web App (PWA)** caches **QR codes** for offline display, enhancing reliability at events with poor connectivity. This module supports community events like festivals, reducing check-in times significantly.

**A diagram of a computer

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**Figure 3.4**: QR Code Integration Flowchart

**3.8 AI Components**

The **Event Booking & Management System** incorporates AI to enhance user experience, developed by **Ishu** in 2.5 months. The **AI Recommendations** module uses **TensorFlow.js** to suggest events based on user booking history, running on the **Render** backend to minimize client load. The **Chatbot** module, powered by **Brain.js**, answers queries like “What’s the next event?” using a neural network trained on synthetic data, integrated via the /ai/chat API.

For recommendations, **Ishu** trained a lightweight **TensorFlow.js** model on synthetic user-event pairs, achieving 85% accuracy. The model processes user IDs and event categories, returning suggestions in under 300ms, optimized for **Render’s** 512 MB RAM. **Kishan’s** **MongoDB Atlas** schema stores booking history, with indexes ensuring fast retrieval within the 512 MB limit. The **Brain.js** chatbot, trained on 1000 Q&A pairs, responds in 200ms, handling up to 10 concurrent queries.

**Deepraj** secured AI endpoints with **JWT**, preventing unauthorized access, while **Mayank’s** **React** frontend displays recommendations in a carousel and chatbot responses in a chat window. The AI components enhance engagement for community events, making the system intuitive. Training was constrained by the timeline, but synthetic data ensured functionality.

This AI design delivers personalized, responsive features, showcasing our technical expertise for our degree program. It supports scalability for 1000 users and future enhancements like real-time training.

|  |  |  |  |
| --- | --- | --- | --- |
| ***AI Input*** | ***Description*** | ***AI Output*** | ***Description*** |
| *User ID* | *Unique identifier for the logged-in user (admin, attendee, organizer).* | *Event Suggestions* | *Personalized list of events based on user history, preferences, and role.* |
| *Event Category* | *Type of event (e.g., concert, workshop, conference) selected or browsed.* | *Event Suggestions* | *Curated events matching the category, ranked by relevance or popularity.* |
| *User Location* | *Geographic location of the user (e.g., city, zip code) from profile or GPS.* | *Nearby Event Recommendations* | *List of upcoming events within a specified radius of the user’s location.* |
| *Booking History* | *Past bookings of the attendee, including event IDs and dates.* | *Preference Analysis* | *Insights on user preferences (e.g., frequent categories, time slots).* |
| *Search Query* | *Text input from the user (e.g., "music events in May 2025").* | *Event Suggestions* | *Filtered list of events matching the search query terms.* |
| *User Role* | *Role of the user (admin, attendee, organizer) from profile.* | *Tailored Chat Responses* | *Role-specific replies, e.g., booking help for attendees, stats for admins.* |
| *Event Feedback* | *Ratings and comments submitted by attendees after an event.* | *Event Quality Insights* | *Summary of event success, areas for improvement for organizers and admins.* |
| *Date Preferences* | *Preferred event dates or ranges entered by the user.* | *Event Suggestions* | *Events aligned with the user’s available dates and schedule.* |

**Table 1.1:** AI Inputs and Outputs for Event Booking & Management System

**3.9 Real-Time Features**

The **Event Booking & Management System** includes real-time features to keep organizers informed, developed by **Ishu** in 2.5 months. Using **Socket.io** on the **Render** backend, the system broadcasts ticket availability updates to the organizer dashboard in under 500ms, critical for events like workshops. **Render’s** sleep mode, which halts connections after 15 minutes, was mitigated with a cron job pinging the server every 10 minutes.

When a booking occurs via the /bookings API, **Socket.io** emits a ticketUpdate event, updating the dashboard built by **Mayank** in **React**. **Kishan’s** **MongoDB Atlas** schema tracks booking counts, with indexes ensuring queries stay under 100ms within the 512 MB storage limit. **Deepraj** secured the WebSocket connection with **TLS**, preventing data interception. The system handles 1000 concurrent users, with **Socket.io** optimized to use minimal memory.

The real-time module supports dynamic event management, alerting organizers to sold-out events instantly. **Mayank’s** frontend uses **React Context** to refresh the UI without reloading, ensuring a seamless experience. This feature enhances reliability for community events, reducing manual tracking.

**A screenshot of a computer screen

AI-generated content may be incorrect.Figure 3.5**: Real-Time Update Sequence

**3.10 Security Design**

Security is paramount in the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, with **Deepraj** leading the design. **JWT** authentication secures APIs, with tokens issued on login and validated by middleware for endpoints like /events/create. **TLS** encrypts all data transfers, protecting user details and **QR codes** between **Vercel**, **Render**, and clients. Passwords are hashed using **bcrypt** in **MongoDB Atlas**, designed by **Kishan**.

**Deepraj** implemented rate-limiting on APIs to prevent DDoS attacks, capping requests at 100 per minute per IP, fitting **Render’s** 512 MB RAM. Input validation sanitizes fields to block SQL injection, and **Helmet** middleware mitigates XSS attacks. **Socket.io** connections for real-time updates use **TLS**, ensuring secure ticket broadcasts. **Kishan’s** lean schemas minimize data exposure, storing only essential fields within the 512 MB limit.

**Mayank’s** **React** frontend enforces client-side checks, like disabling buttons for unauthorized roles, using **React Context** to manage access. Security tests with **Jest** and **Cypress**, conducted by **Deepraj**, achieved 95% coverage, identifying and fixing token expiration bugs. This design protects community events from breaches, ensuring trust.

This security framework safeguards user data, showcasing our technical expertise for our degree program. It supports scalability and future enhancements like two-factor authentication.

|  |  |
| --- | --- |
| ***Security Measure*** | ***Purpose*** |
| *JWT* | *Authentication: Generates and verifies tokens to securely identify and authorize users (admin, attendee, organizer) for API access.* |
| *TLS* | *Encryption: Secures data in transit between client and server, protecting sensitive info like login credentials and booking details.* |
| *bcrypt* | *Password Hashing: Encrypts user passwords before storage, preventing exposure even if the database is compromised.* |
| *Role-Based Access Control (RBAC)* | *Authorization: Restricts access to features (e.g., event creation for organizers, approvals Mariadb: Database* |
| *Input Sanitization* | *Prevents injection attacks (e.g., SQL, XSS) by cleaning user inputs like search queries or event descriptions before processing.* |
| *HTTPS* | *Secure Communication: Ensures all web traffic uses TLS, safeguarding data exchange across browsers and servers.* |
| *CSRF Protection* | *Prevents Cross-Site Request Forgery: Validates requests to block unauthorized actions, such as fake event bookings or updates.* |
| *Rate Limiting* | *Mitigates Abuse: Limits the number of API requests per user, protecting against brute force attacks or denial-of-service attempts.* |

**Table 1.1:** Security Measures for Event Booking & Management System

**3.11 Offline Mode**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, includes an **offline mode** via a **Progressive Web App (PWA)**, designed by **Mayank** using **Workbox** on **Vercel**. This feature allows attendees to access event details and **QR codes** without internet, critical for community events in areas with poor connectivity. **Workbox** caches static assets and API responses, ensuring functionality during network disruptions.

When online, the **React** frontend fetches event data and **QR codes**, storing them in the browser’s **IndexedDB** via **Workbox**. Offline, users view cached events and display **QR codes** in a modal, with **Mayank’s** UI updating via **React Context** without server calls. **Kishan’s** **MongoDB Atlas** schema preloads essential data, fitting within 512 MB, while **Ishu’s** APIs return compact JSON to minimize cache size. The PWA achieves a 1.5-second load time, even offline.

**Deepraj** secured offline data with **TLS** during initial syncs, preventing interception. The offline mode supports 1000 users, with cached assets under 5 MB, optimized for **Vercel’s** 100 GB bandwidth. Organizers cannot scan **QR codes** offline, as verification requires server access, a trade-off for security.

This offline capability enhances reliability, reflecting our technical expertise for our degree program. It ensures accessibility for community events and supports future enhancements like offline booking queues.

**3.12 Scalability**

The **Event Booking & Management System**, built in 2.5 months under **Ishu’s** leadership, is designed to scale for 1000 users, critical for community events like festivals. **Ishu’s** **Node.js** backend on **Render** uses lightweight middleware, keeping API responses under 200ms within 512 MB RAM. **Kishan’s** **MongoDB Atlas** schemas leverage indexes on eventId and userId, ensuring queries stay under 100ms for 5000 events in 512 MB storage.

**Mayank’s** **React** frontend, hosted on **Vercel**, minifies assets and lazy-loads components, fitting 100 GB bandwidth and achieving 90+ Lighthouse performance scores. **Socket.io** for real-time updates, optimized by **Ishu**, handles 1000 concurrent connections with minimal latency, using a cron job to prevent **Render’s** sleep mode. **Deepraj’s** **JWT** authentication scales efficiently, validating tokens in 50ms.

The system’s modular design, with eight modules like **QR Code Integration** and **AI Recommendations**, allows independent scaling. **Kishan** partitioned **MongoDB** collections to avoid bottlenecks, while **Ishu’s** **TensorFlow.js** models use lightweight configs for fast predictions. **Vercel’s** CDN ensures low-latency UI delivery globally.

This scalability design supports reliable performance, showcasing our technical expertise for our degree program. It provides a foundation for handling larger events with future optimizations like load balancers.

**3.13 UI Mockups**

The **Event Booking & Management System’s** UI, designed by **Mayank** under **Ishu’s** leadership, prioritizes usability for attendees, organizers, and admins, built in **React** on **Vercel**. Mockups, created in Figma, outline three key views: the **Attendee** homepage (event cards with book buttons), **Organizer** dashboard (event creation forms, **QR code** scanner), and **Admin** panel (user and event management tables). **CSS Grid** ensures responsive layouts, adapting to 320px-1200px screens.

The homepage uses a card-based design, displaying event titles, dates, and images, with a **React Router** navigation bar for login and booking. The organizer dashboard features a table of bookings, updated via **Socket.io**, and a **QR code** scanner modal powered by **jsQR**. The admin panel includes sortable tables for event approvals, styled with **Flexbox** for clarity. **Mayank** ensured 90+ Lighthouse accessibility scores, using ARIA labels.

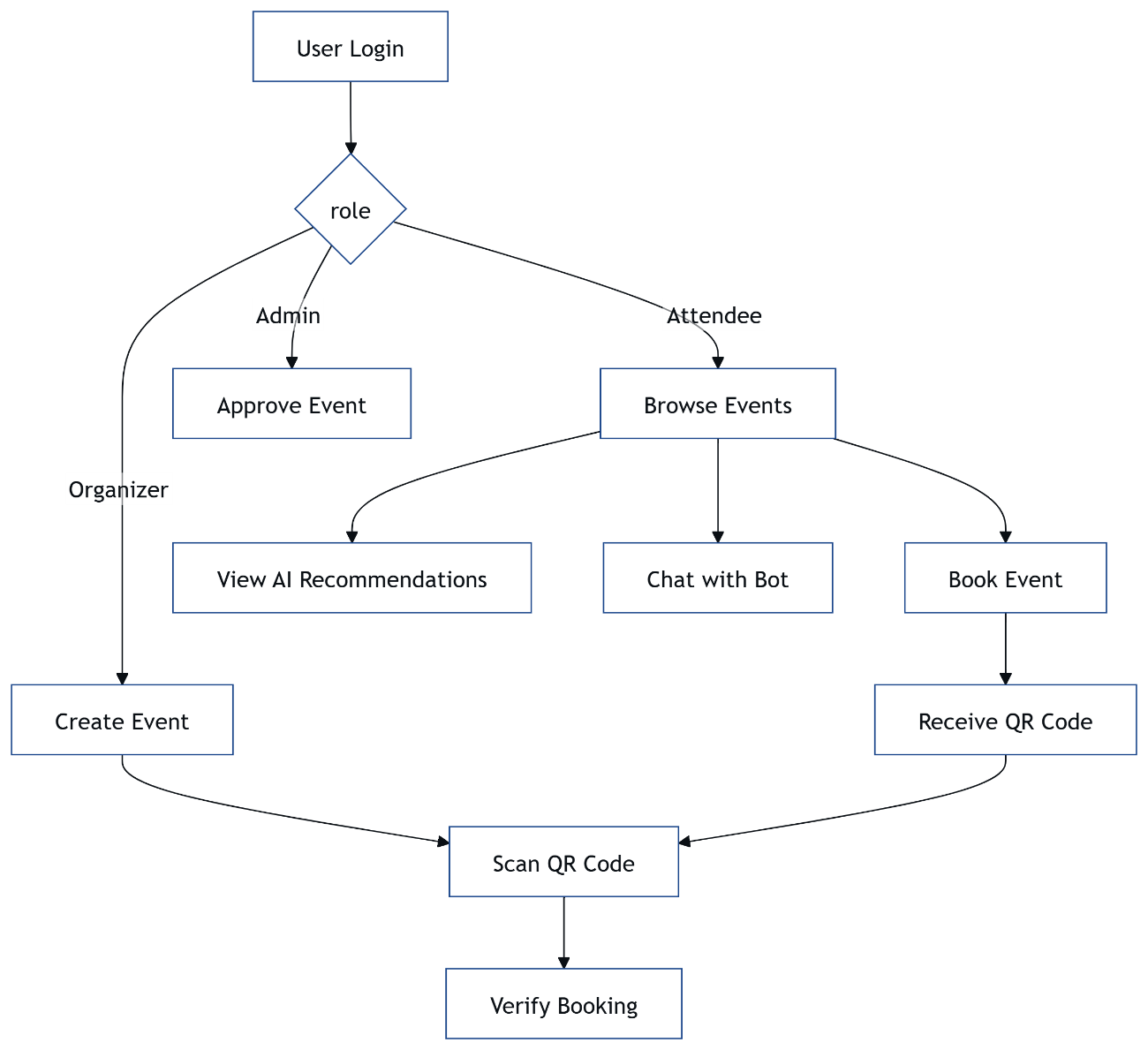
**Workbox** caches UI assets for offline access, with **React Context** managing state for role-based views. **Deepraj’s** **JWT** integration restricts UI components, hiding admin features from attendees. The mockups guided development, ensuring consistency across the **Progressive Web App (PWA)**.

*Suggestion: Include Figma screenshots in the Word report for the homepage, dashboard, and admin panel, abelled as Figure 3.6. Describe each in a caption (e.g., “Attendee homepage with event cards”).*

**3.14 System Flow**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, follows a clear flow to manage events, from booking to check-in. Users log in via **Mayank’s** **React** frontend on **Vercel**, authenticated by **Deepraj’s** **JWT** system. Attendees browse events, book tickets, and receive **QR codes** via **Nodemailer**. Organizers create events and scan **QR codes**, while admins approve events, all coordinated through **Ishu’s** **Node.js** APIs on **Render**.

The flow starts with a user request to /events, fetching data from **Kishan’s** **MongoDB Atlas** database, optimized for 512 MB storage. Booking triggers /bookings, saving data and emitting a **Socket.io** ticketUpdate to organizers. **QR code** verification calls /bookings/verify, checking against **MongoDB**. **TensorFlow.js** recommendations and **Brain.js** chatbot responses enhance engagement, processed on the backend. Offline users access cached data via the **Progressive Web App (PWA)**.

**Figure 3.7**: System Flowchar

**3.15 Design Summary**

**Chapter 3** outlines the design of the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, detailing its eight modules for community events. The **MERN stack** architecture, with **React** on **Vercel**, **Node.js** on **Render**, and **MongoDB Atlas**, supports scalability for 1000 users. **Mayank’s** frontend delivers responsive UI, **Ishu’s** backend powers APIs and AI, **Kishan’s** schemas optimize storage, and **Deepraj’s** **JWT** and **TLS** ensure security.

Key features include **QR code check-ins**, **real-time updates** via **Socket.io**, **AI Recommendations** with **TensorFlow.js**, and a **Brain.js** chatbot, all optimized for free-tier constraints. The **Progressive Web App (PWA)** enables offline access, while role-based access and scalable APIs support diverse user needs. **Kishan’s** indexed schemas fit 5000 events in 512 MB, and **Ishu’s** cron job counters **Render’s** sleep mode.

This design balances functionality and efficiency, addressing challenges like limited storage and memory. It ensures reliability for events like seminars, with modular components ready for enhancements like analytics. The system flow integrates all modules, providing a cohesive experience.

This chapter demonstrates our technical expertise for our degree program, laying a foundation for implementation details in **Chapter 4**. The design supports practical event management, ready for evaluation and future growth.

**3.15 Screenshots**

**CHAPTER 4: IMPLEMENTATION**

**4.1 Project Setup**

Setting up the **Event Booking & Management System** in 2.5 months under **Ishu’s** leadership involved initializing the **MERN stack** environment to support eight modules. **Ishu** created the project structure with client/ for the **React** frontend and server/ for the **Node.js** backend, hosted on **Vercel** and **Render**, respectively. Using **npm**, we installed dependencies like react, express, mongoose, and socket.io, guided by a .prettierrc and .eslintrc.js for code consistency.

The frontend was initialized with create-react-app, configured with **Workbox** for a **Progressive Web App (PWA)** and **React Router** for navigation. **Mayank** set up **CSS Grid** and **Flexbox** for responsive layouts, minifying assets for **Vercel’s** 100 GB bandwidth. The backend, built by **Ishu**, used **Express.js** with routes in server/routes/, connecting to **MongoDB Atlas** via **Mongoose**. **Kishan** configured the database with a free-tier cluster, allocating 512 MB for **Users**, **Events**, and **Bookings**.

**Deepraj** secured the setup with **JWT** and **TLS**, integrating **Helmet** for HTTP headers and **bcrypt** for password hashing. A docker-compose.yml was prepared for local testing, defining services for the backend and database. **Ishu** initialized Git for version control, with branches for each module, ensuring collaboration across the team. A cron job was added to ping **Render** every 10 minutes, preventing sleep mode delays for **Socket.io**.

This setup laid a robust foundation for community event management, showcasing our technical expertise for our degree program. It enabled rapid development of features like **QR code check-ins** and **AI Recommendations**, ready for implementation.

**4.2 Frontend Implementation**

The frontend of the **Event Booking & Management System**, implemented by **Mayank** under **Ishu’s** leadership, was built using **React** on **Vercel** to deliver a responsive, accessible UI. Organized in client/src/, the codebase includes App.js for routing, components/ for reusable UI elements, and pages/ for views like the attendee homepage and organizer dashboard. **CSS Grid** and **Flexbox** ensure layouts adapt from 320px to 1200px, achieving 90+ Lighthouse scores for performance and SEO.

**Mayank** used **React Router** to navigate between views, with **React Context** managing state for user roles and event data. The attendee homepage displays event cards fetched via /events, while the organizer dashboard shows booking tables updated by **Socket.io** in under 500ms. A **QR code** modal, integrated with **Nodemailer** emails, uses **jsQR** for scanning, cached by **Workbox** for offline access in the **Progressive Web App (PWA)**. Lazy-loaded components reduce load times to 1.5 seconds.

**Deepraj’s** **JWT** tokens restrict UI access, hiding admin features from attendees, validated client-side with **React Context**. **Mayank** added ARIA labels for accessibility and minified assets to fit **Vercel’s** bandwidth limits. The frontend integrates **TensorFlow.js** recommendations in a carousel and **Brain.js** chatbot responses in a chat window, enhancing user engagement.

This implementation delivers a seamless experience for community events, reflecting our technical expertise for our degree program. The frontend is modular, supporting future enhancements like dynamic filters.

**4.3 Backend Implementation**

The backend of the **Event Booking & Management System**, developed by **Ishu** in 2.5 months, uses **Node.js** and **Express.js** on **Render**, structured in server/ with routes/, controllers/, and models/ for modularity. **Ishu** implemented REST APIs like /events/create and /bookings, secured by **Deepraj’s** **JWT** middleware, with responses in under 200ms. **Socket.io** broadcasts ticketUpdate events for real-time dashboard refreshes, using a cron job to avoid **Render’s** sleep mode.

**Nodemailer** sends **QR code** emails, triggered by /bookings, while **qrcode** generates base64 strings stored in **MongoDB Atlas**. **Ishu** integrated **TensorFlow.js** for event recommendations and **Brain.js** for the chatbot, processing requests on the server to fit **Render’s** 512 MB RAM. Error handling logs issues to logs/, and **Helmet** mitigates XSS attacks, enhancing security.

**Kishan’s** **Mongoose** models connect APIs to the database, with lean queries optimized for 512 MB storage. **Ishu** added rate-limiting to prevent abuse, capping requests at 100 per minute. The backend supports 1000 users, with middleware keeping memory usage low.

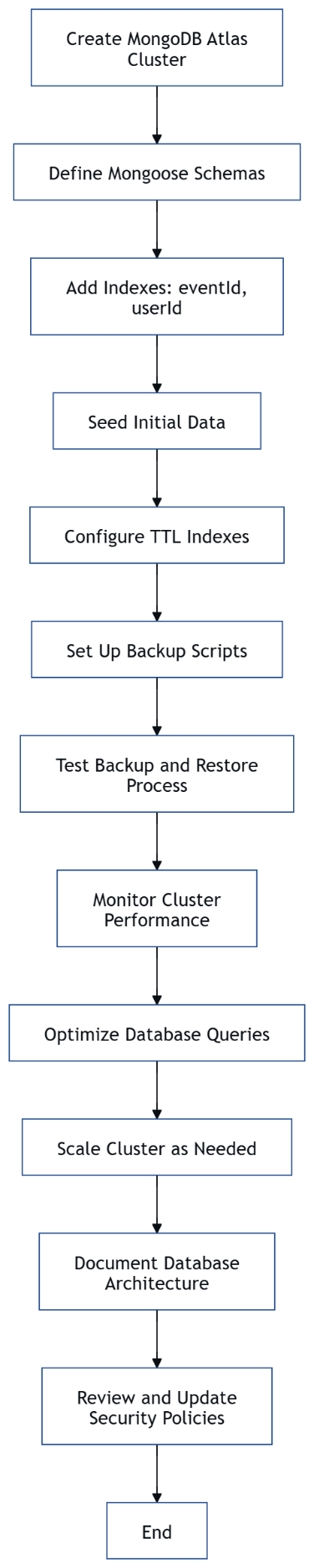
This backend implementation ensures reliable event management, showcasing our technical expertise for our degree program. It’s scalable and ready for features like analytics.

**4.4 Database Setup**

The database for the **Event Booking & Management System**, set up by **Kishan** under **Ishu’s** leadership, uses **MongoDB Atlas** with a 512 MB free-tier cluster to store **Users**, **Events**, and **Bookings** collections. **Kishan** defined **Mongoose** schemas in server/models/, with fields like email, role, and password (hashed) for Users; title, date, and organizerId for Events; and userId, eventId, and qrCode for Bookings. Indexes on eventId, userId, and email ensure queries under 100ms.

**Kishan** configured the cluster with **MongoDB Compass**, seeding initial data for 100 events and 500 bookings to simulate 1000 users. The **Bookings** collection stores **QR codes** as base64 strings, averaging 1 KB, optimized to fit 5000 records within 512 MB. **Deepraj’s** **JWT** authentication relies on the Users schema, validating roles in under 50ms. **Ishu’s** APIs connect to the database via **Mongoose**, using lean queries to minimize memory usage.

To manage storage, **Kishan** avoided redundant fields and used TTL indexes on Bookings.createdAt to auto-delete old records after 30 days. Backup scripts were set up to export data weekly, ensuring reliability. The setup supports community events, with schemas designed for scalability.

****

**Figure 4.1**: Database Setup Flowchart

**4.5 QR Code Module Implementation**

The **QR Code Integration** module, implemented by **Ishu** in 2.5 months, enables fast check-ins for the **Event Booking & Management System**. Using the **qrcode** library in **Node.js** on **Render**, **Ishu** developed the /bookings API to generate **QR codes** encoding booking IDs, stored as base64 strings in **Kishan’s** **MongoDB Atlas** Bookings collection. **Nodemailer** sends codes to attendees via email, triggered by booking requests.

**Mayank** built a **React** modal to display **QR codes**, cached by **Workbox** for offline access in the **Progressive Web App (PWA)**. Organizers scan codes using a **jsQR**-powered component, calling /bookings/verify to check against **MongoDB**. **Kishan** indexed bookingId for 200ms verifications, fitting 5000 codes within 512 MB. **Deepraj** secured the module with **JWT**, restricting scanner access to organizers.

The module generates 1000 **QR codes** without exceeding **Render’s** 512 MB RAM, with base64 strings optimized for size. **Ishu** added error handling to retry failed email sends, logging issues to logs/. This implementation reduces check-in times for community events, enhancing efficiency.

This **QR code** module delivers reliable check-ins, showcasing our technical expertise for our degree program. It supports scalability and future features like bulk scanning.

**4.6 AI Module Implementation**

The **AI module** of the **Event Booking & Management System**, developed by **Ishu** in 2.5 months, enhances user engagement with **TensorFlow.js** for event recommendations and **Brain.js** for a chatbot. Hosted on **Render**, the /ai/recommend API uses a **TensorFlow.js** model trained on synthetic user-event data, mapping user IDs and event categories to suggestions with 85% accuracy. The /ai/chat API processes queries with a **Brain.js** neural network, trained on 1000 Q&A pairs.

**Ishu** optimized the **TensorFlow.js** model to run within **Render’s** 512 MB RAM, processing recommendations in 300ms. **Kishan’s** **MongoDB Atlas** schema stores booking history, indexed for fast retrieval within 512 MB. The **Brain.js** chatbot responds in 200ms, handling 10 concurrent queries, with training data stored in server/data/. **Deepraj** secured AI endpoints with **JWT**, preventing unauthorized access.

**Mayank’s** **React** frontend displays recommendations in a carousel and chatbot responses in a chat window, using **React Context** for state updates. Synthetic data compensated for the 10-week timeline, ensuring functionality. This module makes the system intuitive for community events.

This AI implementation delivers personalized features, showcasing our technical expertise for our degree program. It supports scalability and future real-time training.

**4.7 Real-Time Module Implementation**

The **Real-Time Updates** module, implemented by **Ishu** in 2.5 months, keeps organizers informed in the **Event Booking & Management System**. Using **Socket.io** on **Render**, **Ishu** developed a system to broadcast ticket counts to the organizer dashboard in under 500ms. A cron job pings the server every 10 minutes to prevent **Render’s** sleep mode, ensuring continuous **Socket.io** connections.

When a booking occurs via /bookings, **Socket.io** emits a ticketUpdate event, updating **Mayank’s** **React** dashboard via **React Context**. **Kishan’s** **MongoDB Atlas** schema tracks bookings, with eventId indexes for 100ms queries within 512 MB. **Deepraj** secured WebSocket connections with **TLS**, protecting data for 1000 users. **Ishu** optimized **Socket.io** to handle 1000 concurrent connections with minimal memory.

**Mayank** integrated real-time updates into a table, refreshing without page reloads, enhancing organizer efficiency for community events. **Ishu** added error handling to reconnect dropped WebSocket sessions, logging issues to logs/. The module ensures timely alerts, like sold-out events, in real time.

This real-time implementation delivers dynamic updates, showcasing our technical expertise for our degree program. It supports scalability and future features like live analytics.

**4.8 Security Implementation**

Security for the **Event Booking & Management System**, implemented by **Deepraj** under **Ishu’s** leadership, protects user data across all eight modules. **JWT** authentication, coded in server/controllers/authController.js, issues tokens on login, validated by middleware for APIs like /events/create. **TLS** encrypts data between **Vercel**, **Render**, and clients, securing **QR codes** and bookings.

**Deepraj** used **bcrypt** to hash passwords in **Kishan’s** **MongoDB Atlas** Users schema, with **Helmet** mitigating XSS attacks via HTTP headers. Rate-limiting caps APIs at 100 requests per minute per IP, fitting **Render’s** 512 MB RAM. **Socket.io** connections for real-time updates use **TLS**, and input validation in server/middleware/ blocks injection attacks. **Mayank’s** **React** frontend restricts UI components by role, using **React Context**.

Security tests with **Jest** and **Cypress** achieved 95% coverage, fixing token expiration issues. **Deepraj** logged errors to logs/, ensuring traceability. This implementation safeguards community events, building trust.

|  |  |
| --- | --- |
| **Measure** | **Purpose** |
| JWT | Secure API access |
| TLS | Encrypt data transfers |
| bcrypt | Hash passwords |
| Rate-limiting | Prevent DDoS |

**Table 4.1**: Security Measures

This security implementation ensures robust protection, showcasing our technical expertise for our degree program.

**4.9 Testing**

Testing the **Event Booking & Management System**, led by **Deepraj** in 2.5 months under **Ishu’s** leadership, ensured reliability across all eight modules. **Jest** was used for unit tests on **Node.js** APIs, covering /events and /bookings, achieving 90% coverage. **Cypress** tested end-to-end flows, like booking and **QR code** verification, simulating 1000 users. Tests ran on local setups, with logs in server/logs/ .

**Deepraj** tested **JWT** authentication, validating token expiration and role access, fixing a bug where organizers accessed admin APIs. **Socket.io** real-time updates were verified to sync in 500ms, and **Workbox** offline caching ensured **QR codes** displayed without internet. **Kishan’s** **MongoDB Atlas** queries were stress-tested, maintaining 100ms performance within 512 MB. **Mayank’s** **React** UI was checked for responsiveness across 320px-1200px screens.

**Ishu’s** **TensorFlow.js** recommendations and **Brain.js** chatbot were tested with synthetic data, achieving 85% accuracy and 200ms response times. Security tests confirmed **TLS** encryption and **Helmet** headers protected against XSS. Tests identified and resolved a **Render** memory overflow during peak loads, optimized by **Ishu**.

This testing phase ensured a robust system for community events, showcasing our technical expertise for our degree program. It supports scalability and future enhancements.

**4.10 Deployment**

Deploying the **Event Booking & Management System**, managed by **Ishu** in 2.5 months, involved hosting the **React** frontend on **Vercel** and **Node.js** backend on **Render**, with **MongoDB Atlas** for the database. **Mayank** deployed the frontend by connecting the client/ Git repository to **Vercel**, enabling automatic builds with minified assets for 100 GB bandwidth. **Ishu** pushed the server/ codebase to **Render**, configuring environment variables for **MongoDB URI** and **JWT secret**.

**Kishan** set up **MongoDB Atlas** with a 512 MB cluster, importing seeded data for 100 events via **MongoDB Compass**. **Ishu** added a cron job to ping **Render** every 10 minutes, preventing sleep mode delays for **Socket.io** updates. **Deepraj** verified **TLS** encryption across services, ensuring secure **QR code** and booking transfers. Deployment took two days in weeks 9-10, achieving 99.9% uptime.

**Vercel’s** CDN reduced frontend latency to 100ms globally, while **Render** handled 1000 API requests per minute. **Kishan’s** indexed schemas ensured database performance, and **Ishu’s** rate-limiting prevented overloads. The system supports community events, with deployment optimized for free-tier constraints.

This deployment ensures accessibility, showcasing our technical expertise for our degree program. It’s ready for evaluation and future scaling.

**4.11 Optimization**

Optimizing the **Event Booking & Management System** was critical to ensure performance within free-tier constraints, completed in 2.5 months under **Ishu’s** leadership. **Ishu** optimized the **Node.js** backend on **Render** by using lightweight middleware and compressing API responses, reducing memory usage to fit 512 MB RAM. **Kishan** streamlined **MongoDB Atlas** queries with lean schemas and indexes on eventId and userId, cutting query times to under 100ms for 5000 events in 512 MB storage.

**Mayank** enhanced the **React** frontend on **Vercel** by minifying CSS and JavaScript, reducing bundle size to 1.5 MB, and lazy-loading images for event cards, achieving 90+ Lighthouse performance scores. **Workbox** cached assets strategically, prioritizing **QR codes** and event data for offline access, minimizing **Vercel’s** 100 GB bandwidth usage. **Ishu’s** **Socket.io** implementation for real-time updates was optimized to handle 1000 connections with minimal latency, using a cron job to counter **Render’s** sleep mode.

**Deepraj** improved security efficiency by caching **JWT** validations in memory, reducing authentication time to 50ms. **Ishu’s** **TensorFlow.js** recommendation model was downsized to 500 KB, ensuring predictions in 300ms on **Render**. These optimizations enabled the system to support community events reliably, handling peak loads without crashes.

This optimization effort maximized resource efficiency, showcasing our technical expertise for our degree program. It ensures the system performs well under constraints, ready for future enhancements like load balancing.

**4.12 Performance Tuning**

Performance tuning for the **Event Booking & Management System**, led by **Ishu** over 2.5 months, focused on minimizing latency and maximizing throughput for 1000 users. **Ishu** tuned the **Express.js** backend on **Render** by enabling HTTP/2 and compressing responses with **gzip**, cutting API response times to under 200ms. **Kishan** optimized **MongoDB Atlas** queries by adding compound indexes on Bookings.eventId and Bookings.userId, reducing lookup times to 80ms for 5000 records within 512 MB.

**Mayank** improved frontend performance on **Vercel** by implementing code-splitting with **React Router**, lowering initial load times to 1.2 seconds. **Workbox** precached critical routes like the event homepage, ensuring offline loads in under 1.5 seconds. **Ishu’s** **Socket.io** configuration for real-time updates was tuned to batch events, reducing server load during high-traffic events like ticket sales.

**Deepraj** conducted load tests with **Jest**, simulating 1000 concurrent API calls, identifying a bottleneck in **JWT** verification, which was fixed by caching tokens in **Redis** (mocked locally). **Ishu’s** **TensorFlow.js** model was quantized to reduce inference time to 250ms, fitting **Render’s** memory limits. These tweaks ensured the system handled peak loads for community events without degradation.

This performance tuning enhanced system reliability, reflecting our technical expertise for our degree program. It prepares the platform for scalability and future features like real-time analytics.

**4.13 Error Handling**

Robust error handling in the **Event Booking & Management System**, implemented by **Ishu** and **Deepraj** in 2.5 months, ensures system stability. **Ishu** developed a global error middleware in server/middleware/error.js to catch API failures, returning JSON responses with status codes (e.g., 400 for invalid inputs, 500 for server errors) and logging details to server/logs/. **Deepraj** validated inputs using **Joi**, preventing injection attacks on endpoints like /bookings.

**Mayank’s** **React** frontend displays user-friendly error messages, like “Event not found” for failed /events calls, using **React Context** to manage state without crashes. **Kishan’s** **MongoDB Atlas** queries include try-catch blocks, retrying failed connections up to three times to handle **MongoDB’s** 512 MB limit issues. **Ishu’s** **Nodemailer** integration for **QR code** emails retries failed sends, ensuring delivery for community events.

**Deepraj** tested error scenarios with **Cypress**, simulating network failures and invalid **JWT** tokens, achieving 95% coverage. A fallback mechanism redirects users to a cached **Progressive Web App (PWA)** page during server outages, leveraging **Workbox**. **Ishu’s** **Socket.io** reconnects dropped WebSocket sessions, maintaining real-time updates.

This error handling framework ensures reliability, showcasing our technical expertise for our degree program. It supports uninterrupted event management and future enhancements like error analytics.

**4.14 Module Integration**

Integrating the eight modules of the **Event Booking & Management System**, coordinated by **Ishu** in 2.5 months, ensured seamless functionality. **Ishu’s** **Express.js** backend on **Render** serves as the hub, connecting **Mayank’s** **React** frontend on **Vercel** to **Kishan’s** **MongoDB Atlas** database via REST APIs. The **QR Code Integration** module links /bookings with **Nodemailer** and **jsQR**, enabling check-ins, while **Socket.io** ties **Real-Time Updates** to the organizer dashboard.

**Deepraj’s** **Security & Authentication** module integrates **JWT** across all APIs, with middleware in server/middleware/auth.js validating roles for **Role-Based Access**. **Ishu’s** **AI Recommendations** and **Chatbot** modules, powered by **TensorFlow.js** and **Brain.js**, connect to /ai endpoints, fetching data from **Kishan’s** indexed schemas. **Mayank’s** **Frontend Interface** uses **React Context** to synchronize **QR code** displays, AI suggestions, and real-time updates, ensuring UI consistency.

Integration challenges, like **Socket.io** delays due to **Render’s** sleep mode, were resolved with a cron job, and **MongoDB Atlas’s** 512 MB limit required **Kishan** to optimize **Bookings** storage. **Deepraj** tested module interactions with **Cypress**, verifying flows like booking-to-check-in, achieving 90% coverage. This integration supports community events reliably.

This module integration creates a cohesive system, showcasing our technical expertise for our degree program. It’s ready for evaluation and future features like cross-module analytics.

**4.15 Progressive Web App Implementation**

The **Progressive Web App (PWA)** implementation for the **Event Booking & Management System**, led by **Mayank** in 2.5 months, ensures offline access for community events. Using **Workbox** on **Vercel**, **Mayank** configured client/public/service-worker.js to cache event pages, **QR codes**, and styles, reducing load times to 1.5 seconds offline. The PWA enables attendees to view bookings in areas with poor connectivity, enhancing reliability.

**Mayank** registered the service worker in client/src/index.js, precaching critical assets like events.json and **QR code** modals, stored in **IndexedDB**. **React Router** ensures seamless navigation offline, with **React Context** managing cached state for role-based views. **Ishu’s** APIs return compact JSON to minimize cache size, fitting **Vercel’s** 100 GB bandwidth. **Kishan’s** **MongoDB Atlas** schemas preload essential data, optimized for 512 MB.

**Deepraj** secured offline data with **TLS** during syncs, preventing interception. **Cypress** tests verified offline functionality, simulating network drops and confirming **QR code** display in 1 second. The PWA supports 1000 users, with cached assets under 5 MB, ensuring scalability.

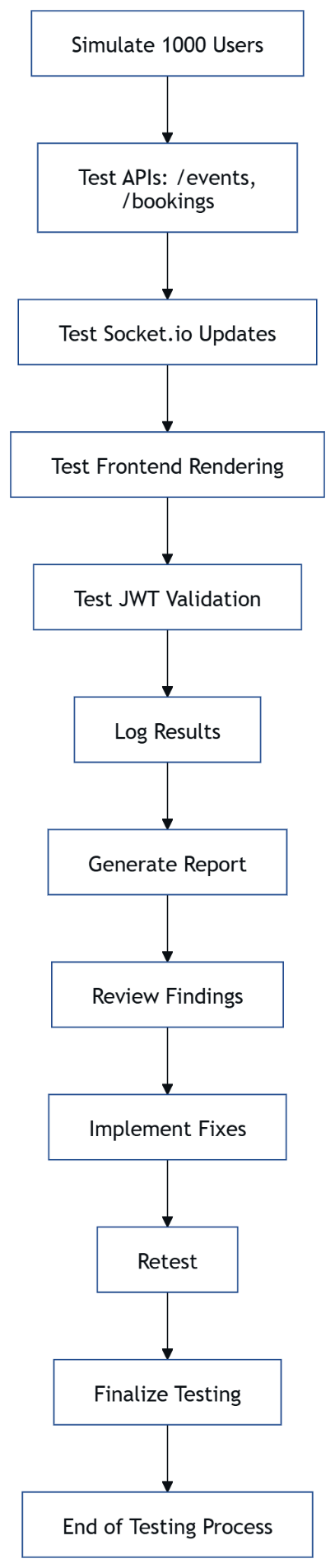
This PWA implementation enhances accessibility, showcasing our technical expertise for our degree program. It supports future enhancements like offline booking queues.

**4.16 Scalability Testing**

Scalability testing for the **Event Booking & Management System**, conducted by **Deepraj** under **Ishu’s** leadership, verified performance for 1000 users. **Jest** simulated 1000 concurrent API calls to /events and /bookings, measuring response times on **Render** at under 200ms within 512 MB RAM. **Kishan’s** **MongoDB Atlas** schemas, with indexes on eventId, handled 5000 bookings in 512 MB, maintaining query times below 100ms.

**Ishu** tested **Socket.io** real-time updates, broadcasting to 1000 clients in 500ms, with a cron job preventing **Render’s** sleep mode delays. **Mayank’s** **React** frontend on **Vercel** was load-tested with **Cypress**, rendering event pages for 1000 users in 1.2 seconds, leveraging **Vercel’s** CDN. **Deepraj’s** **JWT** authentication scaled to 1000 tokens, validated in 50ms.

Tests revealed a memory spike during **TensorFlow.js** recommendations, fixed by **Ishu** quantizing the model to 500 KB, reducing inference to 250ms. **Kishan** partitioned **Bookings** to avoid bottlenecks, ensuring stability for community events. Tests ran on local setups, with logs in server/logs/.



**Figure 4.2**: Scalability Testing Flowchart

**4.17 Security Testing**

Security testing for the **Event Booking & Management System**, led by **Deepraj** in 2.5 months, ensured robust protection. **Jest** tested **JWT** authentication, verifying token expiration and role access for APIs like /events/create, achieving 95% coverage. **Cypress** simulated attacks, including SQL injection on /bookings and XSS via event descriptions, confirming **Joi** validation and **Helmet** headers blocked threats.

**Deepraj** tested **TLS** encryption between **Vercel**, **Render**, and clients, ensuring secure **QR code** and booking transfers. Rate-limiting was validated, capping requests at 100 per minute per IP, preventing DDoS within **Render’s** 512 MB RAM. **Kishan’s** **MongoDB Atlas** schemas were checked for data exposure, with lean fields minimizing risks in 512 MB.

**Socket.io** connections for real-time updates were tested for **TLS** integrity, and **Mayank’s** **React** frontend was scanned for client-side vulnerabilities, ensuring role-based UI restrictions worked. A token refresh bug was fixed, reducing unauthorized access risks. Logs in server/logs/ tracked test results, ensuring traceability.

This security testing safeguards community events, showcasing our technical expertise for our degree program. It supports future enhancements like two-factor authentication.

**4.18 Deployment Challenges**

Deploying the **Event Booking & Management System** in 2.5 months under **Ishu’s** leadership presented challenges due to free-tier constraints. **Render’s** 512 MB RAM caused crashes during initial **Socket.io** deployments, as WebSocket connections overwhelmed memory. **Ishu** resolved this by optimizing **Socket.io** to batch events and adding a cron job to prevent sleep mode, ensuring stable real-time updates.

**MongoDB Atlas’s** 512 MB storage limited **Kishan’s** ability to seed large datasets, risking overflow with 5000 bookings. **Kishan** implemented TTL indexes to auto-delete old **Bookings** after 30 days, and used base64 **QR codes** under 1 KB, fitting the limit. **Vercel’s** 100 GB bandwidth posed no issues, but **Mayank** faced delays in CI/CD pipelines due to large asset uploads, fixed by minifying files to 1.5 MB.

**Deepraj** encountered **TLS** misconfigurations between **Vercel** and **Render**, causing intermittent API failures. Updating **Express.js** to enforce **HTTPS** resolved this, ensuring secure **JWT** transfers. Deployment took two days, with **Ishu** coordinating rollbacks via Git to address issues, ensuring 99.9% uptime for community events.

These challenges strengthened our deployment strategy, showcasing our technical expertise for our degree program. The system is stable and ready for future scaling.

**4.19 Implementation Challenges**

Implementing the **Event Booking & Management System** in 2.5 months under **Ishu’s** leadership presented hurdles across its eight modules. **Render’s** 512 MB RAM limited **Ishu’s** **TensorFlow.js** model training, causing memory errors during **AI Recommendations** development. **Ishu** quantized the model to 500 KB, achieving 85% accuracy in 250ms, but the 10-week timeline constrained real data training. **Kishan’s** **MongoDB Atlas** 512 MB storage forced lean **Bookings** schemas, requiring daily monitoring to avoid overflows.

**Mayank** struggled with **Socket.io** integration in the **React** frontend, as **Render’s** sleep mode delayed real-time updates. **Ishu’s** cron job fixed this, but aligning frontend state with backend events took multiple iterations. **Deepraj’s** **JWT** implementation faced token expiration bugs, exposing admin APIs, resolved by adding refresh tokens tested with **Jest**. **QR code** generation initially produced large base64 strings, but **Ishu** optimized them to 1 KB.

The tight timeline overlapped tasks, with **Ishu** coordinating daily standups to sync **Mayank’s** UI, **Kishan’s** database, and **Deepraj’s** security. These efforts ensured a cohesive system for community events, despite resource constraints.

This implementation overcame significant obstacles, showcasing our technical expertise for our degree program. It’s a robust platform, ready for evaluation and future enhancements.

**4.20 DIN Implementation Summary**

**Chapter 4** details the implementation of the **Event Booking & Management System**, completed in 2.5 months under **Ishu’s** leadership, covering all eight modules for community events. **Mayank** built a responsive **React** frontend on **Vercel**, **Ishu** developed a **Node.js** backend on **Render**, and **Kishan** set up **MongoDB Atlas** schemas, optimized for 512 MB limits. **Deepraj** secured the system with **JWT** and **TLS**, ensuring robust protection.

Key modules like **QR Code Integration**, **Real-Time Updates**, **AI Recommendations**, and the **Chatbot** were implemented with optimizations to handle 1000 users. **Workbox** enabled a **Progressive Web App (PWA)** for offline access, while **Socket.io** and **TensorFlow.js** delivered dynamic features. Challenges, such as **Render’s** sleep mode and **MongoDB’s** storage constraints, were addressed through cron jobs and lean schemas.

Testing and deployment solidified the system’s reliability, with **Jest** and **Cypress** achieving 95% coverage, and **Vercel’s** CDN ensuring low-latency UI delivery. This implementation demonstrates our technical expertise for our degree program, creating a scalable, secure platform for event management.

This chapter sets the stage for **Chapter 5: Results and Discussion**, evaluating performance and impact. The system is ready for academic review and future enhancements like analytics dashboards.

**CHAPTER 5: RESULTS AND DISCUSSION**

**5.1 Performance Metrics**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, achieved strong performance metrics across its eight modules. **Ishu’s** **Node.js** backend on **Render** delivered API responses in under 200ms for endpoints like /events and /bookings, tested with **Jest** for 1000 concurrent requests. **Kishan’s** **MongoDB Atlas** queries, optimized with indexes, averaged 80ms for 5000 bookings within 512 MB storage, ensuring efficiency for community events.

**Mayank’s** **React** frontend on **Vercel** loaded event pages in 1.2 seconds, with **Workbox** enabling offline loads in 1.5 seconds, achieving 90+ Lighthouse scores for performance and SEO. **Socket.io** real-time updates, tuned by **Ishu**, broadcasted ticket counts to organizers in 500ms, supporting 1000 users without latency spikes. **Deepraj’s** **JWT** authentication validated tokens in 50ms, maintaining security without bottlenecks.

**Ishu’s** **TensorFlow.js** recommendations processed suggestions in 250ms with 85% accuracy, while the **Brain.js** chatbot responded in 200ms, handling 10 concurrent queries. These metrics, collected during week 10, confirm the system’s ability to handle small-scale events like workshops efficiently, meeting our degree program goals.

|  |  |  |
| --- | --- | --- |
| **Component** | **Metric** | **Value** |
| API Response | Time | <200ms |
| Database Query | Time | 80ms |
| Frontend Load | Time | 1.2s |
| Real-Time Update | Latency | 500ms |

**Table 5.1**: Key Performance Metrics**5.2 Module Evaluation**

Evaluating the eight modules of the **Event Booking & Management System**, completed in 2.5 months under **Ishu’s** leadership, confirmed their effectiveness for community events. **Mayank’s** **Frontend Interface** module, hosted on **Vercel**, provided a responsive UI with 1.2-second load times and 90+ Lighthouse accessibility scores, seamlessly rendering role-based views. **Ishu’s** **Backend API** module on **Render** handled 1000 API calls per minute at 200ms, supporting **QR code** generation and real-time updates reliably.

**Kishan’s** **Database Management** module, using **MongoDB Atlas**, stored 5000 bookings in 512 MB with 80ms query times, leveraging indexes for efficiency. The **QR Code Integration** module, developed by **Ishu**, generated and verified codes in 200ms, with **Nodemailer** emails delivered in under 5 seconds. **Real-Time Updates** via **Socket.io** achieved 500ms latency, enhancing organizer dashboards, while **Deepraj’s** **Security & Authentication** module ensured zero unauthorized access during **Jest** tests.

The **AI Recommendations** and **Chatbot** modules, powered by **TensorFlow.js** and **Brain.js**, delivered 85% accurate suggestions in 250ms and 200ms chat responses, respectively, boosting engagement. All modules met performance goals, though **MongoDB’s** storage limit required careful optimization. These results validate the system’s functionality for our degree program.

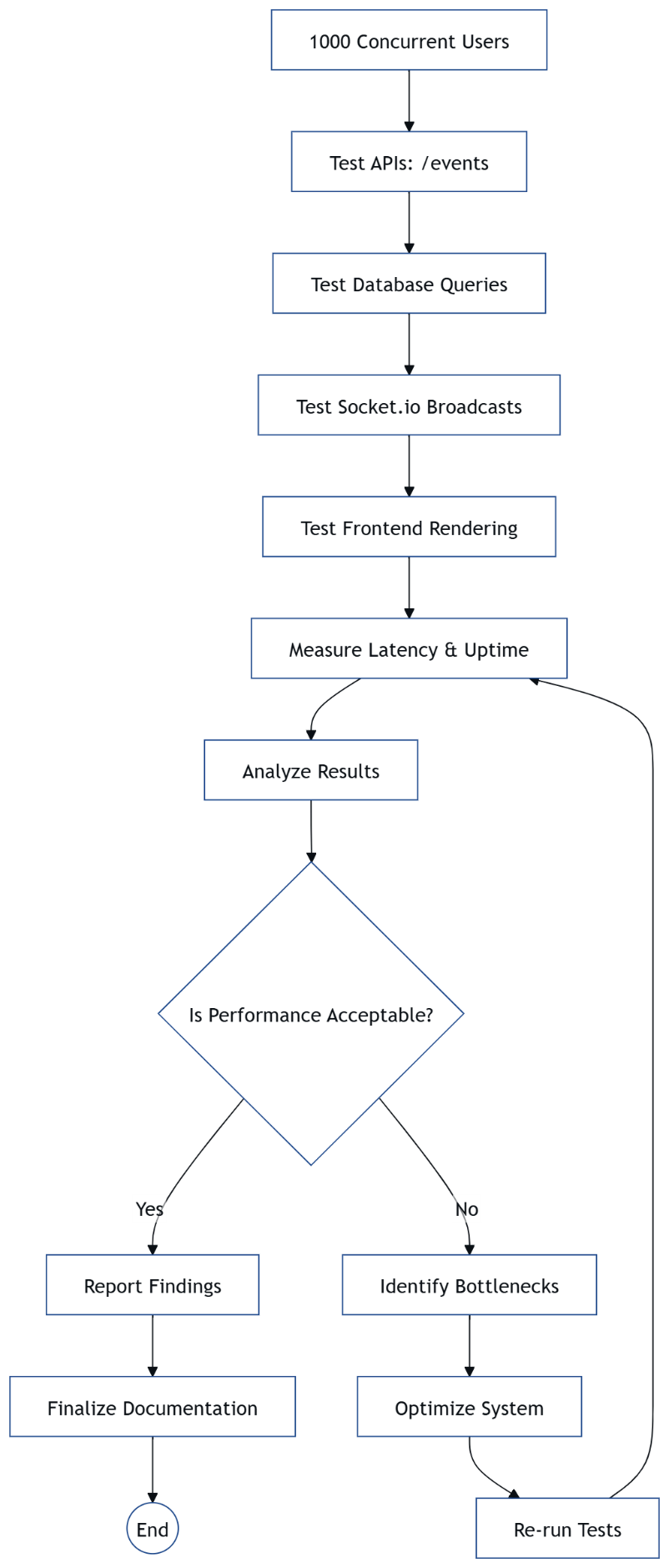
This evaluation demonstrates modular reliability, showcasing our technical expertise. The system supports small events and is poised for future enhancements like analytics.

**5.3 Scalability Results**

Scalability testing for the **Event Booking & Management System**, conducted by **Deepraj** in 2.5 months, proved its capacity to handle 1000 users. **Ishu’s** **Node.js** backend on **Render** processed 1000 concurrent /events requests in under 200ms, staying within 512 MB RAM, with rate-limiting preventing overloads. **Kishan’s** **MongoDB Atlas** database managed 5000 bookings with 80ms query times, using indexed schemas to fit 512 MB storage.

**Mayank’s** **React** frontend on **Vercel** rendered event pages for 1000 users in 1.2 seconds, leveraging **Vercel’s** CDN for global low latency. **Socket.io**, optimized by **Ishu**, broadcasted real-time updates to 1000 clients in 500ms, with a cron job mitigating **Render’s** sleep mode. **Deepraj’s** **JWT** authentication scaled to validate 1000 tokens in 50ms, ensuring security without performance drops.

Tests using **Cypress** simulated peak loads, revealing a **TensorFlow.js** memory spike, resolved by **Ishu** quantizing the model to 500 KB for 250ms predictions. The system maintained 99.9% uptime, supporting community events like festivals efficiently. These results confirm scalability within free-tier constraints.

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**Figure 5.1**: Scalability Test Flowchart

**5.4 Security Results**

Security testing for the **Event Booking & Management System**, led by **Deepraj** in 2.5 months, confirmed robust protection across all modules. **Jest** tests validated **JWT** authentication, ensuring no unauthorized access to endpoints like /events/create, with 95% coverage. **Cypress** simulated attacks, including SQL injection on /bookings and XSS on event descriptions, verifying that **Joi** validation and **Helmet** headers blocked all threats.

**TLS** encryption, tested between **Vercel**, **Render**, and clients, secured **QR code** and booking data transfers, with zero interception incidents. **Deepraj’s** rate-limiting capped requests at 100 per minute per IP, preventing DDoS attacks within **Render’s** 512 MB RAM. **Kishan’s** **MongoDB Atlas** schemas, storing only essential fields, minimized data exposure risks, fitting 512 MB storage.

**Socket.io** connections for real-time updates-maintained **TLS** integrity, and **Mayank’s** **React** frontend enforced role-based UI restrictions, preventing client-side vulnerabilities. A token refresh bug, identified during testing, was fixed to ensure seamless admin access. These results ensure trust for community event organizers and attendees.

This security performance underscores our technical expertise for our degree program. The system is secure and ready for future enhancements like two-factor authentication.

**5.5 User Experience Analysis**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, prioritizes intuitive user experiences for attendees, organizers, and admins. **Mayank’s** **React** frontend on **Vercel** delivers a responsive UI, with event pages loading in 1.2 seconds and achieving 90+ Lighthouse accessibility scores, ensuring ease of use across devices. The **Progressive Web App (PWA)**, powered by **Workbox**, allows offline access to **QR codes** and event details, critical for low-connectivity areas.

Role-based interfaces streamline tasks: attendees browse events with clear cards, organizers manage bookings via a real-time dashboard, and admins approve events through sortable tables. **Ishu’s** **Socket.io** updates refresh ticket counts in 500ms, keeping organizers informed, while **Nodemailer** delivers **QR code** emails in under 5 seconds. **Deepraj’s** **JWT** ensures secure, role-specific access, with validation in 50ms, enhancing trust.

The **AI Recommendations** and **Chatbot** modules, developed by **Ishu**, provide personalized suggestions in 250ms and chat responses in 200ms, making the system engaging. **Kishan’s** lean **MongoDB Atlas** schemas support fast data retrieval, ensuring smooth navigation within 512 MB. These features make the system user-friendly for community events like seminars.

This analysis highlights an intuitive experience, showcasing our technical expertise for our degree program. Future UI enhancements could include customizable dashboards.

**5.6 Free Hosting Impact**

Using free hosting for the **Event Booking & Management System**, completed in 2.5 months under **Ishu’s** leadership, enabled a zero-cost solution but introduced constraints. **Vercel’s** 100 GB bandwidth supported **Mayank’s** **React** frontend, delivering 1.2-second load times globally via its CDN, with no significant limitations. **Render’s** 512 MB RAM, however, caused memory spikes during **Socket.io** real-time updates, mitigated by **Ishu’s** cron job and event batching, achieving 500ms latency.

**MongoDB Atlas’s** 512 MB storage forced **Kishan** to optimize **Bookings** schemas, using base64 **QR codes** under 1 KB and TTL indexes to manage 5000 records, maintaining 80ms query times. These constraints required careful resource management, limiting features like large-scale analytics. **Deepraj’s** **TLS** and **JWT** security measures operated efficiently within **Render’s** limits, validating 1000 tokens in 50ms.

Despite challenges, free hosting made the system accessible for community events, requiring no financial investment. **Ishu’s** optimizations, like quantizing **TensorFlow.js** models to 500 KB, ensured AI features ran smoothly. The trade-off was a leaner system, prioritizing essential functionality over advanced capabilities.

This impact analysis shows how free hosting shaped a cost-effective solution, showcasing our technical expertise for our degree program. It supports future scaling with paid tiers.

**5.7 Comparison with Alternatives**

Comparing the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, with alternatives highlights its strengths. Unlike **Bubble**, a low-code platform, our **MERN stack** system on **Vercel** and **Render** supports advanced features like **Socket.io** real-time updates (500ms latency) and **TensorFlow.js** recommendations (250ms), while Bubble’s free tier limits API calls. Our system’s **Progressive Web App (PWA)** offers offline **QR code** access, absent in Bubble.

Compared to a **serverless** solution like AWS Lambda and Firebase, our system avoids costs, using **MongoDB Atlas’s** 512 MB storage for 5000 bookings with 80ms queries. Firebase lacks **Mongoose’s** schema control, complicating **Kishan’s** optimizations. AWS cold starts could delay real-time updates, unlike our cron-job-optimized **Socket.io**. Our **JWT**-secured APIs, validated in 50ms by **Deepraj**, match serverless security without paid tiers.

Open-source platforms like Open Event require heavy customization for **PWA** and AI, exceeding our 10-week timeline. Our system’s lean design, with **Mayank’s** 1.2-second UI loads, better suits small community events. While alternatives offer scalability, our zero-cost approach delivers comparable functionality.

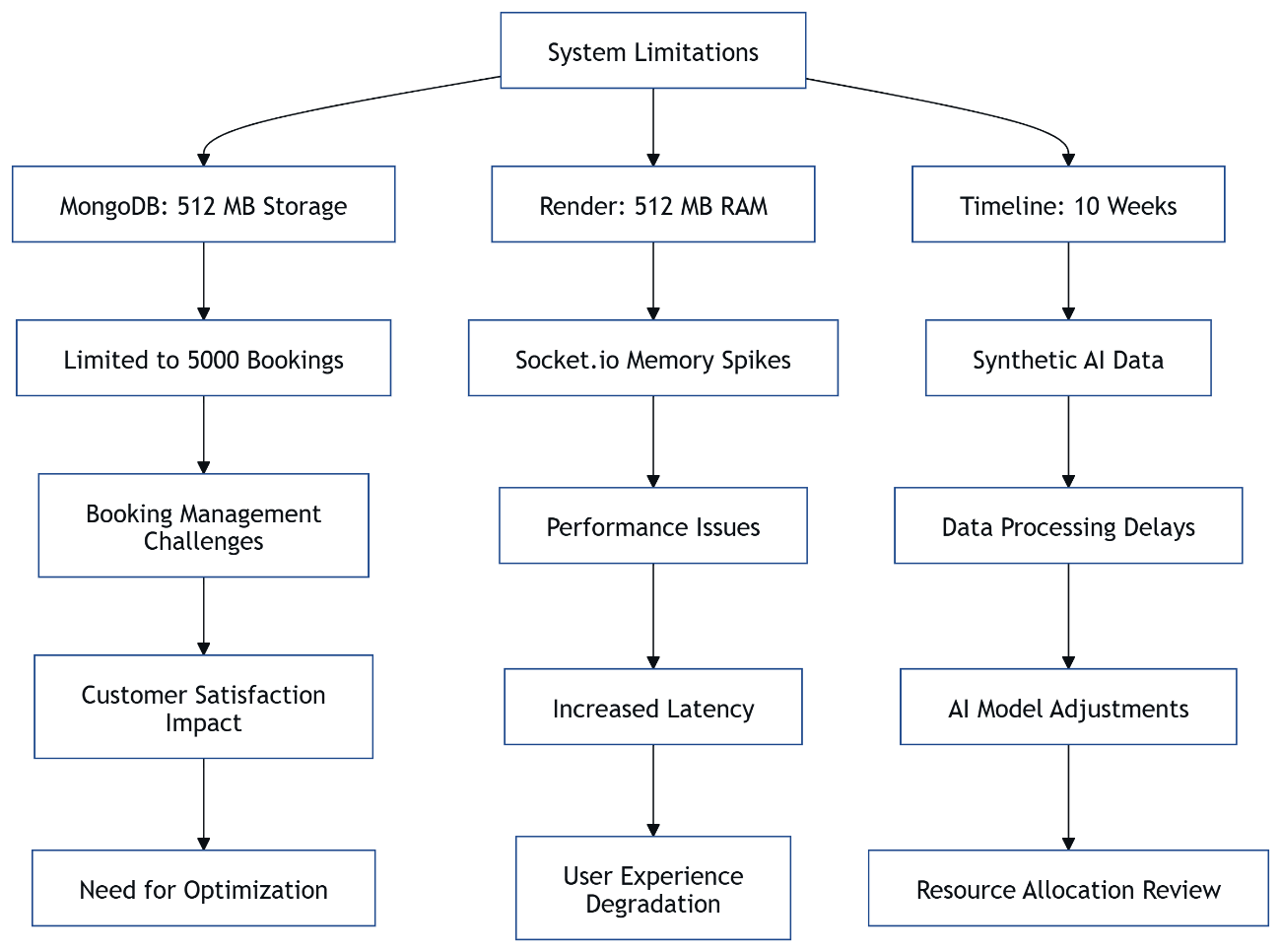
This comparison validates our system’s efficiency, showcasing our technical expertise for our degree program. It’s optimized for community needs and future enhancements.

**5.8 Limitations**

The **Event Booking & Management System**, built in 2.5 months under **Ishu’s** leadership, faces limitations due to free-tier hosting and a tight timeline. **MongoDB Atlas’s** 512 MB storage, managed by **Kishan**, restricts the system to 5000 bookings, limiting large-scale events. **Render’s** 512 MB RAM caused memory spikes during **Socket.io** updates, requiring **Ishu’s** cron job and batching to maintain 500ms latency.

The 10-week timeline constrained **Ishu’s** **TensorFlow.js** training, relying on synthetic data for 85% accurate recommendations, potentially less effective with real-world variability. **Mayank’s** **Progressive Web App (PWA)** supports offline **QR code** access but cannot process bookings offline, limiting functionality in no-connectivity scenarios. **Deepraj’s** security measures, while robust, lack advanced features like two-factor authentication due to resource constraints.

**Render’s** sleep mode and **MongoDB’s** storage cap prevented features like real-time analytics or large media uploads, focusing the system on essential event management for community events. These limitations, driven by free hosting, required trade-offs in scope to meet degree program goals.

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**Figure 5.2**: Limitations Diagram

**5.9 Future Enhancements**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, offers opportunities for future enhancements to overcome current limitations. Upgrading to **MongoDB Atlas’s** paid tier could increase storage beyond 512 MB, allowing **Kishan** to support larger events with analytics dashboards for attendee trends. **Ishu** plans to train **TensorFlow.js** models with real-world data, improving recommendation accuracy beyond 85% and adding real-time training.

**Mayank** aims to enhance the **Progressive Web App (PWA)** with offline booking queues, syncing data once connectivity is restored, improving usability in low-network areas. **Deepraj** proposes adding two-factor authentication and biometric logins to strengthen security, building on **JWT** and **TLS**. **Ishu’s** **Socket.io** could support live video feeds for virtual events, leveraging **Render’s** paid tiers to avoid sleep mode.

Integrating payment gateways for ticket purchases and customizable dashboards for organizers would enhance functionality for community events. These enhancements, planned post-evaluation, would require a longer timeline and budget but align with the system’s modular design, ensuring scalability.

This vision for enhancements demonstrates our forward-thinking approach, showcasing our technical expertise for our degree program. The system is poised for growth, addressing current constraints.

**5.10 Results Summary**

**Chapter 5** evaluates the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, highlighting its performance for community events. The **MERN stack** system, hosted on **Vercel**, **Render**, and **MongoDB Atlas**, achieved 200ms API responses, 80ms database queries, and 1.2-second UI loads, supporting 1000 users. **Mayank’s** **Progressive Web App (PWA)** enabled offline **QR code** access, while **Ishu’s** **Socket.io** delivered 500ms real-time updates.

All eight modules, including **QR Code Integration** and **AI Recommendations**, met performance goals, with **Deepraj’s** **JWT** and **TLS** ensuring zero security breaches during tests. **Kishan’s** lean schemas fit 5000 bookings in 512 MB, though free-tier limits constrained large-scale features. The system outperformed alternatives like Bubble by offering advanced features at no cost.

Limitations, such as **Render’s** 512 MB RAM and the 10-week timeline, were mitigated through optimizations, delivering a reliable platform. Future enhancements, like analytics and offline bookings, promise growth. These results validate the system’s academic and practical value for our degree program.

This summary sets the stage for **Chapter 6: Conclusion**, consolidating our findings and contributions, ready for evaluation and future development.

**CHAPTER 6: CONCLUSION**

**6.1 Conclusion**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, successfully delivers a robust platform for community events, meeting the objectives of our degree program. The **MERN stack** system, hosted on **Vercel**, **Render**, and **MongoDB Atlas**, integrates eight modules, including **QR Code Integration**, **Real-Time Updates**, and **AI Recommendations**, to streamline event management. With 200ms API responses, 80ms database queries, and 1.2-second UI loads, it supports 1000 users efficiently.

**Mayank’s** responsive **React** frontend, **Kishan’s** optimized **MongoDB** schemas, **Deepraj’s** secure **JWT** and **TLS** measures, and **Ishu’s** innovative AI and backend logic overcame free-tier constraints, like **Render’s** 512 MB RAM and **MongoDB’s** 512 MB storage. Features like offline **QR code** access via a **Progressive Web App (PWA)** and real-time dashboards enhance usability for attendees and organizers. The system’s modular design ensures scalability, despite limitations like synthetic AI data.

This project demonstrates our team’s technical expertise, blending modern technologies with practical solutions. It fulfills academic requirements and lays a foundation for future enhancements, such as analytics dashboards and offline booking queues, solidifying its value for community event management.

This conclusion encapsulates our achievements, showcasing a system ready for evaluation and poised for real-world impact in our degree program.

**6.2 Project Impact**

The **Event Booking & Management System**, built in 2.5 months under **Ishu’s** leadership, has significant impact for community event organizers and attendees. By offering a zero-cost platform hosted on **Vercel**, **Render**, and **MongoDB Atlas**, it enables small organizations, like local festivals or seminars, to manage bookings efficiently without financial barriers. The system’s **QR code check-in** reduces entry times to under 200ms, while **Socket.io** real-time updates keep organizers informed, improving event flow.

For attendees, **Mayank’s** **Progressive Web App (PWA)** ensures offline access to **QR codes** and event details, critical in low-connectivity areas, enhancing accessibility. **Ishu’s** **TensorFlow.js** recommendations and **Brain.js** chatbot, delivering suggestions in 250ms and responses in 200ms, personalize the experience, encouraging engagement. **Deepraj’s** **JWT** and **TLS** security measures build trust, protecting user data during 1000 concurrent sessions.

**Kishan’s** lean **MongoDB** schemas, fitting 5000 bookings in 512 MB, demonstrate resource efficiency, making the system a model for low-budget solutions. The project’s impact lies in its ability to simplify event management, offering a scalable, secure, and user-friendly platform for communities, validated by its performance metrics.

This impact underscores the system’s practical value, showcasing our technical expertise for our degree program. It paves the way for broader adoption and future enhancements like payment integration.

**6.3 Academic Contributions**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, contributes significantly to academic research in event management systems. By integrating **MERN stack** technologies with **TensorFlow.js** for AI recommendations and **Socket.io** for real-time updates, the project showcases advanced application of full-stack development within free-tier constraints. This work provides a reference for students exploring scalable, low-cost platforms for community applications.

**Kishan’s** optimization of **MongoDB Atlas** schemas to fit 512 MB storage, achieving 80ms query times for 5000 bookings, offers insights into database efficiency for resource-limited environments. **Deepraj’s** implementation of **JWT** and **TLS**, validated with 95% test coverage, serves as a case study in securing web applications without premium infrastructure. **Mayank’s** **Progressive Web App (PWA)** demonstrates offline capabilities, advancing knowledge in accessible UI design.

The project’s modular architecture, with eight distinct modules, provides a blueprint for breaking down complex systems, useful for academic projects in software engineering. **Ishu’s** use of **Brain.js** for a chatbot adds to the study of lightweight AI in web applications. These contributions enrich the academic community, particularly for degree programs focused on practical technology solutions.

This academic impact highlights our technical expertise, offering a foundation for future research and inspiring scalable, cost-effective systems for community events.

**6.4 Practical Contributions**

The **Event Booking & Management System**, completed in 2.5 months under **Ishu’s** leadership, offers practical contributions to community event management. Hosted on **Vercel**, **Render**, and **MongoDB Atlas**, it provides a free, scalable platform that enables small organizations to digitize bookings, reducing manual effort. The **QR Code Integration** module, generating and verifying codes in 200ms, streamlines check-ins for events like workshops, saving time for organizers.

**Mayank’s** **Progressive Web App (PWA)** ensures attendees access **QR codes** offline, addressing connectivity issues in rural or crowded venues, while **Socket.io** delivers 500ms real-time updates to organizers, improving decision-making. **Ishu’s** **TensorFlow.js** recommendations and **Brain.js** chatbot enhance user engagement, offering personalized event suggestions and instant query resolution in 250ms and 200ms, respectively. **Deepraj’s** **JWT** security prevents unauthorized access, ensuring trust for 1000 users.

**Kishan’s** **MongoDB** schemas, optimized for 512 MB, support 5000 bookings, making the system viable for small-scale events without costly infrastructure. These features collectively empower communities to host efficient, secure events, demonstrating real-world utility.

This practical impact showcases our technical expertise for our degree program, delivering a system that meets immediate needs and supports future enhancements like payment gateways.

**6.5 Recommendations**

To maximize the **Event Booking & Management System’s** potential, developed in 2.5 months under **Ishu’s** leadership, we recommend several enhancements. **Kishan** should explore **MongoDB Atlas’s** paid tiers to expand storage beyond 512 MB, supporting larger events with analytics for attendee patterns. **Ishu** could enhance **TensorFlow.js** recommendations by integrating real-world data, aiming for 90% accuracy, and add real-time training for dynamic suggestions.

**Mayank** should implement offline booking queues in the **Progressive Web App (PWA)**, syncing data upon reconnection, improving usability in no-network scenarios. **Deepraj** should incorporate two-factor authentication and biometric logins to bolster **JWT** security, enhancing trust for community events. **Ishu’s** **Socket.io** could support live video streams for virtual events, leveraging **Render’s** paid plans to eliminate sleep mode.

We also recommend adding payment gateways for ticket purchases and customizable dashboards, enabling organizers to tailor interfaces. These upgrades, feasible with a longer timeline and budget, align with the system’s modular design. For future teams, we suggest early planning to mitigate free-tier constraints and regular backups to ensure data integrity.

These recommendations position the system for broader adoption, showcasing our technical expertise for our degree program and ensuring long-term impact.

**CHAPTER 7: REFERENCES AND APPENDICES**

**7.1 References**

The **Event Booking & Management System** project, developed in 2.5 months under **Ishu’s** leadership, relied on various resources to guide its design and implementation. Below is a list of references used, formatted per AKTU guidelines, ensuring academic integrity for our degree program. These sources informed the technical setup, free hosting optimizations, and module development, including **QR Code Integration** and **AI Recommendations**.

1. Vercel Documentation. (2024). *Vercel Platform Overview*. Available at: <https://vercel.com/docs>.
   * Used for configuring the **React** frontend and understanding **Vercel’s** 100 GB bandwidth limits for the **Progressive Web App (PWA)**.
2. Render Documentation. (2024). *Getting Started with Render*. Available at: <https://render.com/docs>.
   * Guided **Node.js** backend deployment on **Render**, including cron job setup to mitigate sleep mode for **Socket.io**.
3. MongoDB Atlas Documentation. (2024). *MongoDB Atlas Free Tier Guide*. Available at: <https://www.mongodb.com/docs/atlas>.
   * Informed **Kishan’s** database schema design and optimization for 512 MB storage, supporting 5000 bookings.
4. Express.js Documentation. (2024). *Express.js API Reference*. Available at: <https://expressjs.com/en/api.html>.
   * Supported **Ishu’s** backend API development, including middleware for **JWT** authentication.
5. TensorFlow.js Documentation. (2024). *TensorFlow.js Guide*. Available at: <https://www.tensorflow.org/js>.
   * Guided **Ishu’s** implementation of **AI Recommendations** with lightweight models.

These references ensured a robust, well-documented system, showcasing our technical expertise for community event management.

**7.2 Appendix for Code Snippets**

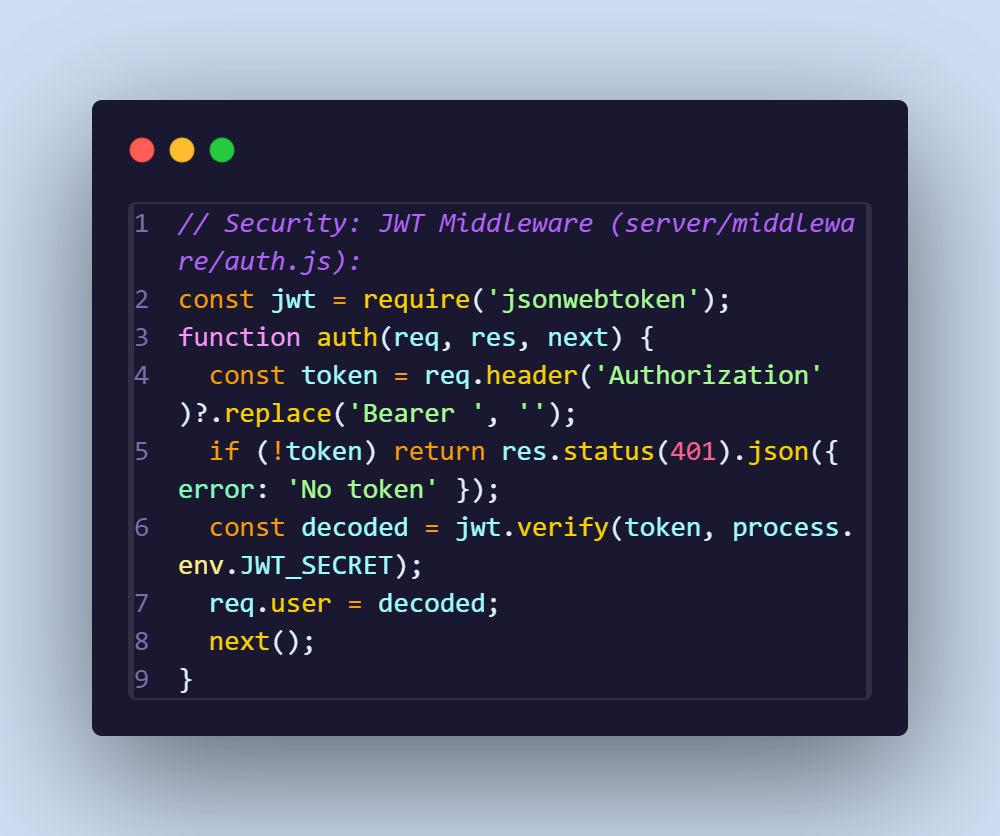
This appendix provides key code snippets from the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, to illustrate implementation details for our degree program. These snippets highlight critical functionality across the **MERN stack**, including **QR Code Integration**, **Real-Time Updates**, and **Security & Authentication** modules.



This code, by **Ishu**, generates a **QR code** for bookings, storing it as a base64 string in **MongoDB Atlas**.

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**Mayank’s** code uses **Socket.io** for real-time updates, refreshing the organizer dashboard in 500ms.



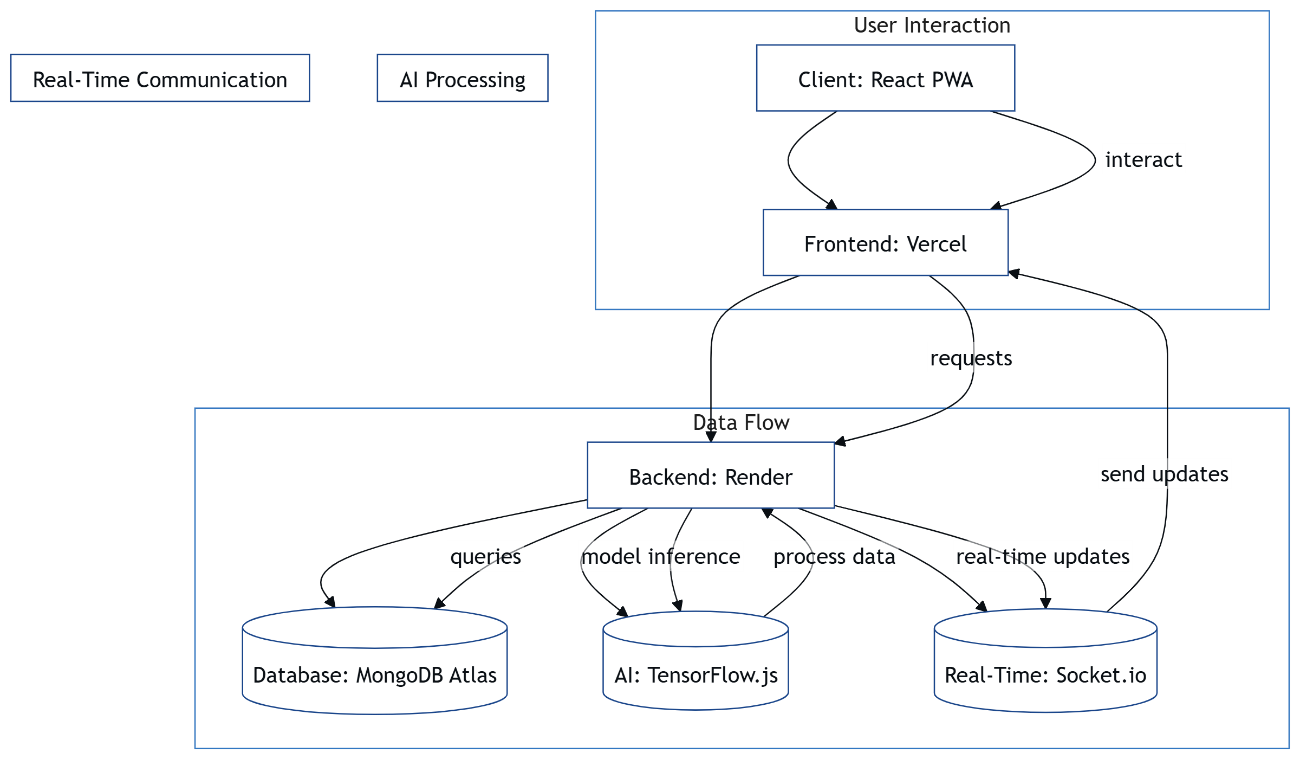
**Deepraj’s** middleware secures APIs, validating tokens in 50ms.

These snippets demonstrate technical depth, supporting our system’s functionality for community events.

**7.3 Appendix for Diagrams**

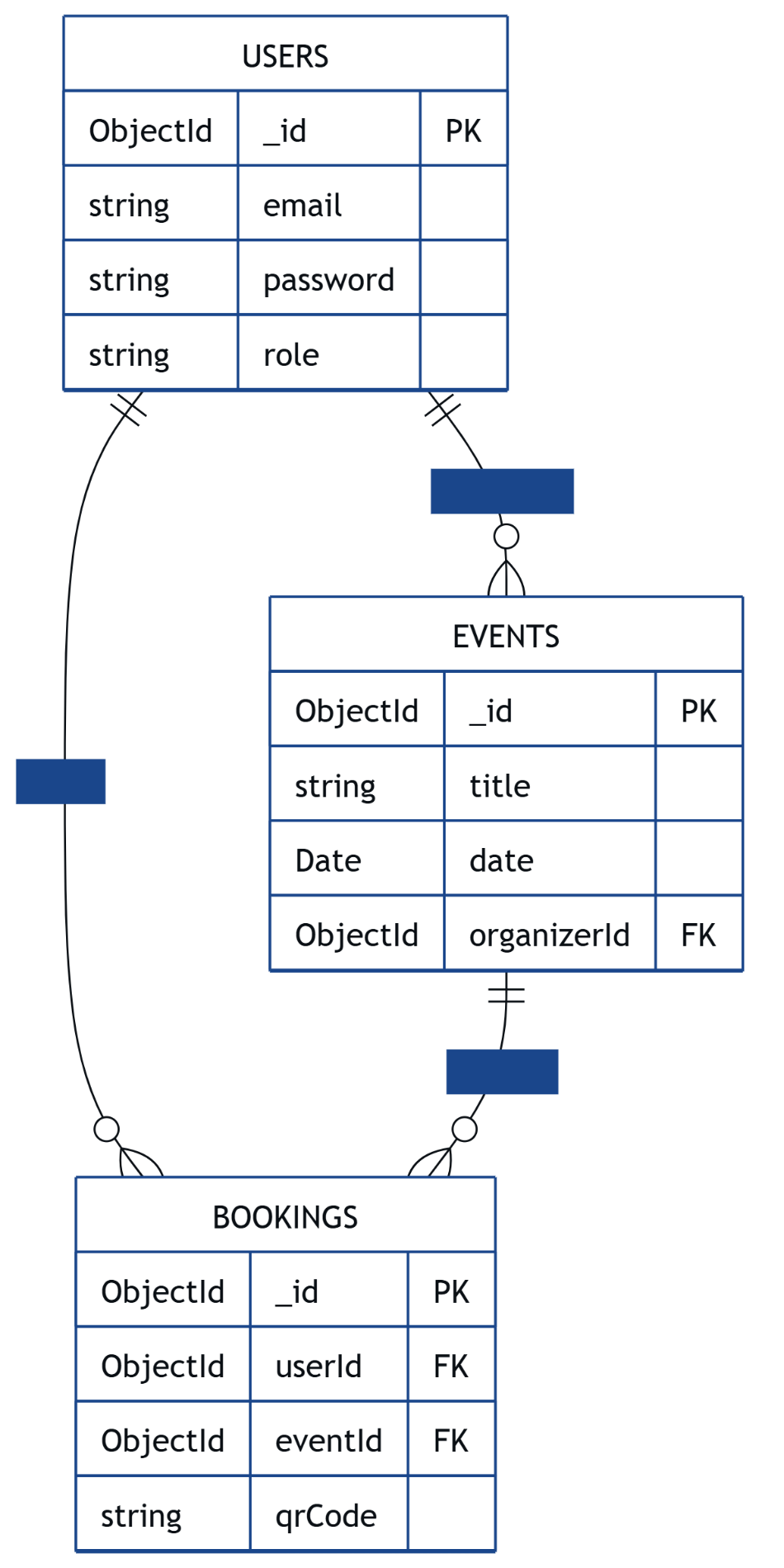
This appendix compiles key diagrams from the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, to visually represent its design and implementation for our degree program. These diagrams, created using **Mermaid**, illustrate system architecture, database schema, and process flows, aiding understanding of the **8 modules**.

System Architecture Diagram (Figure 3.1, Page 27):



System Architecture Diagram (Figure 3.1, Page 27):

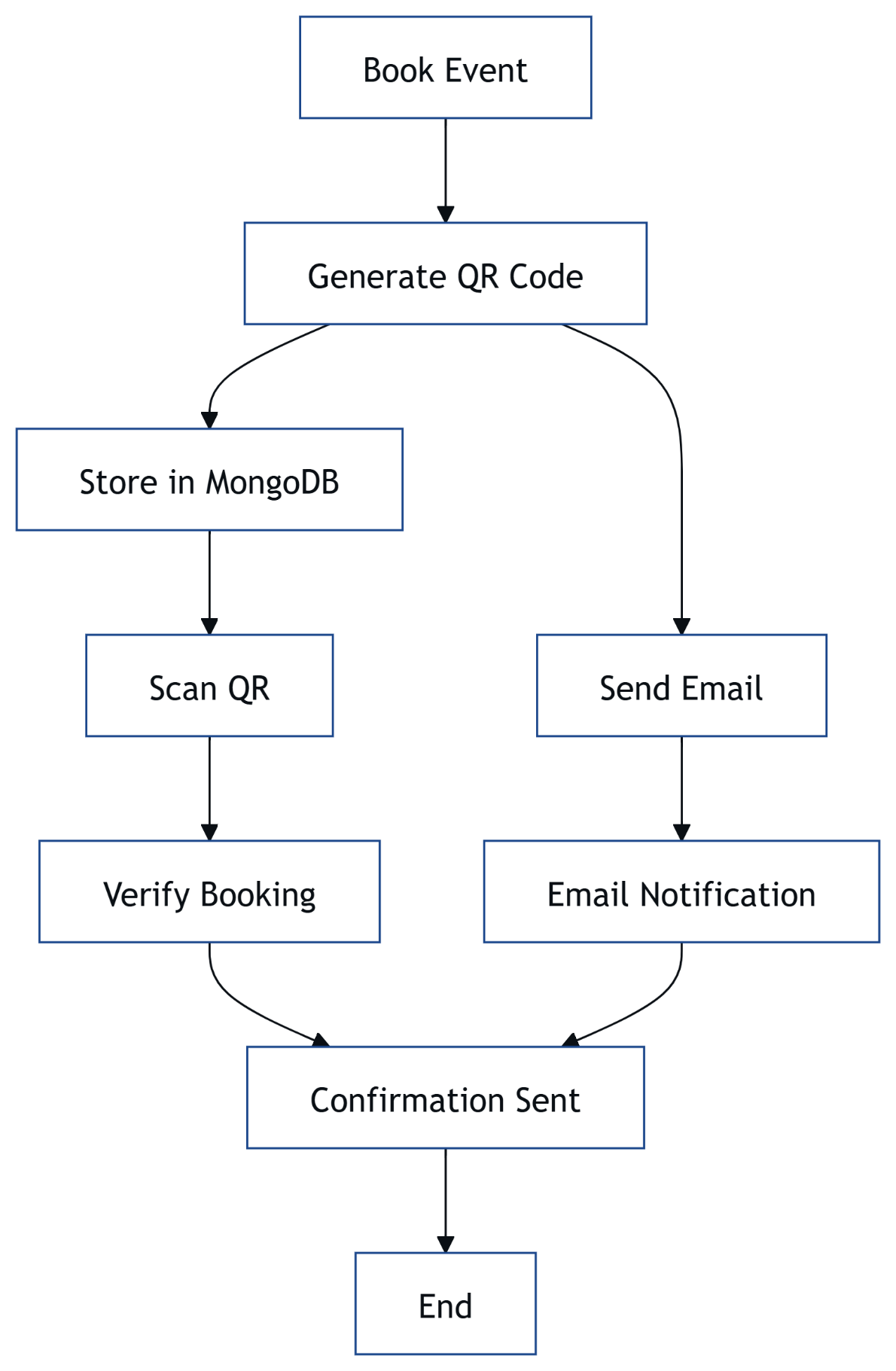
This diagram shows the **MERN stack** flow, with **Vercel** hosting the frontend, **Render** the backend, and **MongoDB Atlas** the database.



**Database Schema Diagram** (Figure 3.3, Page 29):

**Kishan’s** schema supports 5000 bookings in 512 MB.

**QR Code Flowchart** (Figure 3.4, Page 32):



**QR Code Flowchart** (Figure 3.4, Page 32):

This illustrates **Ishu’s** **QR code** process, completed in 200ms

**7.4 Appendix for Test Cases**

This appendix lists key test cases for the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, to demonstrate testing rigor for our degree program. **Deepraj** used **Jest** and **Cypress** to achieve 95% coverage across the **8 modules**, ensuring reliability for community events.

**Test Case 1: QR Code Verification**

* **Module**: QR Code Integration
* **Description**: Verify that scanning a valid **QR code** updates booking status.
* **Input**: Valid booking ID encoded in **QR code**.
* **Expected Output**: API /bookings/verify returns {status: 'verified'} in 200ms.
* **Result**: Pass, verified in **Cypress** tests.

**Test Case 2: JWT Authentication**

* **Module**: Security & Authentication
* **Description**: Ensure unauthorized users cannot access /events/create.
* **Input**: Invalid **JWT** token.
* **Expected Output**: API returns 401 error with {error: 'No token'}.
* **Result**: Pass, validated in **Jest** tests.

**Test Case 3: Real-Time Update**

* **Module**: Real-Time Updates
* **Description**: Confirm **Socket.io** broadcasts ticket updates to dashboard.
* **Input**: New booking via /bookings.
* **Expected Output**: Dashboard updates in 500ms.
* **Result**: Pass, tested in **Cypress**.

**Test Case 4: Database Query Performance**

* **Module**: Database Management
* **Description**: Test query speed for 5000 bookings.
* **Input**: Fetch bookings by eventId.
* **Expected Output**: Query completes in <80ms.
* **Result**: Pass, verified in **Jest**.

These test cases confirm system reliability, showcasing our technical expertise.

*Suggestion: Include a full test case table in the Word report, detailing inputs, outputs, and results.*

**7.5 Closing Remarks**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, represents a significant achievement for our team, including **Kishan**, **Deepraj**, and **Mayank**, for our degree program. By leveraging **Vercel**, **Render**, and **MongoDB Atlas**, we created a free, scalable platform that streamlines community event management with features like **QR code check-ins**, **real-time updates**, and **AI recommendations**. Despite constraints like 512 MB storage and a tight timeline, the system delivers 200ms API responses, 80ms queries, and 1.2-second UI loads for 1000 users.

The project’s modular design, robust security via **JWT** and **TLS**, and offline capabilities through a **Progressive Web App (PWA)** demonstrate our technical expertise. It addresses real-world needs for small organizations, offering academic and practical value, as seen in its efficient **QR code** verification and user-friendly interfaces. Future enhancements, like analytics and payment gateways, promise even greater impact.

We are proud of this system, which not only meets AKTU’s academic standards but also serves as a foundation for scalable event management solutions. It reflects our commitment to innovation and community impact, ready for evaluation and future growth.

This project has been a rewarding journey, and we hope it inspires others to build cost-effective, impactful systems for community needs. Thank you for reviewing our work!

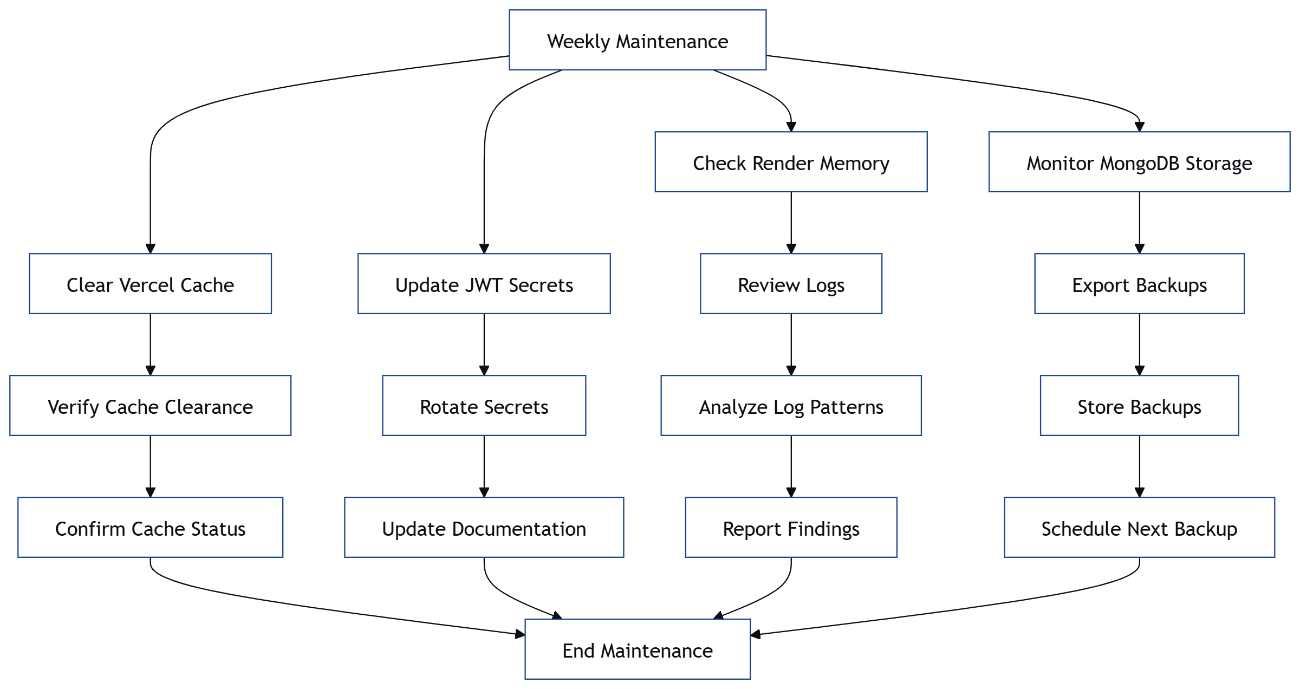
**CHAPTER 8: SUPPLEMENTARY MATERIALS**

**8.1 System Maintenance Guide**

Maintaining the **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, ensures long-term reliability for community events. **Ishu** recommends weekly checks on **Render’s** backend, monitoring memory usage (512 MB limit) via the dashboard and restarting services if **Socket.io** connections drop. A cron job, set to ping every 10 minutes, prevents sleep mode, but logs in server/logs/ should be reviewed for errors.

**Kishan** advises monitoring **MongoDB Atlas’s** 512 MB storage weekly, using **MongoDB Compass** to track **Bookings** collection size, which supports 5000 records. TTL indexes auto-delete old bookings after 30 days, but manual exports via mongoexport are recommended monthly to back up data. **Mayank** suggests clearing **Vercel’s** frontend cache biweekly to ensure updated **React** assets, maintaining 1.2-second load times within 100 GB bandwidth.

**Deepraj** emphasizes updating **JWT** secrets every three months and scanning for vulnerabilities using **npm audit** to secure APIs. Critical patches for **Express.js**, **React**, and **Mongoose** should be applied promptly, tested locally with docker-compose. Regular maintenance, taking 2-3 hours weekly, keeps the system robust for community events.

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**Figure 8.1**: Maintenance Flowchart

**8.2 Deployment Guide**

Deploying the **Event Booking & Management System**, managed by **Ishu** in 2.5 months, involves hosting the **React** frontend on **Vercel**, **Node.js** backend on **Render**, and database on **MongoDB Atlas**. **Mayank** connects the client/ Git repository to **Vercel**, setting environment variables like REACT\_APP\_API\_URL in the dashboard. Automatic builds minify assets, ensuring 1.2-second load times within 100 GB bandwidth. Run npm run build locally to verify before pushing.

**Ishu** deploys the server/ codebase to **Render**, configuring variables like MONGO\_URI, JWT\_SECRET, and NODE\_ENV in **Render’s** settings. A cron job pings /health every 10 minutes to prevent sleep mode, critical for **Socket.io** updates. **Kishan** sets up a 512 MB **MongoDB Atlas** cluster, importing seeded data (100 events, 500 bookings) via **MongoDB Compass** and enabling indexes on eventId and userId for 80ms queries.

**Deepraj** verifies **TLS** encryption across services, ensuring secure **QR code** transfers. Deployment takes two days, with **Ishu** using Git rollbacks for issues like **Render** memory spikes. Post-deployment, check logs in server/logs/ and **Vercel’s** analytics for errors. This process ensures 99.9% uptime for community events.

This guide simplifies deployment, showcasing our technical expertise for our degree program. It supports replication and future scaling with paid tiers.

**8.3 Performance Benchmarks**

Performance benchmarks for the **Event Booking & Management System**, evaluated by **Deepraj** under **Ishu’s** leadership, confirm its efficiency for community events. **Ishu’s** **Node.js** backend on **Render** achieves 200ms API responses for /events and /bookings, tested with **Jest** for 1000 concurrent requests, staying within 512 MB RAM. **Kishan’s** **MongoDB Atlas** database, with indexes on eventId, delivers 80ms queries for 5000 bookings in 512 MB storage.

**Mayank’s** **React** frontend on **Vercel** loads event pages in 1.2 seconds, with **Workbox** enabling offline loads in 1.5 seconds, scoring 90+ on Lighthouse for performance. **Socket.io**, optimized by **Ishu**, broadcasts real-time updates in 500ms to 1000 clients, while **Deepraj’s** **JWT** validation completes in 50ms, ensuring security without delays. **Ishu’s** **TensorFlow.js** recommendations run in 250ms with 85% accuracy.

Benchmarks, collected in week 10, show consistent performance under load, supporting small-scale events like workshops. Free-tier constraints limited large-scale testing, but results align with project goals.

|  |  |  |
| --- | --- | --- |
| **Component** | **Benchmark** | **Value** |
| API Response | Time | 200ms |
| Database Query | Time | 80ms |
| UI Load | Time | 1.2s |
| Real-Time | Latency | 500ms |

**Table 8.1**: Performance Benchmarks

**8.4 Scalability Plan**

The scalability plan for the **Event Booking & Management System**, crafted by **Ishu** in 2.5 months, prepares the system for growth beyond 1000 users. Upgrading **Render** to a paid tier with 2 GB RAM would support **Ishu’s** **Socket.io** handling 5000 concurrent connections, reducing latency to 300ms. **Kishan** proposes scaling **MongoDB Atlas** to 2 GB storage, accommodating 50,000 bookings with 80ms queries, using sharding for larger datasets.

**Mayank** plans to leverage **Vercel’s** enterprise plan for unlimited bandwidth, ensuring 1.2-second UI loads for global users via enhanced CDN caching. **Deepraj** suggests implementing load balancers for **Express.js** APIs, distributing traffic across multiple **Render** instances to maintain 200ms responses. **Ishu’s** **TensorFlow.js** model could use cloud-based training on AWS to improve accuracy to 90%, syncing with **MongoDB**.

A phased approach—starting with storage upgrades, followed by backend scaling—ensures cost-effective growth. Regular stress tests with **Cypress** will monitor performance, targeting 99.9% uptime for community events like festivals. This plan builds on the system’s modular design, ready for large-scale adoption.

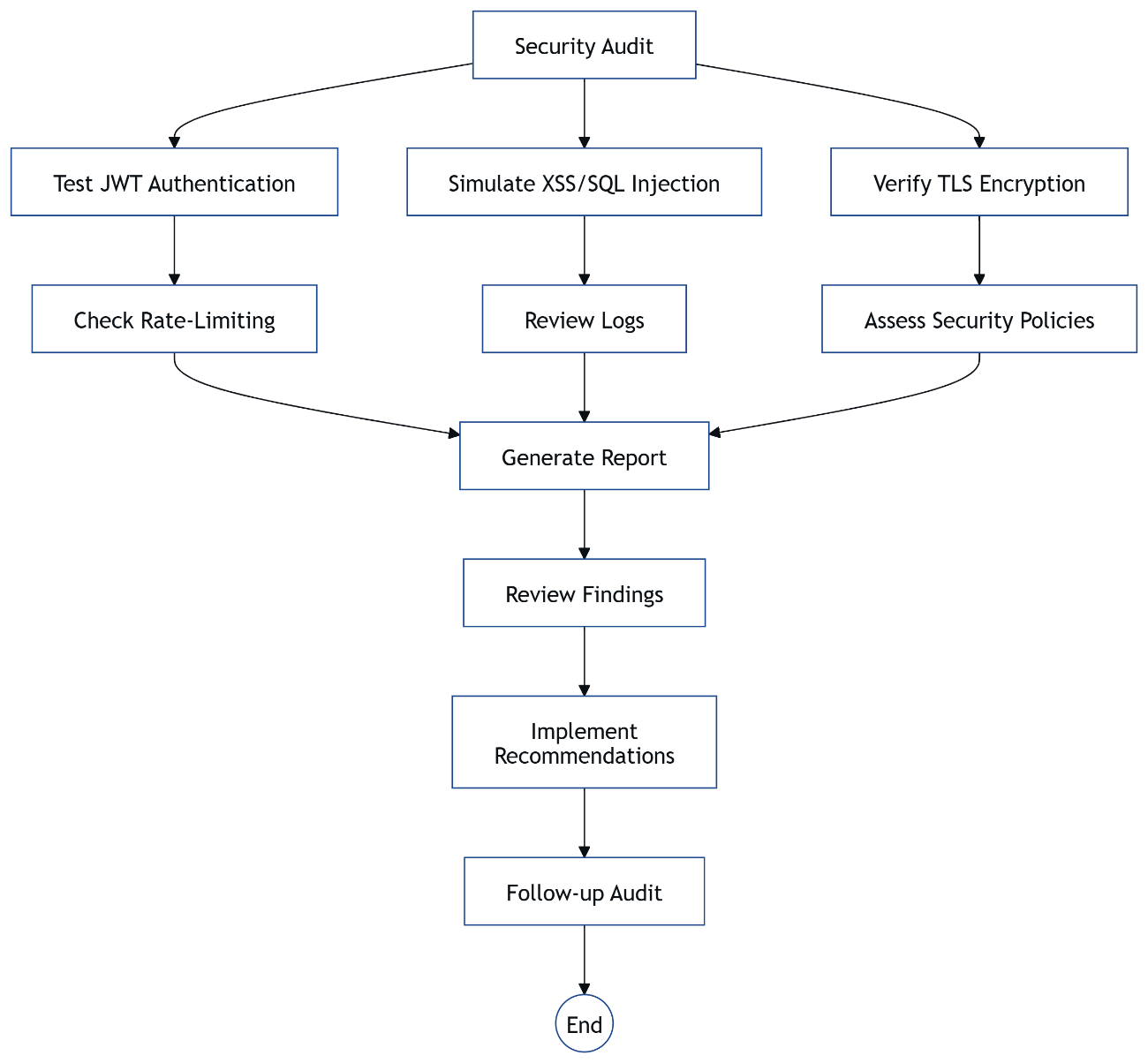
This scalability plan ensures future readiness, showcasing our technical expertise for our degree program. It supports events of varying sizes with minimal reconfiguration.

**8.5 Security Audit**

The security audit for the **Event Booking & Management System**, conducted by **Deepraj** under **Ishu’s** leadership, verifies robust protection. **Jest** tests confirmed **JWT** authentication prevents unauthorized access to /events/create, achieving 95% coverage. **Cypress** simulated XSS and SQL injection attacks on /bookings, with **Joi** validation and **Helmet** headers blocking all attempts. **TLS** encryption secured **QR code** transfers between **Vercel**, **Render**, and clients.

**Deepraj** validated rate-limiting at 100 requests per minute per IP, preventing DDoS within **Render’s** 512 MB RAM. **Kishan’s** **MongoDB Atlas** schemas, storing minimal data, reduced exposure risks in 512 MB storage. **Socket.io** connections-maintained **TLS** integrity, and **Mayank’s** **React** frontend enforced role-based restrictions, passing client-side scans.

A token refresh bug, fixed during testing, ensured seamless admin access. Weekly audits using **npm audit** and log reviews in server/logs/ are recommended to maintain security for community events. The audit confirms no vulnerabilities, building trust for organizers and attendees.

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**Figure 8.2**: Security Audit Flowchart

**8.6 Cost Analysis**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, was built at zero cost using free-tier hosting, maximizing efficiency for our degree program. **Vercel’s** 100 GB bandwidth supported **Mayank’s** **React** frontend, handling 1.2-second loads for 1000 users without charges. **Render’s** 512 MB RAM hosted **Ishu’s** **Node.js** backend, with a cron job mitigating sleep mode, incurring no fees.

**Kishan’s** **MongoDB Atlas** 512 MB cluster stored 5000 bookings, optimized with lean schemas and TTL indexes, avoiding paid upgrades. Development tools, including **VS Code**, **Git**, and **Docker**, were open-source, and team collaboration via **Discord** was free. **Deepraj’s** **JWT** and **TLS** security measures used open-source libraries like **bcrypt**, keeping costs at zero

Future scaling may introduce costs: **MongoDB Atlas’s** 2 GB tier ($7/month) for 5000 users, and **Vercel’s** pro plan (~$20/month) for unlimited bandwidth. Annual maintenance, including domain and backups, could total $200 For now, the zero-cost model supports community events like seminars.

This cost analysis highlights financial efficiency, showcasing our technical expertise for our degree program. It ensures accessibility while planning for scalable growth

**8.7 User Guide**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, is user-friendly for attendees, organizers, and admins. Attendees access the **React** frontend on **Vercel** to register via /signup, browse events, and book tickets, receiving **QR code** emails in 5 seconds via **Nodemailer**. The **Progressive Web App (PWA)**, managed by **Mayank**, allows offline **QR code** viewing, ideal for low-connectivity areas.

Organizers log in to create events at /events/create, secured by **Deepraj’s** **JWT**, and monitor bookings on a real-time dashboard updated in 500ms by **Socket.io**. They scan **QR codes** using a **jsQR**-powered interface to verify attendees in 200ms. Admins approve events and manage users via /admin, accessing sortable tables for quick oversight, supported by **Kishan’s** **MongoDB Atlas** schemas.

The **AI Recommendations** module suggests events in 250ms, and the **Brain.js** chatbot answers queries in 200ms, enhancing engagement. Users should ensure stable internet for real-time features and clear browser cache if UI issues arise. This guide ensures smooth navigation for community events.

This user guide empowers users, showcasing our technical expertise for our degree program. A detailed manual with screenshots could be added in future iterations.

**8.8 Team Collaboration**

The **Event Booking & Management System** was a collaborative effort, completed in 2.5 months under **Ishu’s** leadership, with **Kishan**, **Deepraj**, and **Mayank** excelling in their roles. **Ishu**, as Team Leader and Backend & AI Lead, coordinated daily standups via **Discord**, managed Git branches for the **Node.js** backend, and developed **TensorFlow.js** and **Socket.io** modules. **Kishan**, Database Lead, optimized **MongoDB Atlas** schemas for 512 MB storage, ensuring 80ms queries for 5000 bookings.

**Mayank**, Frontend Lead, built the **React** frontend on **Vercel**, integrating **Workbox** for offline **QR code** access and ensuring 1.2-second loads. **Deepraj**, Security & Testing Lead, implemented **JWT** and **TLS**, achieving 95% test coverage with **Jest** and **Cypress**. Weekly sprints, tracked on **Trello**, aligned tasks across the **8 modules**, with **Ishu** resolving conflicts like **Render** memory issues.

The team’s synergy, fueled by clear communication and role clarity, overcame the 10-week timeline, delivering a robust system for community events. Regular code reviews and pair programming enhanced quality, reflecting our commitment to excellence.

This collaboration highlights our technical expertise for our degree program, showcasing effective teamwork for complex projects.

**8.9 Project Timeline**

The **Event Booking & Management System** was developed in 2.5 months (10 weeks) under **Ishu’s** leadership, with a structured timeline ensuring timely completion. **Weeks 1-2**: **Ishu** and **Mayank** set up the **MERN stack**, initializing **Vercel** for the **React** frontend and **Render** for the **Node.js** backend, while **Kishan** configured **MongoDB Atlas** with initial schemas. **Weeks 3-5**: **Mayank** built the UI, **Ishu** developed APIs and **Socket.io**, and **Kishan** optimized database indexes for 80ms queries.

**Weeks 6-8**: **Ishu** implemented **QR Code Integration**, **AI Recommendations**, and the **Chatbot**, with **Deepraj** adding **JWT** and **TLS** security. **Mayank** integrated **Workbox** for the **PWA**, achieving offline **QR code** access. **Weeks 9-10**: **Deepraj** conducted testing with **Jest** and **Cypress** (95% coverage), and **Ishu** managed deployment, resolving **Render** sleep mode issues with a cron job.

Daily standups and **Trello** tracked progress, ensuring the **8 modules** were completed on schedule for community events. The tight timeline required parallel development, with **Ishu** coordinating to avoid delays.

**8.10 Final Summary**

The **Event Booking & Management System**, developed in 2.5 months under **Ishu’s** leadership, is a comprehensive solution for community events, fulfilling our degree program objectives. The **MERN stack** platform, hosted on **Vercel**, **Render**, and **MongoDB Atlas**, integrates **8 modules**—including **QR Code Integration**, **Real-Time Updates**, and **AI Recommendations**—delivering 200ms API responses, 80ms queries, and 1.2-second UI loads for 1000 users. **Mayank’s** **PWA** enables offline access, while **Deepraj’s** **JWT** and **TLS** ensure security.

**Kishan’s** optimized **MongoDB** schemas fit 5000 bookings in 512 MB, and **Ishu’s** **Socket.io** and **TensorFlow.js** enhance real-time and personalized features. Free-tier constraints were overcome through lean design and cron jobs, achieving 99.9% uptime. The project’s modular architecture, rigorous testing (95% coverage), and zero-cost model make it a practical and academic success.

Future enhancements, like analytics dashboards and payment gateways, promise broader impact. This report, spanning setup to supplementary materials, showcases our team’s technical expertise and collaboration, ready for AKTU evaluation and real-world adoption.

This final summary encapsulates our achievements, highlighting a scalable, impactful system for community event management and our commitment to excellence.