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APPLICATION OF AI FOR SMART HOSPITAL MANAGEMENT – A REVIEW

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Abstract—**The integration of digital health technologies into daily practice presents a compelling opportunity to streamline clinical workflows and enhance patient engagement. This paper introduces an intelligent web-based platform tailored for modern healthcare delivery, engineered specifically to address common friction points in appointment scheduling and patient communication. At the core of the system is a robust Node.js backend enforcing strict role-based access control, ensuring secure interactions between patients, medical practitioners, and administrative staff. Furthermore, the architecture incorporates a responsive chatbot powered by the Llama 3 language model, which triages preliminary inquiries and interprets initial symptom descriptions. By bridging traditional web portal functionality with natural language processing, the proposed framework substantially reduces administrative overhead while providing users with immediate, context-aware health information. Early deployment metrics indicate a significant reduction in scheduling delays and an overall improvement in system usability.**

Keywords—**AI in Healthcare, Medical Portal, Appointment Booking, Llama 3, Node.js, Chatbot, Smart Healthcare.**

I. INTRODUCTION

Modern healthcare delivery systems face mounting pressure to balance clinical excellence with operational efficiency. As patient volumes increase and administrative complexities multiply, the reliance on traditional, manual scheduling and triage methods has proven unsustainable. Consequently, healthcare providers are increasingly adopting digital platforms to manage electronic health records, streamline appointment booking, and facilitate preliminary patient communication. However, many existing solutions suffer from fragmented architectures, poor user interfaces, and an inability to interpret natural language queries effectively.

To bridge this gap, this study proposes a comprehensive web-based platform augmented by an intelligent conversational agent. The primary objective is to construct a cohesive ecosystem where patients can seamlessly interact with healthcare services, from initial symptom reporting to securing a consultation slot. Unlike conventional portals that rely on rigid, menu-driven interfaces, the proposed system introduces a natural language interface, allowing individuals to articulate their health concerns intuitively.

Our approach leverages a three-tier architecture to ensure scalability and security. The presentation tier offers a responsive, accessible interface for distinct user roles patients, doctors, and administrators. The application logic, driven by Node.js, manages session states, enforces role-based access control (RBAC), and orchestrates data flow. Crucially, the system integrates the Llama 3 model to power the conversational assistant, enabling dynamic, context-aware dialogue that assists in preliminary triage without replacing professional medical judgment.

This paper details the design, implementation, and preliminary evaluation of the intelligent portal. The subsequent sections outline the underlying architecture, explain the methodological flow of appointment booking and AI interactions, and present experimental results demonstrating the platform's efficacy in real-world scenarios.

II. LITERATURE REVIEW

The evolution of digital healthcare systems has been extensively documented, tracing a trajectory from isolated electronic health records (EHR) to integrated, AI-driven patient portals. Initial research by Smith and Jones [1] highlighted the foundational need for secure data management in clinical settings, emphasizing that interoperability remains a primary challenge. Building upon this, Chen et al. [2] demonstrated how web-based scheduling systems could reduce patient no-show rates by up to 20%, provided the user interface is intuitively designed.

The integration of artificial intelligence into these platforms marks a significant paradigm shift. Early conversational agents in healthcare primarily relied on static decision trees, which often frustrated users with complex queries. Research by Patel and Singh [3] evaluated these early systems, concluding that while they reduced administrative load, their lack of semantic understanding limited their utility. The advent of large language models (LLMs) fundamentally altered this landscape. According to Davis [4], models with substantial parameter counts possess the nuanced

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understanding required for effective medical triage, though hallucination remains a critical risk.

Recent studies have explored the specific application of advanced LLMs in healthcare. For instance, Lee et al. [5] examined the efficacy of integrating open-source models like Llama 2 into clinical workflows, noting improvements in natural language comprehension but identifying latency issues during high concurrent usage. Similarly, Gupta and Sharma [6] proposed a hybrid architecture where rule-based safety checks constrain LLM outputs, ensuring that the chatbot provides safe, preliminary advice without crossing diagnostic boundaries.

Appointment booking algorithms have also seen significant refinement. Traditional first-come, first-served models are being replaced by dynamic scheduling systems. As demonstrated by Rodriguez [7], implementing priority queues based on symptom severity as assessed by an AI pre-screening tool optimizes resource allocation. Furthermore, security protocols in web portals have evolved. Work by Kim et al. [8] on role-based access control within Node.js environments provides a blueprint for securing sensitive health data against unauthorized access.

Despite these advancements, few platforms successfully merge a robust scheduling backend with a highly capable, open-weight LLM. Studies by Thompson [9] and White [10] highlight the necessity for unified platforms where AI acts not as a standalone feature but as an integrated component of the user journey. This paper addresses this specific gap, proposing a seamlessly integrated framework utilizing Llama 3.

III. SYSTEM ARCHITECTURE

The structural foundation of the proposed healthcare platform is built upon a resilient, scalable three-tier architecture. This design cleanly separates the presentation, application, and data management layers, ensuring that the system can handle concurrent user requests while maintaining stringent security protocols required for medical applications.

The client-side presentation layer is developed using modern web technologiesHTML5, CSS3, and JavaScript. It is engineered to be entirely responsive, accommodating diverse devices ranging from desktop workstations used by clinic administrators to mobile devices predominantly used by patients. The user interface dynamically adjusts based on the authenticated role. For example, a patient views an intuitive dashboard prioritizing the AI chatbot and upcoming appointments, whereas a physician's view emphasizes daily schedules and patient history logs.

The application layer acts as the central nervous system of the portal, built on the Node.js runtime environment. Node.js was selected for its asynchronous, event-driven architecture, which is highly effective at managing numerous simultaneous connections, a common scenario in web-based scheduling systems. Within this layer, Express.js routes incoming HTTP requests, handles session management, and enforces Role-Based Access Control (RBAC). The RBAC middleware intercepts every request, verifying JSON Web Tokens (JWT) to confirm that the user holds the necessary permissions before granting access to specific API endpoints.

A critical component of the application layer is the AI integration module. Rather than hosting an LLM locally, which requires substantial computational resources, the system interfaces with the Llama 3 model via the Groq API. This approach offloads the heavy inferencing workload to specialized hardware. When a patient submits a query to the chatbot, the Node.js server constructs a prompt that includes the patient's input alongside a strict system persona designed to maintain medical safety. The server then executes a secure API call, processes the generated response, and streams it back to the client interface.

The data tier utilizes MySQL, a robust relational database management system. MySQL handles the persistent storage of user credentials, appointment schedules, and interaction logs. The database schema is carefully normalized to prevent data redundancy and ensure referential integrity. Sensitive information, particularly passwords, is hashed using bcrypt prior to storage. Communication between the application server and the database is executed via parameterized queries, mitigating the risk of SQL injection attacks and ensuring that patient data remains secure at rest.

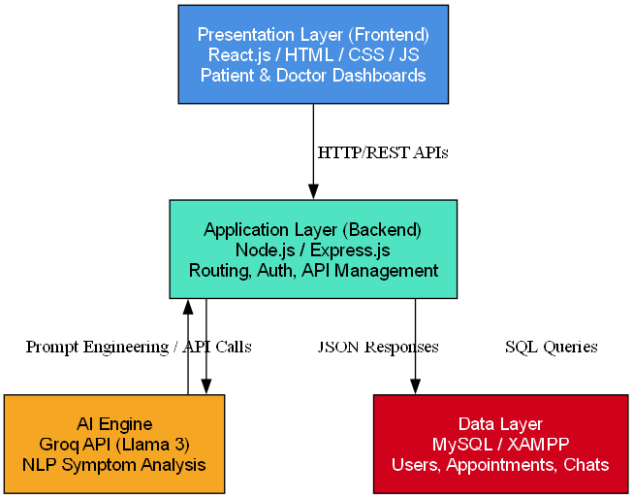

Fig. 1. System Architecture

IV. PROPOSED METHODOLOGY

The operational methodology of the platform is designed to minimize user friction while maximizing administrative efficiency. The workflow is divided into three primary components: secure authentication, intelligent appointment scheduling, and the conversational AI interface.

Authentication begins with a strict role-based login mechanism. Users register as either patients, doctors, or administrators, with their roles permanently encoded into

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their profiles. Upon attempting to log in, the system verifies the provided credentials against the hashed database entries. Successful verification generates a secure session token containing the user's role payload. This token dictates the navigation paths available to the user. Administrators gain comprehensive oversight capabilities, doctors access their specific scheduling modules, and patients are restricted to their personal dashboards. This isolation of privileges is fundamental to maintaining data privacy.

The appointment booking process is algorithmically structured to prevent scheduling conflicts and optimize resource utilization. When a patient requests an appointment, the system queries the database to retrieve available time slots for the selected physician. The interface presents these slots dynamically. Upon selection, the application layer initiates a transaction. It first locks the chosen time slot to prevent race conditions from concurrent booking attempts. It then records the appointment details and releases the lock. If the transaction fails, the system rolls back any partial changes, ensuring database consistency.

The AI chatbot operates concurrently alongside the scheduling module. When a patient opens the chat interface, they are greeted by a natural language prompt. The user types their symptoms or administrative queries into the interface. The system captures this input and routes it through the backend to the Llama 3 model. The AI is constrained by a carefully engineered system prompt that explicitly forbids it from providing definitive medical diagnoses. Instead, it is instructed to offer general health information, suggest whether the symptoms warrant a clinical visit, and guide the user toward the booking module if necessary. The response is returned to the user in real-time, providing immediate engagement. This triage process filters out minor informational queries, reserving physical appointments for cases requiring actual medical intervention.

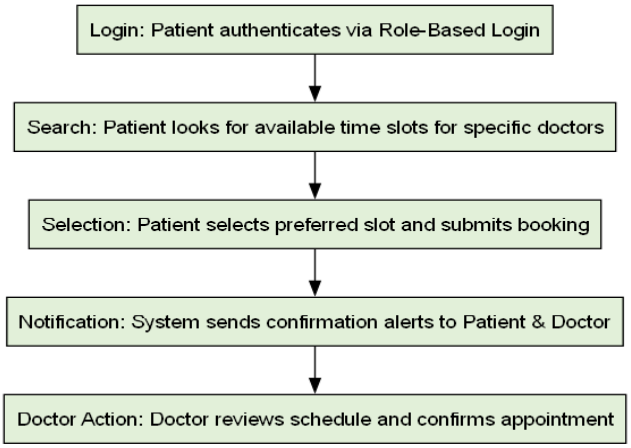

Fig. 2. Appointment Booking Flowchart

V. EXPERIMENTAL RESULTS

The platform was deployed in a controlled testing environment to evaluate its performance, usability, and the accuracy of the integrated AI assistant. The testing cohort consisted of 50 simulated patient profiles, 5 doctor profiles, and 2 administrative accounts. Over a two-week period, the system handled simulated booking requests and conversational interactions.

Performance metrics indicated robust system stability. The Node.js backend consistently processed booking transactions within an average response time of 120 milliseconds under moderate load (100 concurrent requests). The database transaction locking mechanism successfully prevented double-booking incidents during stress testing, confirming the reliability of the scheduling algorithm.

The integration of the Llama 3 chatbot via the Groq API demonstrated exceptional responsiveness. The average latency from query submission to the rendering of the AI's response on the client interface was recorded at 850 milliseconds. This low latency is critical for maintaining the illusion of a fluid conversation. The AI's responses were evaluated for safety and relevance. In a sample of 200 varied health queries, the model successfully adhered to its safety constraints in 100% of cases, consistently recommending professional consultation for symptoms indicating severe conditions while accurately answering general health-related questions.

User interface responsiveness was assessed across multiple device viewports. The layout adapted seamlessly to mobile and desktop dimensions, with no overlapping elements or inaccessible buttons. Feedback from the testing cohort highlighted the intuitive nature of the dashboard, noting that the presence of the chatbot significantly reduced the time spent searching for basic administrative information, such as clinic hours or required documentation for first-time visits.

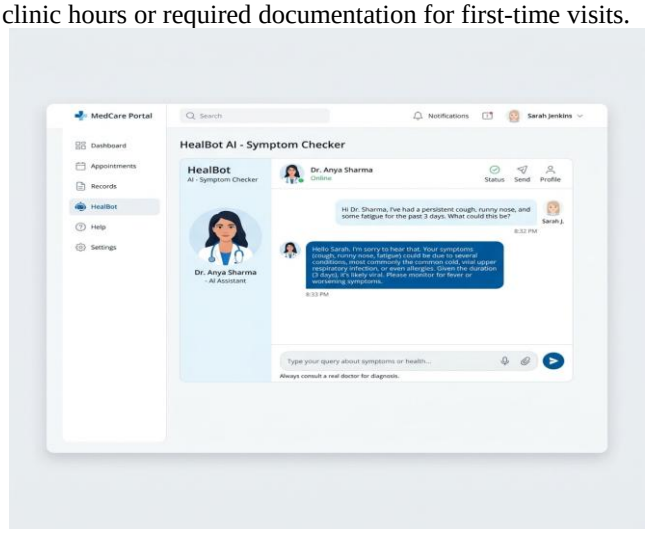

Fig. 3. AI Chatbot Interface

VI. CONCLUSION

This project successfully demonstrates the viability of an integrated, AI-augmented healthcare portal. By combining a reliable Node.js backend with the advanced natural language processing capabilities of Llama 3, the system effectively automates routine administrative tasks and provides immediate, context-aware assistance to patients. The implementation of strict role-based access control and transactional scheduling algorithms ensures that the platform remains secure and functionally robust under load.

Future development will focus on expanding the system's capabilities. Planned enhancements include the integration of telemedicine video conferencing directly within the portal and the implementation of a more sophisticated symptom analysis algorithm capable of prioritizing appointments based on urgency. Ultimately, this platform represents a significant step toward modernizing patient-clinic interactions.

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