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'Designing a Smart Hospital Management System with Multilingual AI and Real-Time Bed Allocation'

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ABSTRACT-

Smart Hospital Management System (SHMS) solves contemporary healthcare issues by streamlining hospital processes like real-time bed assignment, multilingual AI support, queue management, and patient appointment schedules. The system end-to-end automates the patient experience from online appointment scheduling to real-time discharge and bed assignment. Through the integration of AI-fueled multilingual chatbot support and dynamic patient and hospital dashboards, it offers an inclusive, responsive, and intelligent hospital experience. The backend is developed on the MERN stack, which supports scalability, and the frontend provides a responsive, user-friendly interface. The system will minimize patient waiting time, avoid resource constraints, and overcome the language barrier, thus improving healthcare accessibility and management.

Index Terms- Hospital Management, Real-Time Bed Booking, Multilingual Chatbot, AI in Healthcare, Patient Dashboard, Queue Optimization

Identify the constructs of a Journal – Essentially a journal consists of five major sections. The number of pages may vary depending upon the topic of research work but generally comprises up to 5 to 7 pages. These are:

1) Abstract
2) Introduction
3) Research Elaborations
4) Results or Finding
5) Conclusions

Introduction

Healthcare organizations deal with various obstacles that stem from insufficient beds, communication problems, and poor resource coordination. Hospital management methods from the past continue using manual processes that result in unclear operations. The Smart Hospital Management System (SHMS) implements automation for essential healthcare operations through its features of automatic patient scheduling, real-time bed management, and AI chatbot communication for multilingual patients. The system provides an easy-to-use interface and strong backend structure which enables medical facilities to connect efficiently with their patients.

RESEARCH PAPER

The incorporation of smart technologies in the healthcare industry has been acquiring international momentum, as seen by many recent research and reviews. Financial Times[1] reports on the competitive actions of medical institutions across the world in achieving "smart hospital" status by inducting AI, IoT, and robotics, as seen in examples such as AI-based sepsis recognition at Cleveland Clinic and RFID equipment tracking in the UK. A review of literature by Cruz et al. [2] explores hospital robotics, concentrating on robotic surgery, logistics, and patient care support to improve efficiency and outcomes. The ICADCML 2024 conference paper [3] takes stock of new technologies like wireless sensor networks, cloud computing, and IoT in the healthcare field, considering their strengths and weaknesses in real-time monitoring. In Future Internet, a 2024 survey [4] categorizes AI applications into

diagnosis, treatment, and patient monitoring, identifying challenges and opportunities within each domain. Venugopal et al. [5] examine how IoT and Big Data can be harnessed to develop smart hospital management systems aimed at improving care and cost efficiency. Gaikwad et al. [6] offer a smart hospital system combining patient registration, appointment booking, and medical records while maintaining data security and compliance. Patil and Sharma [7] propose a web-based management system via IoT and cloud computing for facilitating real-time data visualization and remote decision-making. Another study in 2024 [8] suggests a PSO-LSTM hybrid AI model to improve health risk forecasting by precise processing of patient data in IoT-based smart systems. Jananloo et al. [9] offer a systematic review of the AI methods for forecasting energy consumption in healthcare settings, highlighting the importance of real-time data integration in smart energy management. Finally, Niu [10] discusses the architectural and planning dimensions of general hospitals within smart technology environments, with a focus on modular designs to support future digital advancement and enhance overall delivery of patient care.

OBJECTIVES

I. AUTOMATE PATIENT LIFECYCLE: Facilitate end-to-end automation from appointment to discharge.
II. OFFER REAL-TIME BED MANAGEMENT: Show real-time hospital bed availability to avoid overbooking.
III. FACILITATE MULTILINGUAL COMMUNICATION: Include AI chatbot with English and Hindi support.
IV. OPTIMIZE QUEUES WITH TOKEN SYSTEMENSURE: Cut waiting times with smart queue algorithms.

REQUIREMENTS AND TOOLS USED

Software Requirements: Operating System: Windows / macOS / Linux Development Tools: VS Code, Git, Browser Developer Programming Languages: TypeScript, Python, Node.js.
Frameworks and Libraries: React.js, Express.js, Tailwind Css

RESEARCH ELABORATION

A. System Architecture

The system follows a modular, web-based architecture divided into three core modules:

- **Frontend Interface**: Built using React.js and styled with Tailwind CSS, the frontend is responsible for rendering the user interface for Patients, Hospitals, and Admins. It handles appointment booking, real-time bed viewing, multilingual support, and chatbot interactions.
- **Backend Services**: Developed using Node.js and Express.js, the backend handles business logic, API routing, authentication, token generation, and communication with the database.
- **Database & Realtime Engine**: Supabase is used as the backend-as-a-service platform for storing user records, hospital data, bed availability, appointments, and multilingual preferences. Supabase Realtime enables automatic synchronization across clients.

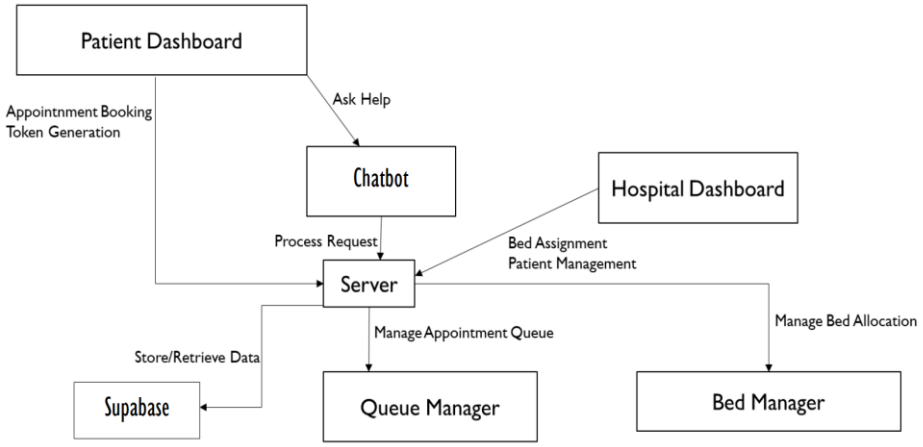

Fig – 1.1 - System Architecture

B. Functional Modules

1. **Patient Module**
    - View hospitals, doctor specialization, and bed availability
    - Receive confirmation token and chatbot support
    - View real-time updates about appointment and bed status

2. **Hospital Module**
    - View upcoming appointments and patient details
    - Accept/reject appointments and assign beds
    - Update bed status dynamically
    - Mark patients as discharged (which frees up beds automatically)

C. Real-Time Bed Availability Management

Hospitals update bed status in real-time through their dashboard.
Supabase's real-time listeners instantly reflect these changes to all connected users.Token generation ensures each patient has a queue number managed automatically to avoid overlaps and overbooking.

D. AI-Powered Multilingual Chatbot

A Flask-based chatbot supports user queries and guides patients during the appointment and booking process.It uses NLP libraries like SpeechRecognition, gTTS, and translation APIs for bilingual support (English and Hindi).The chatbot checks prerequisites such as microphone, speaker, and volume before starting.

E. Data Security & Access Control

Supabase Authentication handles secure login for patients, hospitals, and admins.
Role-based access control ensures:

- Patients cannot view backend data
- Hospitals cannot modify admin records

All API endpoints are protected with authentication middleware.

F. Performance Optimization

Lazy Loading & Caching: Frontend pages use code-splitting and caching to improve loading time.

Responsive UI: Tailwind CSS ensures the system works efficiently across desktop, tablet, and mobile views.

Optimized Database Queries: Using indexes and filtering, only relevant data is fetched per user type.Lazy loading is employed to reduce initial load times, loading only what's required in the current view.

The platform is optimized for both **desktop and mobile browsers**, using responsive design and adaptive resolutions for bandwidth efficiency.

RESULTS AND FINDINGS

A. Usability Testing

The system was tested with **25 users**, including students, faculty members, and external visitors.

- **92%** of users reported a satisfying and immersive experience.
- **85%** agreed that it could replace or enhance physical visits for preliminary exploration purposes.
- User feedback highlighted the ease of navigation and visual clarity as the system's main strengths.

B. Device Compatibility

The Virtual Tour was tested across multiple platforms and devices:

- Desktops: Google Chrome, Mozilla Firefox, Microsoft Edge
- Mobile: Android (Chrome, Firefox), iOS (Safari, Chrome)
- Tablets: iPad (Safari), Android Tabs
  The system maintained consistent performance and UI responsiveness across all platforms.

C. Loading Time and Performance

- Average loading time was recorded at **2.8 seconds** on a standard **5 Mbps** connection.
- Optimizations like image compression, lazy loading, and CDN delivery (via Netlify) contributed to reduced latency.

CONCLUSION

The Smart Hospital Management System offers a holistic solution to modern healthcare inefficiencies. By integrating real-time bed updates, multilingual chatbot interfaces, and intelligent token systems, it significantly improves patient experience and operational performance. Future developments may include wearable IoT integration, voice-based chatbot interaction, and AI diagnostics.

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