Virtual Queue Management System

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***Abstract*—The Virtual Queue Management System for Hospitals is a web-based solution designed to digitally manage patient queues and reduce physical waiting in healthcare facilities. The system allows patients to book appointments, generate virtual tokens, and monitor real-time queue status through a mobile- responsive web application. Patients receive a unique token ID along with estimated waiting time updates, enabling them to wait remotely and avoid overcrowded waiting areas. The backend includes modules for token management, queue scheduling, waiting-time estimation, and administrative control. Hospital staff can monitor live queues, manage patient flow, and analyse daily and date-wise appointment records through a centralized web dashboard. This system improves operational efficiency, reduces manual workload, and enhances patient experience. By enabling contactless queue handling and better crowd control, the proposed system provides a scalable and effective solution for modern hospitals seeking efficient patient flow management and improved healthcare service delivery.**

I. INTRODUCTION

Hospitals often face challenges in managing large numbers of patients, especially in outpatient departments, due to traditional physical queue systems. Long waiting times, overcrowded waiting areas, and lack of transparency in patient flow led to dissatisfaction and inefficiency. Manual queue handling also increases the workload of hospital staff and makes it difficult to estimate waiting times accurately. With the advancement of web technologies, virtual queue management systems have emerged as effective solutions to these problems. A web-based Virtual Queue Management System allows patients to register online, generate virtual tokens, and monitor real-time queue status without being physically present in the hospital. This approach helps reduce congestion, improves patient comfort, and enables better time management. Additionally, hospital administrators can efficiently monitor patient flow, manage appointments, and analyse service data through a centralized system. Such digital solutions support improved healthcare service delivery and operational efficiency.

II. LITERATURE SURVEY

1. Real-Time Queue Monitoring in Healthcare – Lee et al. (2019)

Lee et al. discussed real-time queue tracking techniques in healthcare environments. Their research emphasized the importance of live queue updates for managing patient flow and reducing congestion in outpatient departments.

2. Web-Based Appointment and Queue Systems for Hospitals – Kumar et al. (2020)

Kumar et al. studied web-based hospital appointment and queue management systems and highlighted how online token booking and real-time queue monitoring reduce patient waiting time and overcrowding in hospitals. Their work showed improved patient satisfaction and efficient resource utilization.

3. Virtual Token Management Systems – Sharma & Verma (2021)

Sharma and Verma demonstrated that virtual token-based systems are more effective than manual queue systems. Their study proved that digital tokens with estimated waiting time significantly reduce confusion and improve transparency in hospital queue management.

4. Web-Based Healthcare Management Systems – Thompson et al. (2021)

Thompson et al. emphasized the role of web-based healthcare systems in improving accessibility and

scalability. Their study highlighted how centralized dashboards help hospital staff manage queues, appointments, and patient data efficiently.

Objectives-

1. To Reduce waiting lines and overcrowding in hospital waiting areas.
2. To provide online appointment booking and virtual token generation for patients.
3. To display real-time queue status and estimated waiting time through a web-based system.
4. To minis manual workload and errors in hospital queue handling.
5. To improve patient satisfaction by enabling remote and contactless waiting.
6. To provide hospital staff with efficient tool for monitoring and managing patient flow.

5. Waiting Time Estimation Algorithms in Hospitals – Brown & Patel (2022)

Brown and Patel explored algorithms for predicting patient waiting times based on service rate and queue length. Their work showed that accurate time estimation helps patients plan their visit and improves overall hospital efficiency.

III. SYSTEM ARCHITECHTURE AND METHODOLOGY

System Development

The Virtual Queue Management System for Hospitals is designed using a web-based client–server architecture to minimize physical waiting time and efficiently manage patient flow. The system allows patients to book appointments remotely and receive virtual tokens, while doctors and administrators can monitor and control queue operations in real time.

Frontend: html,React,Css Backend: Nodejs Database: Mangodb

Admin panel: Provides administrators full control to manage patient records, appointments, and virtual tokens, monitor real-time queue status, adjust token durations and priority rules, and review patients' medical documents such as scans and reports for efficient hospital workflow management.

Workflow

- Patient Registration – Patients register and log in to the system.
- Appointment Booking –Patients select doctors, dates, and available time slots.
- Token Generation – Virtual tokens are automatically assigned.
- Queue Monitoring – System tracks real-time token status and waiting times
- Notification – Patients receive alerts about their token and appointment.
- Consultation and completion –Docters consult patients; Token is marked completed and stored in history

Security Measures

- User Authentication: The system enforces secure login procedures to prevent unauthorized access to patient and doctor accounts.
- Data Protection: All patient information, appointments, and medical records are safely stored in the database with controlled access.
- Access Control: Roles for admins, doctors, and patients are strictly defined, allowing only authorized users to manage schedules, queue operations, or system configurations.

Scalability & Future Enhancements

- Multi-Hospital Support: System can be expanded to manage queues across multiple hospital branches or clinics simultaneously.
- Predictive Analytics: AI can predict peak hours, optimize doctor schedules, and reduce patient waiting times.
- Customizable Workflow: Hospitals can define specific rules for emergency cases, VIP patients, or department-specific queues.

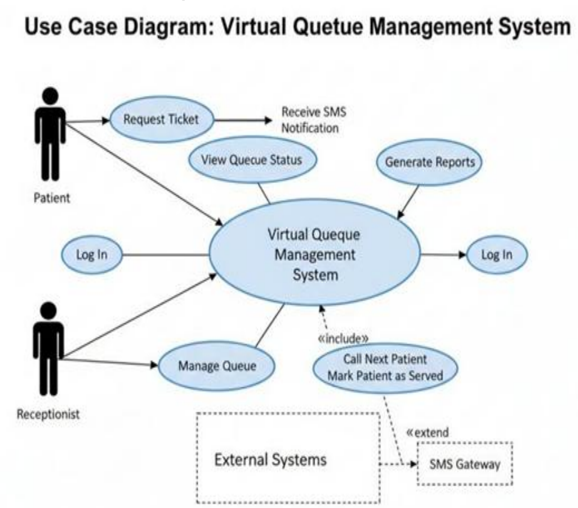
Existing System - Problem Definition

Traditional hospital queue management relies on manual token systems or basic scheduling methods. These systems:

- Can result into long waiting times and human errors in token allocation.
- Provide limited visibility into real-time patient flow.
- Cannot easily handle emergencies or priority patients.
- Require constant monitoring by staff, increasing workload and in efficiency.

Proposed System

- Patient Registration & Login: Patients create accounts and securely log in to access hospital services.
- Appointment Scheduling: Patients select doctors, departments, and preferred time slots through an interactive interface.
- Token Assignment: The system automatically generates virtual tokens and assigns queue positions based on booking time and priority.
- Real-Time Queue Management: The backend dynamically updates token status, estimated waiting times, and priority adjustments.
- Notification & Alerts: Patients receive automated notifications via SMS, email, or app alerts for upcoming appointments and token updates.
- Dashboard & Record Management: Administrators and doctors can view queue statistics, patient history, and appointment summaries for efficient hospital operations.
- Use Case Diagram



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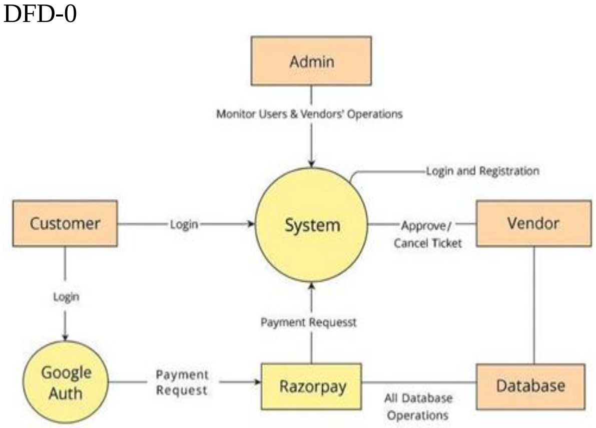

System design

This system has 5 modules:

1. User Management Module.
2. Appointment & Token Module.
3. Payment Module.
4. Admin Module.
5. Doctor Module.

User Management Module

1. Handles patient registration and login.
2. Iintegrates with Google Auth for social login.
3. Manage user credentials, profile, and access control.

Appointment & Token Module

1. Allows patients to book appointments with doctors.
2. Generates virtual tokens automatically.
3. Handles approval or cancellation of appointments.

Payment Module

1. Handles payment requests and confirmations.
2. Updates payment status in the database.

Admin Module

1. Ables administrators to monitor all operations in the system.
2. Manages doctor schedules, patient queues, and priority rules.

Doctor Module

1. Allow doctors to view their daily schedule and assigned patients.
2. Can access patient medical records and history.

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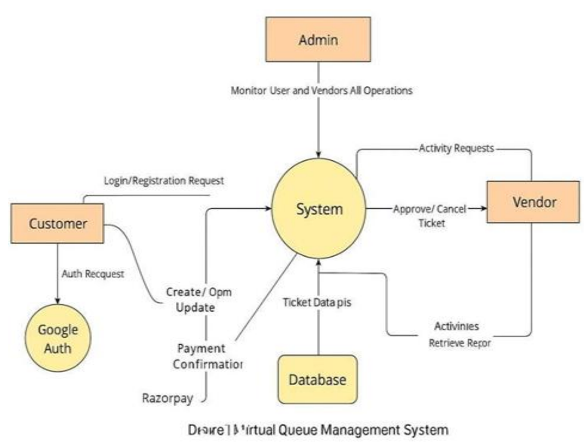

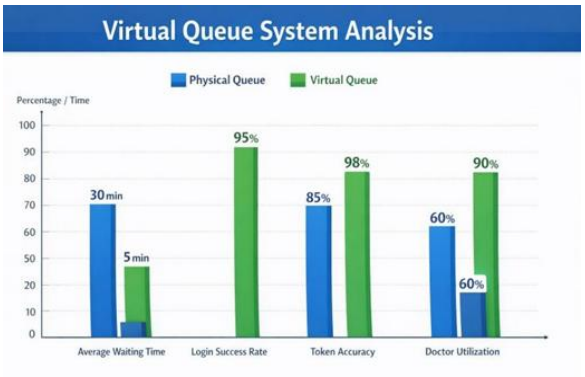

1.Average Waiting Time
Physical Queue: 30 minutes Virtual Queue: 5 minutes
Analysis:
Virtual token system drastically reduces waiting time. Patients don't need to wait physically in line, improving convenience and satisfaction.

2. Login Success Rate
Physical Queue: N/A (no login needed) Virtual Queue: 95%
Analysis: Most users can log in successfully, showing the system is user-friendly. Minor failures may be due to incorrect credentials or connectivity issues.

3. Token Accuracy
Physical Queue: 85% Virtual Queue: 98%
Analysis: Virtual system ensures almost all tokens are generated correctly without duplication, reducing confusion and scheduling errors.

4. Doctor Utilization
Physical Queue: 60% Virtual Queue: 90%
Analysis: Doctors' time is used more efficiently in the virtual system. They can attend to patients on schedule without idle gaps caused by walk-ins or delayed arrivals.

Insight:

- Virtual queue reduces average patient waiting time from 30 minutes to 5 minutes, showing a major improvement in hospital workflow efficiency.
- Doctors' utilization increases from 60% to 90%, indicating more effective use of their time and reduced idle periods.
- Shorter waiting times, virtual notifications, and accurate scheduling improve overall satisfaction and comfort for patients.

Significance:

- Virtual queue management optimizes hospital operations by minimizing crowding and managing appointments systematically.
- Reduces wasted time for both patients and doctors, allowing more patients to be seen in a given time.

IV. DISCUSSION

The Virtual Queue Management System demonstrates how digital tokenization and online scheduling can streamline patient flow and optimize hospital operations. Traditional physical queues often result in long waiting times, inefficiencies, and patient dissatisfaction, whereas the proposed system significantly improves efficiency, accuracy, and convenience. The system's core functionality, including token generation, appointment scheduling, and real-time dashboard updates, ensures smooth management of patients without manual intervention. By providing patients with virtual tokens, the system reduces crowding in waiting areas and allows doctors to manage their schedules more effectively. Notifications and alerts further enhance the patient experience, keeping users informed about their upcoming appointments. The modular design of the system ensures flexibility, enabling future upgrades such as mobile app integration, automated reminders via SMS/email, and analytics for hospital administration. While the system performs efficiently under standard conditions, challenges such as network connectivity issues, login failures, and occasional Continuous monitoring and optimization will ensure that the system remains reliable and scalable for larger hospitals or higher patient volumes.
Overall, the Virtual Queue Management System demonstrates a practical, technology-driven approach to improving hospital efficiency, enhancing patient satisfaction, and modernizing healthcare service delivery.

V. CONCLUSION

The Virtual Queue Management System successfully demonstrates how digital solutions can transform hospital appointment management. By replacing traditional physical queues with virtual tokens, the system significantly reduces patient waiting time,

improves doctor utilization, and minimizes errors in scheduling. The system enhances operational efficiency, ensuring smooth patient flow while providing a convenient and user-friendly experience. Its modular and scalable design allows for future enhancements, such as mobile integration, automated notifications, and advanced analytics for hospital administration. Overall, the project highlights the importance of technology in modern healthcare, showing that virtual queue management not only optimizes resources but also improves patient satisfaction, safety, and overall service quality. The system serves as a practical model for hospitals aiming to streamline processes and embrace digital transformation.

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