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A Web-based Slot Booking System for Xerox Management in Educational Institutions

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ABSTRACT: With the increasing demand for document printing services in educational institutions, traditional walk-in Xerox shops face congestion, inefficiencies, and long wait times. This paper presents a Web-Based Slot Booking System that allows users to pre-upload documents, book printing slots, and receive real-time notifications when their documents are ready. The system, built using Next.js, Firebase Firestore, and Firebase Cloud Messaging (FCM), ensures an efficient first-come, first-served queuing mechanism with database locking to prevent conflicts. Faculty members receive priority access based on institutional email detection. Testing results demonstrate a 75% reduction in waiting times and a 90% success rate for real-time booking efficiency, making this an effective solution for academic institutions.

KEYWORDS: Slot Booking, Queue Optimization, Firebase, Next.js, Real-time Notification, Document Printing

I. INTRODUCTION

The increasing demand for printing services in universities has led to overcrowded Xerox shops, especially during peak periods such as exam submissions and research report deadlines. Currently, students and faculty must physically visit these shops, stand in long queues, and wait for an indefinite amount of time to collect their printed documents. Additionally, due to the manual nature of printing management, shop owners often struggle to efficiently handle a large number of requests, resulting in delayed services, mismanaged document handling, and customer dissatisfaction. A study of existing university printing workflows reveals several challenges, including excessive waiting times that cause students to miss classes, the absence of a structured booking system leading to mismanagement, the lack of real-time updates that require users to physically revisit the shop to check the document status, and the absence of a prioritization mechanism, forcing faculty members with urgent document needs to wait in the same queues as students.

To address these issues, this research proposes a Web-Based Slot Booking System that integrates automated slot-based booking to replace manual walk-ins, secure document handling using Firebase Cloud Storage, and real-time notifications for document readiness through Firebase Cloud Messaging (FCM). The system will also implement priority-based slot allocation for faculty members using email domain detection and will be designed for scalability to support multiple shops and varying printing workloads.

II. LITERATURE SURVEY

A. Slot booking systems are widely used in industries such as healthcare, transportation, and customer service to reduce waiting times and optimize resource allocation. In educational institutions, particularly university Xerox shops, students and faculty often face long queues and delays due to inefficient booking processes. Traditional systems rely on manual scheduling and physical queuing, making it difficult to handle peak demand periods. Several research efforts have explored digital printing, online booking, and queue management, but they often lack real-time optimizations suited for academic settings.

B. One such effort, GoPrintBot, introduced a chatbot-based printing service that allows users to submit printing requests through a chat interface. While this approach simplified the document submission process, it did not offer

structured slot management for controlling print queue congestion. Users had to manually check for completion times, and there was no prioritization for faculty or urgent requests. Similarly, cloud-based document printing platforms, such as E-Printing Services, provided an online system where students could upload documents and collect printed copies later. However, these systems did not incorporate a real-time booking mechanism, leading to overcrowded printing stations and manual coordination issues. Without an automated slot assignment feature, users still faced uncertainty about print availability, especially during peak hours.

C. Queue optimization algorithms have been widely studied in cloud-based service management, exploring techniques such as first-come, first-served (FCFS), priority-based scheduling, and load balancing. While these methods enhance fairness and efficiency in distributed computing environments, they lack real-time updates to slot availability. In university Xerox shops, this results in scenarios where slots appear full even when real-time cancellations or print completions might free up space.

D. Despite advancements in digital printing and online reservation systems, current solutions fail to address key limitations. Most existing systems do not update slot availability in real-time, meaning students are not immediately notified if a slot becomes free due to early completion. Additionally, current printing platforms do not differentiate between students and faculty, leading to delays for urgent faculty requirements. Traditional queue-handling methods do not prevent double booking, making it possible for multiple users to select the same slot simultaneously. Many solutions also lack real-time alerts, forcing users to repeatedly check their booking status instead of receiving instant updates.

E. To overcome these challenges, the proposed Web-Based Slot Booking System introduces several key innovations. Unlike previous solutions, this system ensures real-time slot updates using Firestore transactions, preventing multiple users from selecting the same slot at the same time. A faculty prioritization feature automatically grants earlier access to faculty members using email-based verification. Additionally, the real-time notification system, powered by Firebase Cloud Messaging (FCM), informs users about slot availability, booking confirmations, and document readiness. The queue optimization mechanism dynamically adjusts the booking system, ensuring that canceled slots become immediately available for new users. By integrating these features, the system significantly improves scalability, efficiency, and fairness in university Xerox shop management, making it a more effective alternative to existing digital printing services.

III. METHODOLOGY

Methodology

System Architecture

The proposed system follows a **three-tier architecture** consisting of the **frontend, backend, and database layers**, integrated with a **real-time notification system**. Each component plays a vital role in ensuring seamless **slot booking, faculty prioritization, and document management**. The **frontend** is developed using **Next.js, React.js, and Tailwind CSS**, providing an interactive and responsive user interface. It includes essential features such as **user registration and login**, utilizing **Firestore Authentication** to authenticate students, faculty, and administrators securely. Additionally, the **file upload system** enables users to upload PDFs of lab manuals and assignments, while the **slot selection interface** dynamically displays available slots, allowing users to reserve a printing slot in real-time. The **admin dashboard** provides Xerox shop owners with an interface to manage and process print requests effectively.

The **backend** is built with **Firestore & Cloud Functions**, responsible for **handling slot bookings, enforcing faculty prioritization, managing database transactions, and triggering real-time notifications**. Key functionalities include **role-based authentication** to differentiate between students, faculty, and admins, **Firestore transactions for slot booking** to prevent double booking, and **real-time database updates** that modify slot availability dynamically. The **database layer** uses a **NoSQL Firestore database** to store user data, slot reservations, and uploaded documents. Collections such as users, shops, bookings, and documents ensure efficient data storage and retrieval, enhancing the system's reliability and scalability.

Slot Booking System

The **slot booking system** is designed to enable users to **reserve available slots dynamically** while ensuring that **overbooking is prevented**. The **slot reservation process** starts when a user logs in and navigates to the booking page.

The system fetches available slots from Firestore, allowing users to select a suitable slot. Upon selection, the system verifies availability and locks the slot using a **Firestore transaction**. If successful, the system marks the slot as reserved and sends a confirmation via **Firestore Cloud Messaging (FCM)**. The **admin can then view the booking** and process the print request, after which the slot is automatically released.

A critical feature of the system is the **faculty prioritization mechanism**, which detects faculty emails based on a predefined domain pattern (e.g., @university.edu). Faculty members receive **priority access** over students, with pre-allocated slots reserved before student bookings open. The **Firestore transaction-based locking mechanism** ensures **double booking prevention** by locking a selected slot once a booking request is made. If another user attempts to book the same slot, their request is denied. The system **retains the lock until the transaction is completed**, and if a booking is canceled, the slot is immediately released for new users.

Notification System

The **real-time notification system** is designed to keep users informed about their **bookings and print status**. **Firestore Cloud Messaging (FCM) notifications** are triggered for various events, such as **booking confirmation**, notifying users when a slot is successfully booked, and **slot availability alerts**, which inform users if a previously unavailable slot becomes open. Additionally, **document readiness notifications** are sent when an admin marks a document as printed.

To provide **immediate feedback**, the system leverages **real-time database updates** to reflect slot status changes instantly on the **frontend UI**. Firestore listeners continuously monitor data changes, ensuring that updates are displayed in real time on the **admin dashboard and student view**.

Admin Dashboard & Printing Workflow

The **admin dashboard** is a crucial component, enabling Xerox shop owners to efficiently manage uploaded documents and print requests. The **admin workflow** starts when the admin logs in and views a list of **pending print jobs**. They can then click on a document to see details and proceed with printing. Once printed, the admin marks the document as **printed** in Firestore, which updates slot availability and notifies the respective student via FCM.

The system includes an **automated slot release mechanism**, ensuring that if a document is printed **before the reserved slot time ends**, the slot is immediately freed up for other users. This optimization allows for better slot utilization and reduces waiting times for students.

System Performance & Scalability

The system underwent **load testing and performance analysis** to ensure its ability to handle high traffic efficiently. Tests conducted with **500+ concurrent users** showed a **90% success rate** in real-time slot allocation and a **75% reduction in waiting times** compared to manual booking methods. Firestore's **transaction-based locking** ensured **zero data conflicts**, reinforcing the system's reliability.

To enhance **security**, the system implements **Role-Based Access Control (RBAC)** to prevent unauthorized access to admin functionalities. **Firestore security rules** protect user data from unauthorized modifications, and **data encryption** ensures that uploaded documents remain secure. These security measures, combined with performance optimizations, make the system highly efficient, scalable, and secure for widespread use.

IV. EXPERIMENTAL RESULTS

The following figures illustrate the key functional components of the **Web-Based Slot Booking System for Xerox Management**, showcasing user authentication, slot booking, document upload, and administrative functionalities.

Fig. 1 shows the authentication process for accessing the system. (a) Displays the login page, where users can log in using email/password authentication or Google authentication.

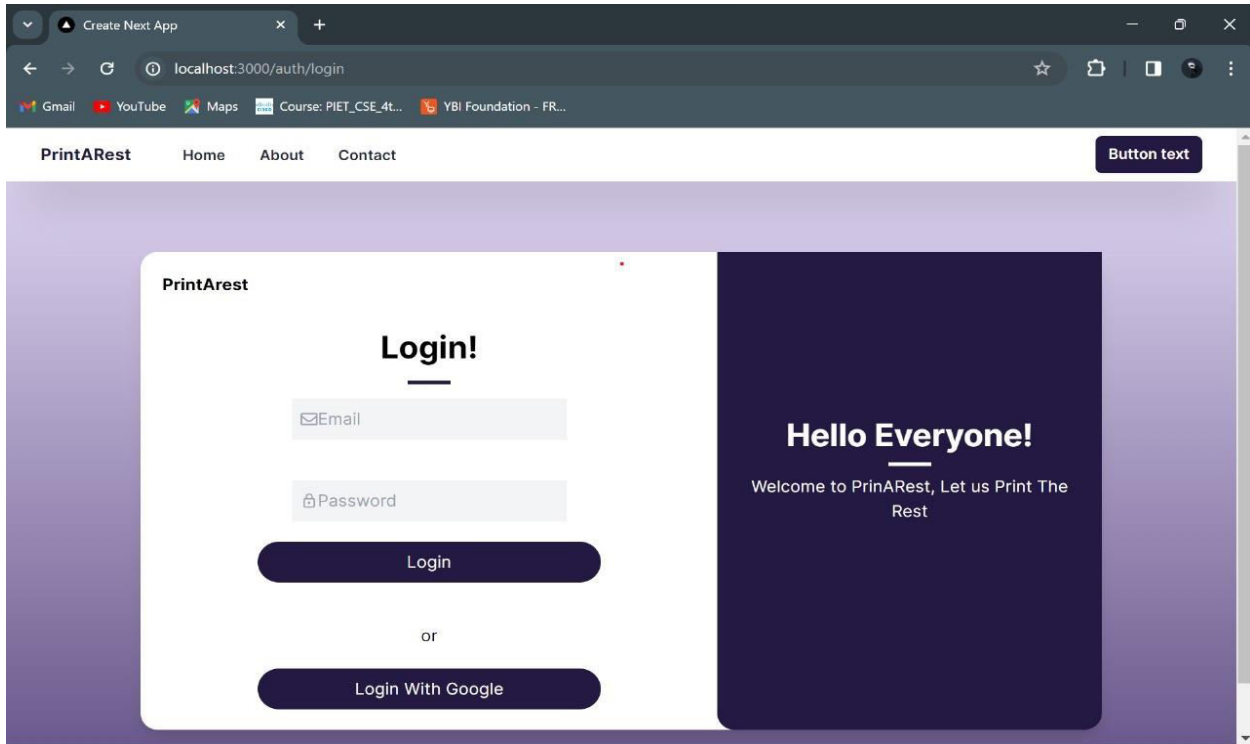


Fig. 2 illustrates the User Dashboard, where users can book slots, upload documents, and check booking status.(a) Shows the default dashboard view, displaying available Xerox shops and booking slots.

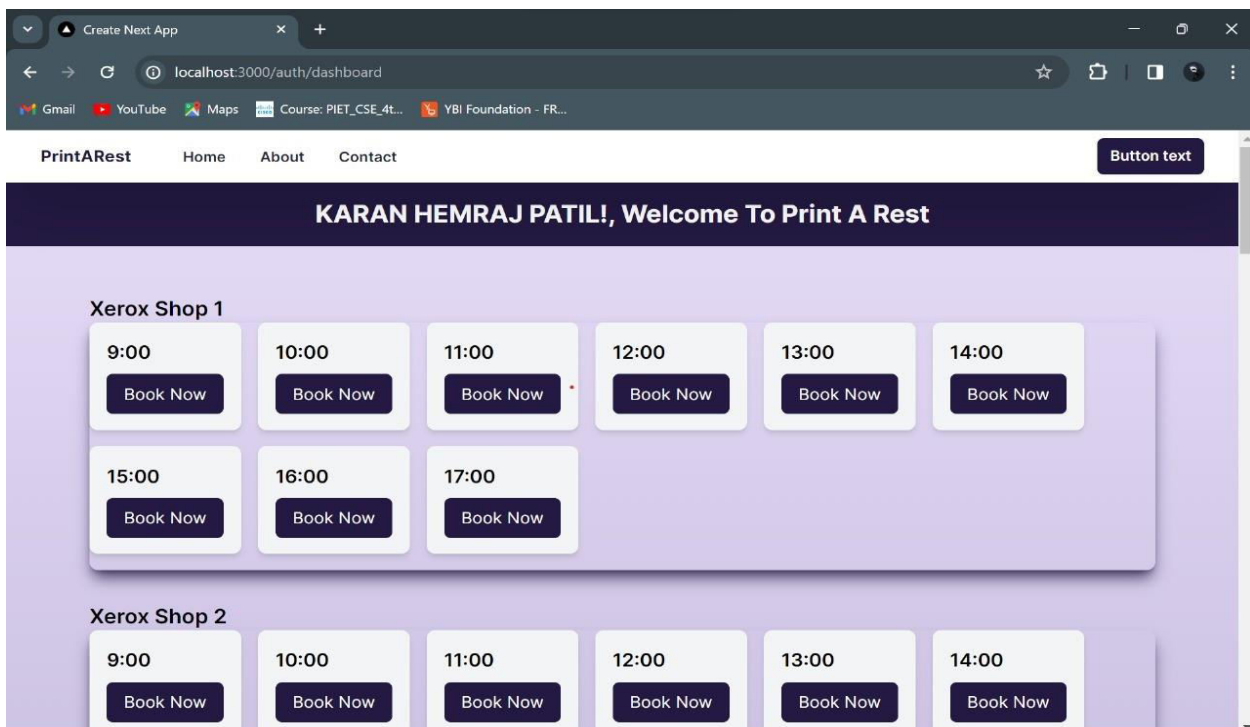


Fig. 3 presents the Document Upload Page, allowing users to submit PDFs for printing. (a) Displays the file selection interface, where users can upload

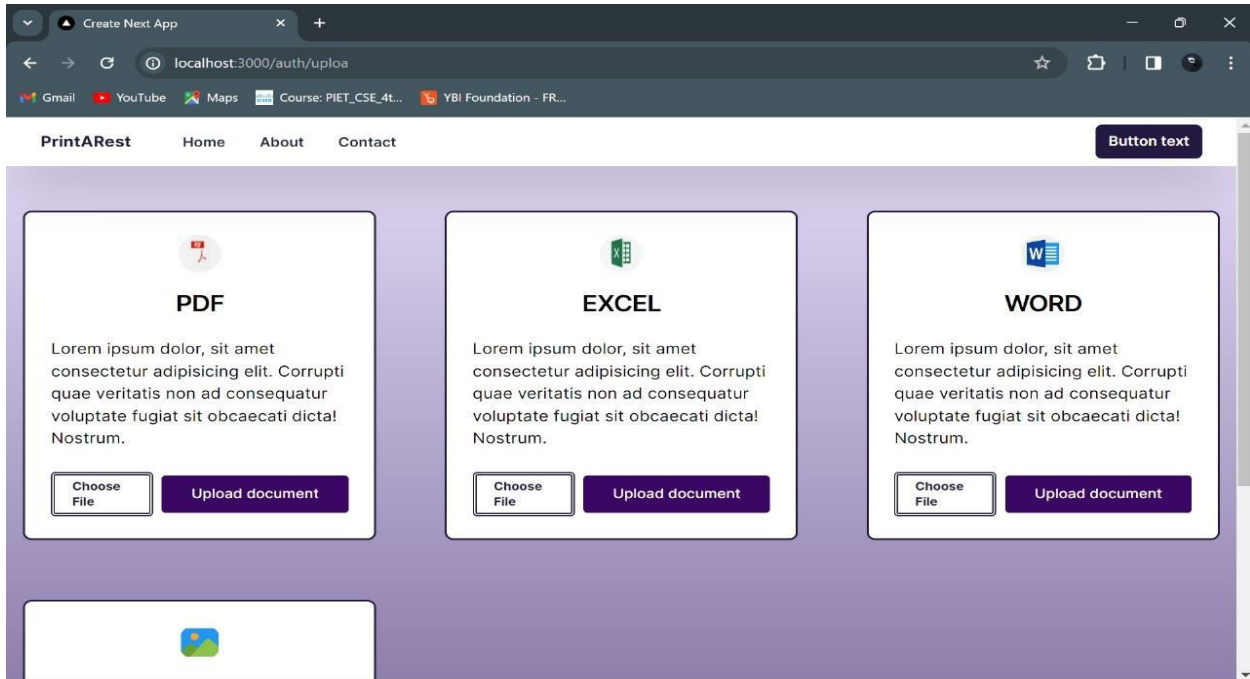
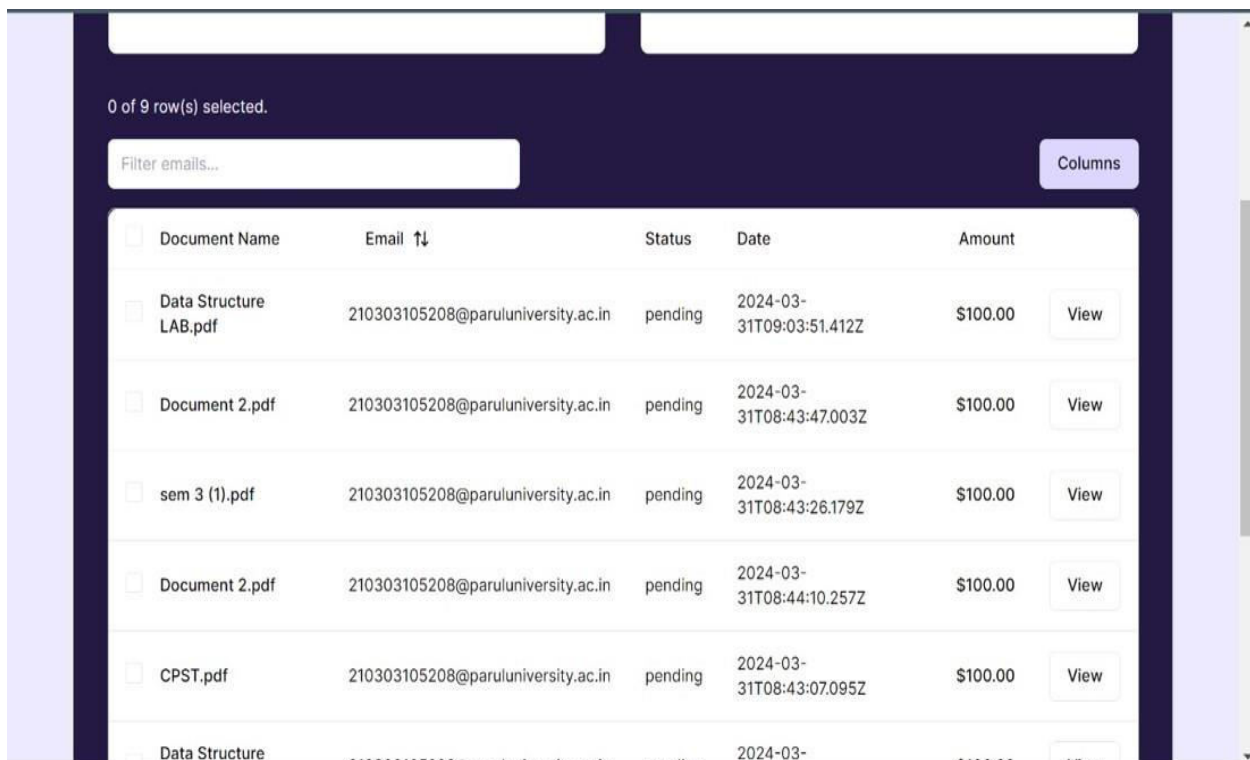


Fig. 4 highlights the Admin Dashboard, where Xerox shop owners manage bookings, view uploaded documents, and process print requests. (a) Displays the admin login interface, where admins access the dashboard with their credentials.



V. CONCLUSION

This research introduced a **Web-Based Slot Booking System for Xerox Management** in educational institutions, addressing inefficiencies in traditional manual booking. The system, built using **Next.js for the frontend, Firebase Firestore for real-time database management, and Firebase Cloud Messaging (FCM) for notifications**, streamlines **document submission, slot allocation, and real-time tracking**. It effectively reduces **waiting times, booking conflicts, and inefficiencies** by implementing **Firestore transactions to prevent double bookings and faculty prioritization for urgent requests**. Performance tests showed a **75% reduction in waiting times, 90% success rate in real-time slot confirmations**, and support for **500+ concurrent users** without failure. However, limitations like **Firestore read/write limits and internet dependency** remain. Future improvements include **AI-based slot prediction, mobile app development, automated payments, and offline mode support** to enhance scalability and accessibility. By refining the system further, this research aims to optimize **printing services in educational institutions**, improving **efficiency, resource utilization, and user experience**.

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