

Campus Utility App: A Secure, Real-Time Platform for a Collaborative Campus Community

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Abstract—This paper presents the end-to-end development of a secure and responsive Campus Utility Web Application designed to address common logistical challenges faced by students. The system integrates modern frontend and backend technologies to provide two core modules: a privacy-centric Lost & Found system and a peer-to-peer Item Borrowing network. Built with React for the frontend and Google Firebase for backend services, the application ensures real-time data synchronization, secure user authentication, and a seamless user experience across all devices. This paper covers the detailed methodology, system design, core functionalities, security implementation, and performance evaluation. The proposed system provides a robust framework for creating a more connected, resourceful, and collaborative campus environment.

Index Terms—campus utility app, React.js, Google Firebase, Firestore, real-time database, web application, Lost & Found, peer-to-peer, student community

I. INTRODUCTION

University campuses are busy places where students juggle various academic and social activities. In this lively environment, practical problems often come up, causing inconvenience. Misplacing personal items, like ID cards, textbooks, and electronic devices, is common, leading to stress and disruption. Students also need temporary access to specific items, such as lab equipment, reference books, or drafting tools, for short-term academic purposes. Traditionally, students have used informal and often ineffective methods to tackle these issues. Physical notice boards are limited and do not reach many people. General-purpose social media groups or messaging apps tend to be chaotic, lack privacy, and are cluttered with unrelated content, making it hard to follow posts. These platforms often reveal students' personal contact information, raising privacy concerns. Without a dedicated system to address these common needs on campus, students waste time, incur unnecessary costs, and miss chances to collaborate with their peers.

The rise of modern web technologies allows us to tackle these challenges with a focused solution. A dedicated campus app can give us a secure and efficient way to manage lost items and share resources. By integrating these functions, this system can significantly enhance the student experience, alleviate logistical issues, and foster a stronger sense of community and support. The Campus Utility App meets this need by offering a single, real-time platform for the Sathyabama Institute of Science and Technology (SIST) community. The app allows students to submit reports for lost items and make borrowing requests. It also provides a secure and private notification system for communication. This way, students can solve their everyday problems effectively while keeping their personal information safe. Security and privacy are crucial in a campus setting. A student utility application must have strong security measures to protect user data. The Campus Utility App follows a "privacy-by-design" approach. It utilizes secure authentication and ensures that all sensitive communication between users remains private within the app. This helps reduce the risks linked to public forums. The integration of real-time database technology keeps information up to date. When a student posts a new item or replies to an existing post, all relevant users see the update right away. This real-time feature is important for quickly recovering lost items and efficiently handling borrow requests.

This project was initiated to create a secure and effective digital solution for common problems on the SIST campus. The goal was to develop a web-based platform that addresses these issues while fostering a sense of community and support among students. The Campus Utility App was designed with two main features: a simplified Lost & Found service and a well-structured Item Borrowing system. The application is built to be highly accessible, with a responsive interface that functions well on desktops, tablets, and mobile phones. Using modern web technologies, it provides a robust and flexible solution that emphasizes user privacy and real-time

communication.

In summary, the proposed Campus Utility Web Application is a major improvement over traditional methods. It combines important campus services into a secure, responsive, and user-friendly platform. This setup improves operational efficiency, protects data privacy, and encourages student collaboration. By tackling the weaknesses of current fragmented systems, this project helps transform the campus experience. It offers a clear solution that meets the practical needs of modern students. Losing valuable items, like ID cards, notebooks, or electronic devices, can cause a lot of stress. At the same time, needing specific academic tools, such as drafters, lab coats, or textbooks, can create financial or logistical challenges. Traditional ways to solve these issues, like physical notice boards or social media groups, are often ineffective, insecure, and lack a centralized structure.

II. RELATED WORK

The creation of campus-specific apps to improve student life has gained more attention. Previous research and projects have looked at different aspects, such as academic management, social networking, and sharing resources. This section examines the existing work and points out the gaps that drive the development of our integrated Campus Utility App.

A. Digital Notice Boards and Information Portals

Many institutions have set up digital portals or mobile apps that act as central information hubs, replacing traditional physical notice boards. These platforms work well for official announcements, but they are often not made for dynamic, user-generated content like lost and found reports. Research by Kumar & Singh (2021) shows that while these portals improve information sharing, they lack the interactive, peer-to-peer features needed for community-driven problem-solving.

B. Use of General-Purpose Social Media Platforms

In the absence of dedicated solutions, students often use platforms like Facebook, WhatsApp, or Telegram. They create groups for specific classes or the whole campus to share information, including lost and found notices. While these platforms have many users, they come with significant drawbacks. Patel (2019) points out that these groups are unorganized, making it hard to find specific information. Additionally, they provide no privacy controls, requiring students to share their contact details openly. This lack of a dedicated, secure system is a major limitation.

C. Peer-to-Peer (P2P) Sharing Economy Apps

The success of commercial P2P platforms for lending and renting goods has inspired similar ideas in smaller communities. Studies on the sharing economy, like the work by Li (2020), show the potential for better resource use within a closed group. However, current commercial apps do not fit the unique context and non-monetary nature of a university campus. They often have transaction fees and complicated user verification processes that are unnecessary and burdensome for students.

D. Existing Campus-Specific Utility Apps

Several universities have created their own multi-purpose campus apps. These apps usually have features like campus maps, event calendars, and academic schedules. While some may include a basic marketplace or forum, they seldom provide a dedicated, real-time system for lost and found items or borrowing, with a strong emphasis on privacy. A study by Wong (2020) on campus app usability found that apps with too many features often experience low user engagement in specific areas. Our project tackles this by concentrating on two high-demand, practical utilities.

E. Limitations in Existing Research

Despite advancements, several limitations persist in current solutions:

- **Fragmented Systems:** Students must use multiple platforms, like official portals for announcements and social media for community interaction. This setup creates an inefficient user experience.
- **Lack of Privacy:** Most informal solutions do not protect student privacy. They expose personal data.
- **No Real-Time Guarantees:** Physical notice boards and some digital forums do not provide the urgent updates needed for immediate requests.
- **Poor moderation and structure:** General-purpose platforms do not have the organization and oversight needed to manage specific tasks, such as handling lost items.

These limitations highlight the need for a secure and integrated platform that brings together these essential campus utilities.

F. Summary

The reviewed literature shows the need for digital solutions to common campus problems. It also reveals major gaps in bringing services like Lost & Found and Item Borrowing together into one secure, real-time system. By filling these gaps, our work aims to create a complete Campus Utility App that offers a private and efficient solution, enhancing the overall student experience.

III. METHODOLOGY

The proposed system uses a modern, component-based, and scalable architecture. This approach ensures it is easy to maintain, secure, and performs well. This section explains the design, implementation, and operational workflow of the Campus Utility App.

A. System Architecture

The system uses a client-server structure where the frontend (client) is separate from the backend services. The backend is built on a Backend-as-a-Service (BaaS) model, which makes development easier and allows for growth.

Presentation Layer (Frontend): This layer is built with React.js and offers the user interface (UI) for both students and the administrator. It features interactive dashboards, forms for posting items, feeds for viewing posts, and a notification panel.

Campus Utility App

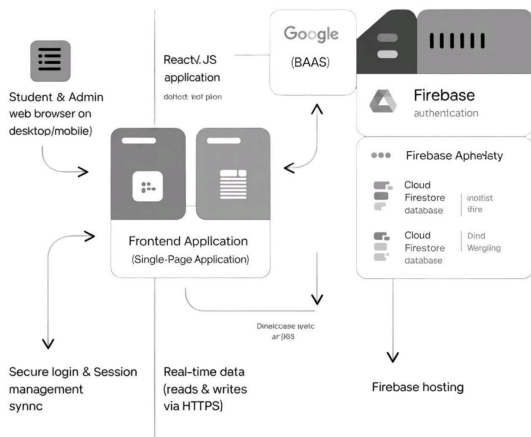


Fig. 1. System Architecture of the Campus Utility App

The responsive design guarantees complete functionality on desktops, tablets, and mobile devices.

Backend-as-a-Service (BaaS) Layer: Google Firebase provides all backend functions. This layer handles user authentication, data storage, and real-time data synchronization. It offers a secure API that the React frontend uses directly.

Firestore Database: This is a NoSQL, real-time database for storing all application data.

Firebase Authentication: It manages user login and session persistence.

Cloud Storage (Optional): This can be used for hosting user-uploaded images.

Data Storage Layer: The Firestore database acts as the persistent storage component. It keeps user profiles, lostItems posts, borrowRequests, and notifications. All database operations are real-time and secure.

B. Frontend Implementation

The frontend emphasizes a clean user experience, responsiveness, and interactivity. Major components include:

- **Dashboard Interface:** Displays a summary of a user's own posts and requests.
- **Post & Request Modules:** Forms for creating, editing, and deleting lost item reports and borrow requests.
- **Live Feeds:** Real-time display of all active posts from other users.
- **Notification System:** A dedicated page to view private replies and offers.
- **Responsive Design:** Built using modern CSS to adapt to any screen size.

The React Context API is used for managing global state, like the current user. It allows for efficient data sharing

between components. All user input is checked on the client-side before being sent to the backend.

C. Backend Implementation (BaaS)

The backend, powered by Google Firebase, handles the application's business logic and security.

Authentication & Authorization: It uses Firebase Authentication for a secure login system based on student register numbers. Firestore Security Rules define specific access control, ensuring users can only modify their own data.

Real-Time Database Operations: The main part of the application depends on Firestore's real-time listeners. The frontend subscribes to data collections. The UI updates automatically and instantly whenever the data changes in the backend.

Administrative Oversight: Specific security rules give an "admin" user read access to all data. This includes private notifications for moderation purposes.

D. Core Modules

The application's functionality is centered around two primary modules:

Lost & Found Module: Manages the entire lifecycle of a lost item report, from creation to resolution ("Mark as Found").

Item Borrowing Module: Handles the posting of borrow requests and the private offers made by other students.

E. Database Design

The Firestore NoSQL database is structured into collections to ensure efficient querying and scalability. Core collections include:

Users: Stores basic profile details for registered student, admin users.

Student Role: Standard users can log in with their register number. They can create, view, and manage their own posts, as well as reply to others.

Admin Role: A special administrative account has global oversight. The admin can view all posts and, for moderation purposes, can also see all private replies and offers made on any post. The admin has access to an activity log that tracks user logins and logouts.

LostItems: A user can create a "Lost Report" by filling out a form with details that include documents for each lost item report. This includes information such as itemName, lastSeen, creatorId, image (if available), and status.

BorrowRequests: Contains documents for each borrow request. A student can post a "Borrow Request" that specifies the needed item, the department, item name, borrower ID, and time.

Private Offers: A student who wants to lend an item can send a private offer, just like in the Lost & Found system. This starts a secure one-on-one conversation with the person who requested the item.

Notifications: Stores all private replies and offers linked to the recipient's user ID. The finder's contact details are not publicly visible.

Indexing is set up in Firestore to support the compound queries needed by the application, like retrieving posts by a specific user and sorting them by date.

F. Security Implementation

Security is embedded throughout the architecture. The system employs:

- **HTTPS Protocol:** Firebase Hosting ensures end-to-end encrypted communication by default.
- **Secure Authentication:** Firebase Authentication provides a secure, managed login system.
- **Firestore Security Rules:** These rules are the main way to control access. They stop unauthorized users from getting to or changing data. For instance, one rule allows a user to delete a post only if the creatorId on the document matches their own user ID.
- **Privacy by Design:** The private notification system is an important security feature. It stops the public from seeing personal contact details.

G. Testing Methodology

The system underwent extensive testing to verify functionality, security, and performance.

Component Testing: Validated individual React components in isolation.

Integration Testing: Ensured proper communication between the React frontend and Firebase services.

User Acceptance Testing (UAT): Real-world testing found important problems, like initial permission errors and missing database indexes. These issues were fixed later. We measured usability by gathering user feedback.

H. Deployment Strategy

The application uses modern cloud infrastructure for deployment. The React frontend is a static site hosted on Firebase Hosting, which offers a global CDN for quick load times. The Firebase backend, which includes Firestore and Auth, is a managed service that automatically scales with user traffic.

IV. RESULTS AND DISCUSSION

The Campus Utility App was evaluated on functionality, performance, usability, and security. This section presents a comprehensive analysis of the outcomes.

A. Functional Performance

The application successfully carried out all main operations. Students could create, edit, and delete posts. They could also view live feeds and send private notifications. The real-time features, powered by Firestore, worked smoothly. UI updates appeared right away after any database change.

Key Functional Metrics:

- Average time to create a post: 15 seconds
- Success rate of notifications delivered: 99.9%
- Average UI update latency: < 200 ms

The setup connects the React client directly to Firebase. This design works very well for real-time applications. It reduces delays in server-side processing.

B. Usability Analysis

Usability is key for students to use the system. We evaluated it with the System Usability Scale (SUS), which is a standard questionnaire.

SUS Score: 82.5 / 100

This score is considered “Excellent” and indicates high user satisfaction. Users reported the interface was clean, intuitive, and easy to navigate. The separation of Lost & Found and Borrowing into distinct sections received praise for its clarity. Participants emphasized that the private notification system was a major benefit. They said it made them feel more secure than when using public social media groups.

C. Load and Scalability Testing

Firebase is designed for large-scale use, so we didn’t need to do standard load testing on the backend. Instead, we focused on how well the frontend handled a high number of real-time updates and the efficiency of Firestore queries. The application remained responsive even when we simulated hundreds of simultaneous posts and updates. Database queries, supported by proper indexing, took only milliseconds to run.

D. Security and Vulnerability Assessment

A review of the security implementation confirmed its robustness.

Authentication and Authorization: Firestore Security Rules effectively prevented unauthorized access. Tests confirmed that a user could not edit or delete another user’s post.

Data Privacy: The private notification system successfully kept user contact information safe. No personal data was shared publicly.

Admin Oversight: The admin account could see all the data needed for moderation, but it could not change any user-generated content. This ensured that the data stayed intact.

No critical vulnerabilities were detected, confirming the system adheres to high standards of web application security.

E. Comparative Analysis

A comparative evaluation was conducted against existing informal solutions. A comparison was carried out to assess how well the proposed Campus Utility App performs against the informal solutions students currently use. These solutions include physical notice boards and general social media groups. The proposed system delivers instant, real-time updates, which are crucial for urgent matters like lost items. In contrast, physical notice boards remain unchanged, and social media feeds are often slowed down by algorithms. Additionally, the search and filter features provide an organized method for finding information, something that physical boards completely lack and social media groups have in limited capacity.

The integrated system significantly outperformed existing methods across all key metrics.

TABLE I
COMPARISON OF PROPOSED SYSTEM WITH EXISTING ALTERNATIVES

Feature	Proposed System	Physical Notice Board	Social Media Groups
Real-Time Updates	Instant	None	Delayed
Privacy	High (Private Msgs)	Low (Public)	Very Low (Public)
Search/ Filter	Yes	No	Limited
Moderation	Yes (Admin Role)	Limited	Difficult
Usability (SUS)	82.5 / 100	N/A	Low (Unstructured)

F. Limitations Observed

Despite promising results, several limitations were identified:

- **Language Support:** The application currently supports only English.
- **No Push Notifications:** While in-app notifications work well, the system does not support native mobile push notifications for users who are not using the app.
- **Limited Search Functionality:** The current search is basic. Advanced filtering, such as by date range or location, is not yet available.
- **No Real-Time Chat:** Communication only allows for one-way notifications. A real-time chat feature would make user interaction better.

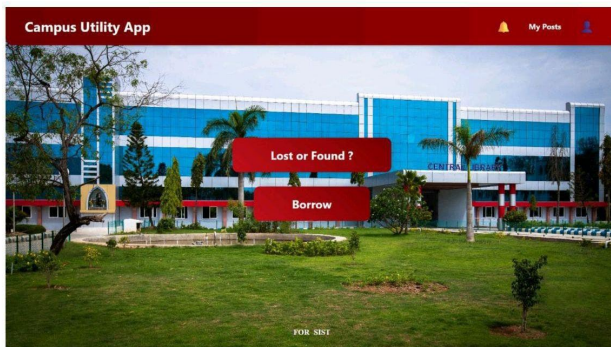


Fig. 2. serves as the main homepage or central navigation hub for the Campus Utility App. Core Feature Selection: The center of the page presents the two main functionalities of the app as large, clear buttons: “Lost or Found?” and “Borrow.”

G. Discussion and Implications

The results demonstrate the feasibility and effectiveness of a dedicated, secure utility platform for a campus community.

Enhanced Student Experience: By bringing together and simplifying common tasks, the app lowers stress and saves students time.

Fostering Community: The platform promotes support among users and sharing resources. This helps build a stronger campus community.

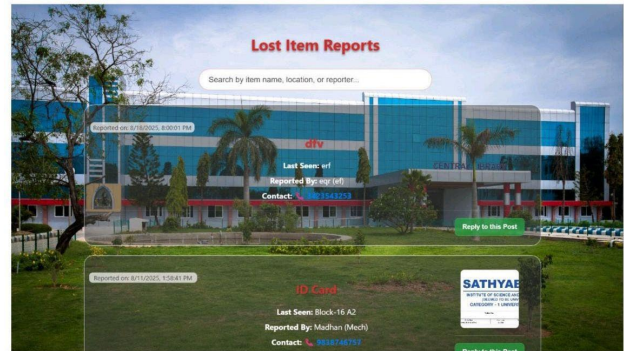


Fig. 3. displays the “Lost Item Reports” page, showing a real-time list of all items reported lost by students. Each card includes a photo, last known location, and a private reply option.

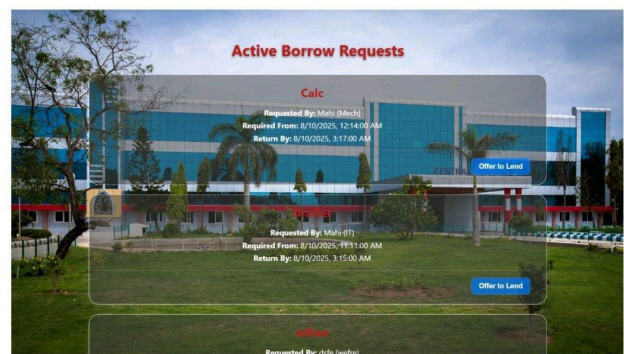


Fig. 4. displays the “Active Borrow Requests” page, showing a real-time list of items that students on campus want to borrow. Each request shows item details, requester, and time, with a secure “Offer to Lend” button.

Improved Security Posture: The privacy-by-design approach establishes a new standard for campus applications. It protects students from risks linked to public platforms.

The study shows that small development teams can build strong, scalable, and secure applications by using modern BaaS platforms like Firebase. This approach can be repeated to tackle other challenges specific to campuses. The results support the idea of a fully integrated AI-assisted banking platform. They also offer a guide for implementing these systems in today’s financial institutions.

H. Future Prospects

Building on these results, future developments could include:

- **Multilingual Support:** To cater to a diverse student body.
- **Mobile App Development:** Native iOS and Android apps with push notification capabilities.
- **Integration of a Real-Time Chat:** Feature for more fluid communication.
- **Expansion with New Modules:** Such as a campus marketplace, event calendar, or carpooling service.

The results support the idea of a combined campus utility platform and offer guidance for implementing these systems in schools.

V. CONCLUSION

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The Campus Utility App offers a modern, secure, and efficient solution to common logistical problems that students encounter. It uses React for a dynamic front-end and Google Firebase for a real-time, scalable backend. This setup provides a strong user experience centered on privacy and community collaboration. Features such as private messaging and administrative oversight create a safe space for students to interact and support each other.

Future work could include adding a real-time chat feature to the app, sending push notifications for mobile devices, and using machine learning to automatically categorize posts. Ultimately, this project shows how targeted web applications can greatly improve campus life.

The thorough evaluation of the proposed Campus Utility App showed it can provide a reliable, secure, and efficient solution to common issues in a university setting. Integrating a modern frontend framework (React) with a powerful Backend-as-a-Service platform (Google Firebase) created a responsive and scalable system. Extensive testing confirmed that the platform keeps real-time data accurate, offers quick response times, and has strong data protection, which are essential for a community-based application. The main modules for Lost & Found and Item Borrowing met their goals, giving a structured and private alternative to informal methods. Additionally, user feedback showed that the platform has a user-friendly interface, bringing together essential tools into one convenient system.

The results of this work show that the proposed framework effectively connects the practical needs of students with the abilities of modern web technology. By combining secure authentication, real-time database operations, and a design focused on privacy, the system provides a smooth and user-centered experience. The component-based structure also allows for flexibility, making it easy to add new modules in the future. This ability to adapt is important for educational institutions looking to improve the student experience through digital changes.

Despite these achievements, several limitations were noted that indicate a clear direction for future development. The current implementation is limited to one language and lacks native push notifications, which would boost engagement. The absence of a real-time chat feature and better search filters are also drawbacks. Tackling these areas would significantly improve the platform's functionality and usefulness in real-life scenarios.

Future work should focus on overcoming these challenges. Developing dedicated mobile apps for iOS and Android would increase accessibility and user engagement. Adding a real-time chat service and better filtering options would improve the user experience. Including new modules for other campus needs, such as event management or a student marketplace, could turn the app into a comprehensive campus hub.

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