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RADIT: An RFID based Student Wallet System

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Abstract
The RADIT system represents a pioneering approach to campus management that transforms chaotic administrative processes into a streamlined, technology-driven ecosystem. Leveraging RFID technology coupled with biometric verification, this comprehensive platform creates a secure, cashless environment for students across four essential campus modules. The digital wallet serves as the central hub, enabling seamless financial transactions for canteen purchases, stationery items, and miscellaneous college expenses, eliminating physical cash handling while providing pattern-based wallet top-up suggestions. The library management system incorporates book recommendations based on student borrowing history and academic interests. The bus tracking module delivers real-time updates to parents regarding student transportation, while the classroom attendance system employs facial recognition to ensure accurate student verification. RADIT's cloud-based architecture ensures scalability, reliability, and real-time data synchronization across all modules, with recommendation systems providing personalized wallet recharge recommendations based on historical spending patterns. By centralizing these services on a secure cloud platform, RADIT enhances operational efficiency, strengthens security protocols, reduces manual paperwork, and generates valuable data analytics for institutional decision-making, creating a more organized, responsive, and student-centred campus experience.

Keywords: RFID technology, cloud computing, usage pattern-based recommendations, cashless campus, biometric verification, smart campus

1. Introduction

RADIT: An RFID based Student Wallet System is a comprehensive, modular campus management system designed to streamline and unify essential student services within educational institutions. By leveraging RFID technology, biometric verification, and cloud-based data storage, RADIT provides a secure, cashless, and highly efficient environment for students, administrators, and service providers. The system integrates four core modules—digital wallet, library management, bus tracking, and classroom attendance—into a single, user-friendly platform. Through usage pattern-based recommendation systems, RADIT enhances the student experience by offering personalized suggestions for wallet recharges and book borrowing, while real-time data synchronization ensures up-to-date information across all modules. The result is a connected, organized, and responsive campus ecosystem that eliminates manual processes and data silos, improving operational efficiency and campus safety.

1.1 Problem Definition

Traditional campus management suffers from fragmentation—separate systems for finances, library, transportation, and attendance create inefficiencies and poor user experiences. Physical cash poses security risks, library operations are cumbersome, bus tracking lacks real-time updates, and attendance systems are vulnerable to proxy attendance. These disconnected systems result in data silos and limited operational insights.

1.2 Existing Applications

Current solutions like Blackboard, Canvas, and Koha typically address isolated aspects of campus management without comprehensive integration. Most lack pattern-based recommendations, RFID/biometric verification, and are often costly or complex for smaller institutions.

1.3 Proposed Application

RADIT provides a unified cloud-based system built with Python/Tkinter and Firebase Firestore. The digital wallet enables cashless transactions with spending-based recharge suggestions. The library module streamlines lending with personalized recommendations. Bus tracking delivers real-time updates, while the attendance module uses RFID and facial recognition for security. The modular architecture ensures seamless data synchronization while allowing customization for institutions of various sizes.

2. Literature Survey

"Biometric and RFID Passive Tag-Based Student Identification System for Secure Attendance Management" by N. R, et al. presents an advanced attendance management system integrating biometric authentication with RFID tags for secure and accurate student tracking [1]. By combining fingerprint recognition with RFID-based ID cards, the system prevents proxy attendance and manual entry errors. It also includes real-time attendance updates via a GSM-based SMS notification system for guardians and a web application for monitoring student attendance and location. For our project, this highlights the effectiveness of multi-factor authentication and automated notifications in enhancing security and reliability in student attendance tracking.

"**An RFID-Based Smart School Attendance and Monitoring System"** by Farag, et al. proposes an RFID-based automated attendance system (RFID-AS) to enhance student tracking and evaluation [2]. By using passive RFID technology, the system ensures cost-effectiveness while improving security and grading accuracy. The system integrates RFID readers, SQL Server for data management, and a Visual Studio-based GUI, allowing parents and faculty to monitor student records. Attendance is recorded as students pass through RFID-enabled classroom doors. For our project, this highlights the practicality of RFID for seamless attendance tracking and real-time student monitoring in educational institutions.

"E-Wallet: A Study on Cashless Transactions Among University Students" by Chelvarayan A, et al. explores university students' adoption of e-wallets using the Technology Acceptance Model (TAM) [3]. It highlights key influencing factors such as perceived usefulness, ease of use, risk, and trust. The research, based on a survey of 140 students from a Malaysian private institution, suggests that e-wallets provide a more convenient alternative to cash and traditional payment methods. Findings can help institutions, businesses, and policymakers understand students' financial behaviour and improve digital payment

adoption. For our project, this study reinforces the importance of user trust, security, and convenience in implementing a student-focused digital wallet system.

"RFID-Based Library Management System used in Library" by Srinivasan, et al. presents an RFID-based library management system that enhances efficiency in book transactions, tracking, and security [4]. By integrating RFID readers and tags, the system automates borrowing and returning, reducing manual intervention. Key benefits include preventing book losses, improving stock verification, and enabling real-time updates via GSM. For our project, this research highlights how RFID can streamline library management, ensuring accurate book tracking and automated fine management, making it a relevant model for implementing RFID-based book lending and return systems.

"IoT-Based School Bus and Student Monitoring System Using RFID and GSRM Technologies" by Ranjan, et al**.** introduces an IoT-based system that enhances school bus safety by integrating RFID and GPS tracking [5]. RFID records students' presence inside or outside the bus, while GPS enables real-time vehicle tracking. The system also features an emergency SOS button that sends alerts via GSM to predefined contacts. The research emphasizes automation, real-time monitoring, and parental notifications. For our project, this highlights the potential of RFID and IoT for tracking student bus usage, ensuring safety, and providing real-time updates to stakeholders.

"The Role of Internet of Things in Smart Education" by Valentina T, et al. explores how IoT can transform education by creating smart learning environments [6]. It discusses IoT's role in optimizing educational processes through sensor-based data collection and intelligent communication protocols. The research presents two IoT prototypes designed to enhance smart schools by automating data gathering and information dissemination. For our project, this highlights the integration of IoT for efficient student tracking, automated attendance, and real-time updates in an educational setting.

"RAFI: Robust Authentication Framework for IoT-Based RFID Infrastructure" by Kumar, et al. addresses security concerns in IoT-based RFID systems by proposing a robust authentication framework [7]. It highlights vulnerabilities in RFID communication, such as data privacy risks and security threats, and presents a model that ensures secure communication using formal security analysis. The research emphasizes the need for authentication mechanisms in RFID infrastructure to prevent unauthorized access. For our project, this underscores the importance of implementing secure authentication and encryption methods in RFID-based student tracking and transaction systems.

"A College Student Behaviour Analysis and Management Method Based on Machine Learning Technology" by Shen, et al. explores how machine learning, specifically an adaptive K-means algorithm, can analyse student behaviour in digital campuses [8]. By clustering data related to study patterns, lifestyle, and financial habits, the system identifies issues like excessive online time, low book borrowing rates, and financial constraints. The insights help institutions improve student management, safety, and academic performance. For our project, this highlights the potential of using data-driven decision-making for personalized student support, optimizing resource allocation, and enhancing financial monitoring in an RFID-based campus system.

3. Design and Methodology

This section outlines the comprehensive methodology and design principles used to develop the RADIT (RFID-Attendance-Digital Wallet-Integrated-Tracking) system—a modular, role-based, and scalable campus management solution. The system integrates RFID authentication, facial recognition, and real-time cloud synchronization to streamline student services such as attendance, wallet transactions, library access, and bus tracking.

3.1 Technologies Used

A robust selection of technologies was adopted to ensure performance, scalability, and ease of maintenance:

- **Programming Language: Python 3.8+**
  Chosen for its readability, vast ecosystem, and support for hardware integration (RFID, webcam) and cloud services.
- **GUI Framework: Tkinter/ttk**
  Provides a lightweight and native interface, enabling cross-platform support and ease of use for both administrators and students.
- **Database Systems:**
  - **Development Stage:** SQLite (student_wallet.db) – used for rapid prototyping and local storage.
  - **Production Stage:** Firebase Cloud Firestore – a NoSQL real-time cloud database supporting secure, synchronized access to student, transaction, library, attendance, and bus data.
- **Image Processing & Face Recognition:**
  - **OpenCV** for facial recognition during attendance verification.
  - **Pillow** for image resizing and format management.
- **RFID Integration:** Compatible with 13.56 MHz or 125 KHz RFID readers using USB/Serial interfaces, enabling secure, fast student authentication.
- **Email Notifications: smtplib** for sending automated parent notifications during student bus boarding or exit.
- **Supporting Libraries:** firebase-admin, datetime, re, threading for cloud integration, time handling, regular expressions, and background processing tasks.

3.2 Development Process

RADIT was developed through an iterative, modular approach, allowing for continuous refinement and adaptability:

- **Requirement Analysis:** Engaged stakeholders (students, faculty, project guides) to define key modules: digital wallet, library, attendance, and bus tracking.
- **System Design:** The architecture emphasized modularity, enabling each service to function independently while maintaining centralized data management through shared authentication and database systems.
- **Module Implementation:**
  - **Digital Wallet:** Implemented first to establish RFID transaction logic.

- **Library Management:** Integrated book lending/returns and catalogue recommendations.
- **Bus Tracking:** Enabled RFID-based boarding and exit logging with parent notifications.
- **Attendance:** Added facial recognition to prevent proxy attendance.

- **Database Integration:** Cloud Firestore and SQLite were used to store and manage student information, attendance, transaction logs, book data, and bus route activities.
- **Testing:** Conducted unit and integration testing for each module. User acceptance testing validated workflows and usability.
- **Deployment and Feedback:** The system was deployed in a controlled academic setting. User feedback guided further optimization.

3.3 System Design

RADIT is built on a scalable and maintainable modular architecture incorporating object-oriented programming principles, a centralized database, and role-based access controls.

3.3.1 System Architecture

As shown in Figure 1, the architecture includes:

- **RFID Scanner:** Captures student UID for identity verification.
- **Application Modules:** Attendance, Wallet, Library, and Bus tracking.
- **Database Backend:** SQLite (for local prototyping) and Firebase Firestore (for cloud deployment).
- **Graphical User Interface:** Tkinter-based dashboards tailored to specific user roles.

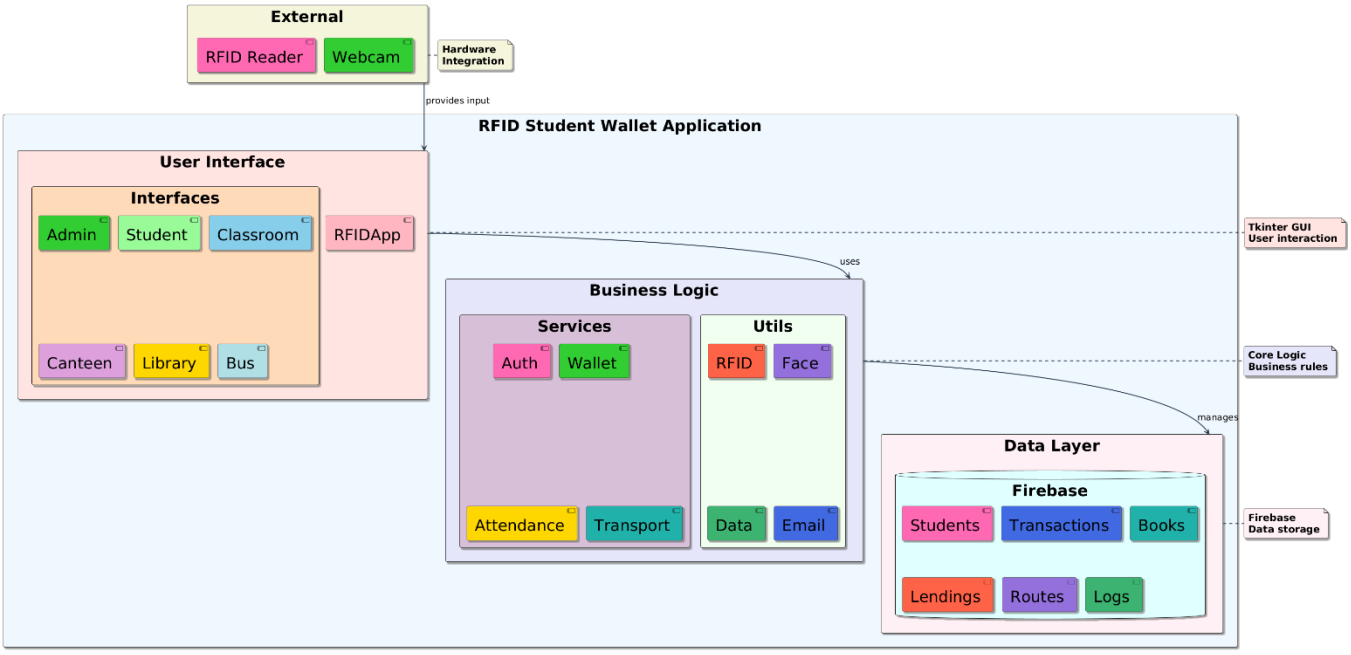

Figure 1: System Architecture diagram

3.3.2 Database Schema

The system utilizes a Firebase Firestore document database. Its schema includes the following collections as shown in the ER diagram in Figure 2:

- Admin – Stores administrative user details including name, RFID, and role.

- Students – Contains student profiles, wallet balance, face data (optional), and bus pass information, identifiable by RFID UID.
- Routes – Defines bus routes with details like stops, fare, and schedule.
- Books – Lists available library books with title, author, and status.
- Transactions – Logs all digital wallet activities (payments, recharges), referencing the involved student.
- Lendings – Records library book borrowing details, referencing the student and the borrowed book.
- Returns – Logs library book returns, referencing the student and the returned book.
- Attendance – Stores timestamped logs for student presence, referencing the student.
- Bus_Logs – Records bus boarding and offboarding events, referencing the student and the specific route.

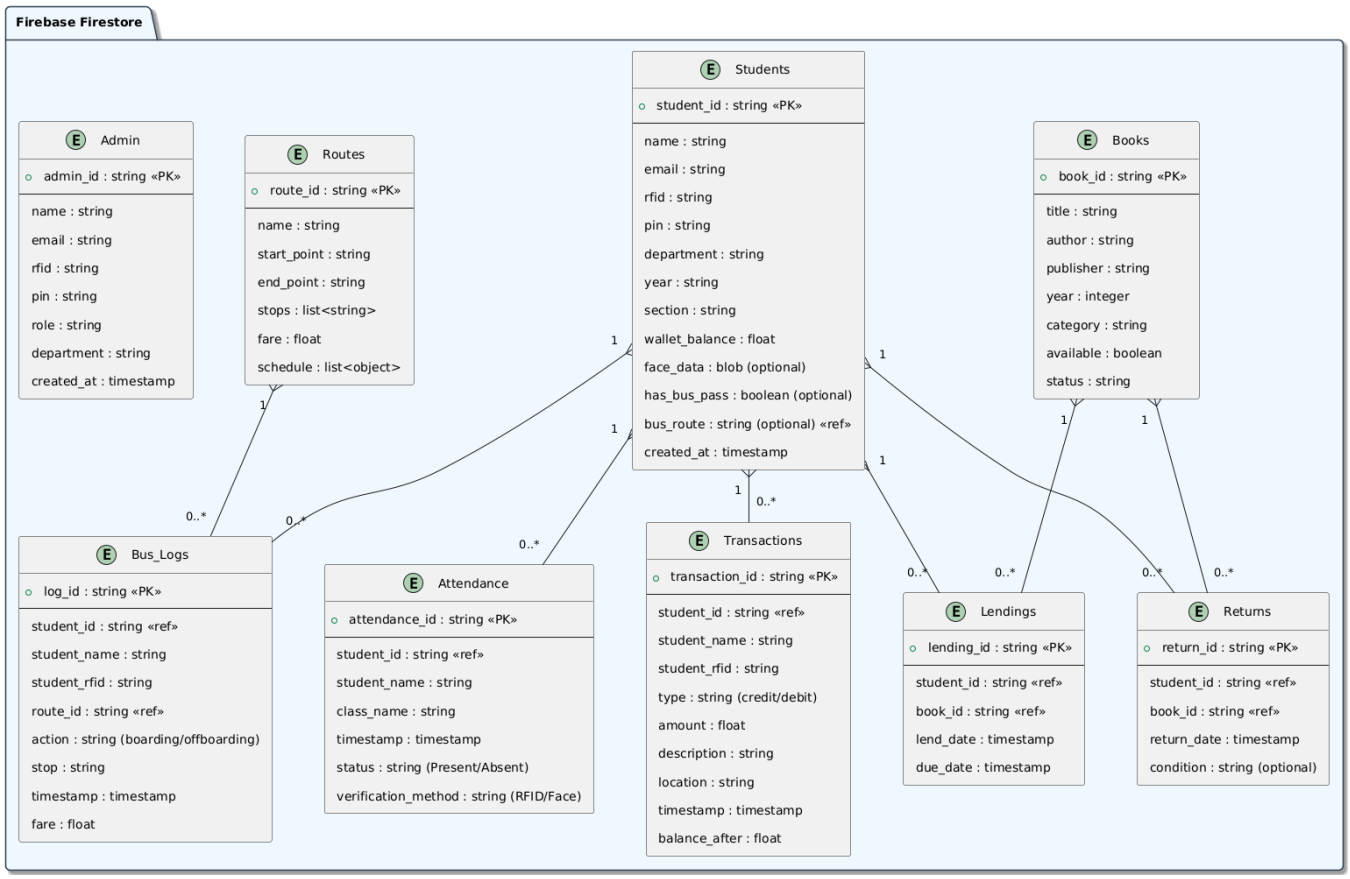

Figure 2: Entity Relationship diagram

3.3.3 Control Flow

The control flow follows a streamlined pattern for all modules as shown in Figure 3:

1. RFID scan or facial recognition.
2. Identity verification and role validation.
3. Action execution (e.g., log attendance, deduct balance, log bus event).
4. Database update and optional user notification.

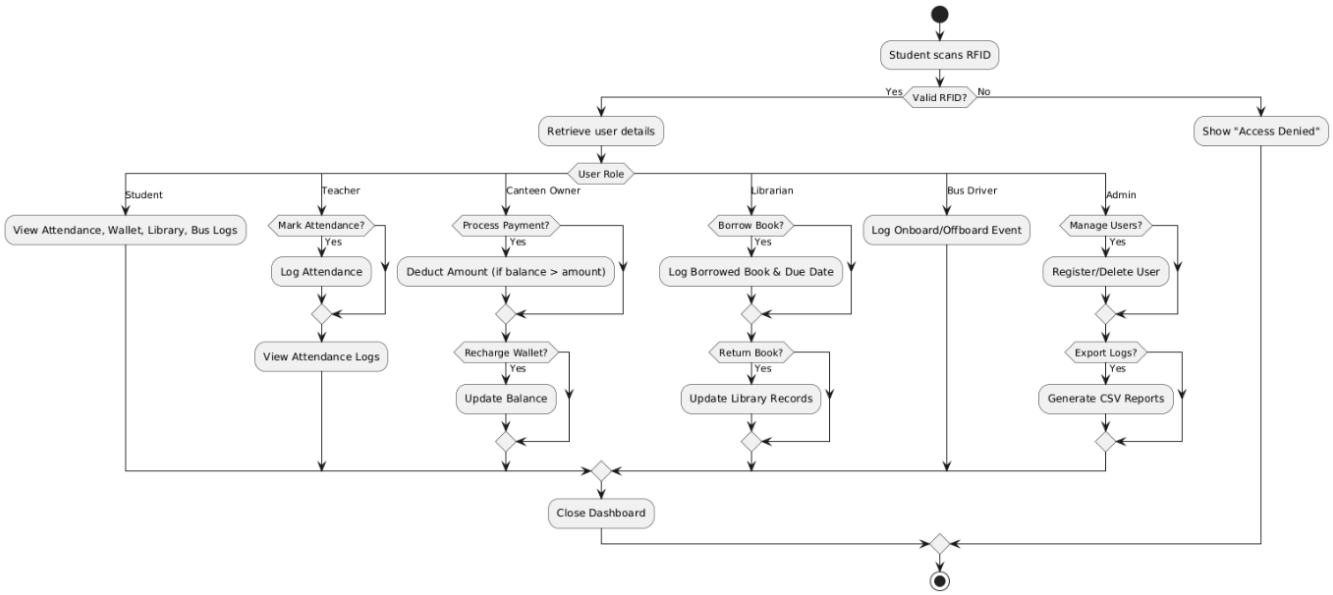

Figure 3: Control Flow diagram

3.3.4 Role-Based Access Control

Access is governed by user roles assigned during registration. Each RFID UID is linked to specific permissions as shown in the Figure 4:

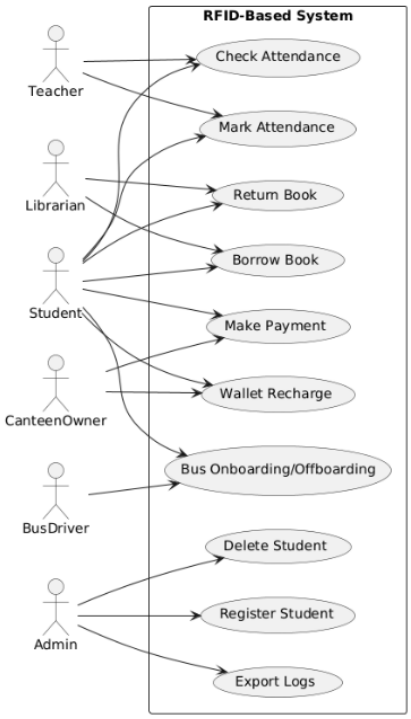

Figure 4: Use Case diagram

3.3.5 Student Interaction Workflow

A typical student interaction (e.g., attendance marking) follows this sequence (also shown in Figure 5):

1. Student scans RFID card.
2. The system retrieves and verifies the UID.

3. Attendance is logged with a timestamp.
4. Confirmation is displayed or sent to relevant users.

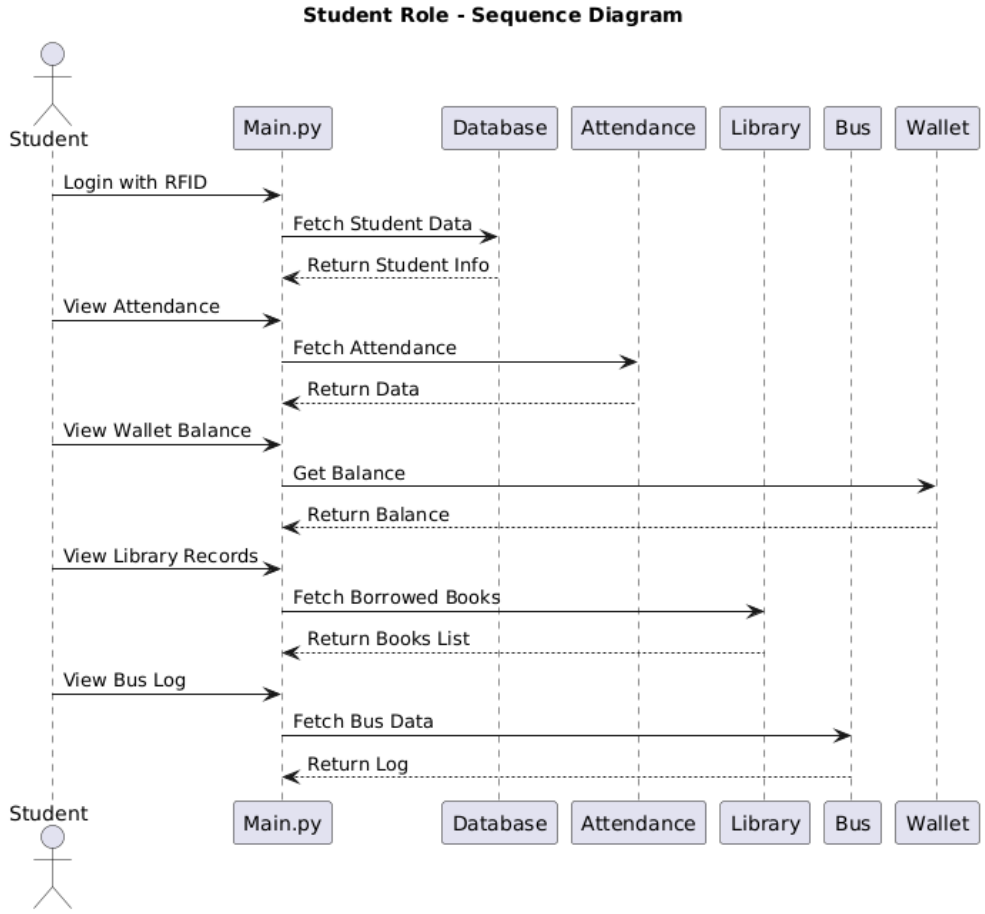

Figure 5: Sequence diagram

4. Implementation

RADIT is architected as a modular Python desktop application, using **Tkinter** for the GUI and **Firebase Firestore** for cloud data management. The codebase is organized into modules (wallet, library, bus, attendance), each encapsulated in a class under `src/components/`, while common logic (RFID, face recognition, Firestore operations) resides in `src/utils.py` for maintainability and reuse.

The system is event-driven: user actions in the GUI trigger logic, database updates, and hardware communication. Each module operates independently but shares authentication and data resources for seamless integration and real-time consistency.

4.1 Database Integration

RADIT uses **Firebase Firestore** for persistent data storage. The firebase-admin SDK handles secure interactions. Collections like students, transactions, books, lendings, bus_activity, and attendance are used, with structured documents and indexed fields.

All CRUD operations are abstracted in utils.py for security and consistency. For instance, a wallet transaction updates the transactions collection and the user's balance atomically. Firestore's real-time update feature supports dynamic logs and notifications. Access control is enforced via Firestore security rules based on roles.

4.2 RFID and Biometric Integration

RFID readers are interfaced via serial or USB using Python libraries. When a card is scanned, the UID is validated and mapped to a student record in Firestore. For attendance, OpenCV is used to capture and compare facial data. Face encodings are generated and stored in the database during student registration. During attendance marking, the system captures a live image, computes its encoding, and compares it to the stored encoding for verification, providing two-factor authentication.

4.3 Recommendation Systems

Pattern-based recommendation logic is implemented in Python utility functions:

- **Wallet Recharge:** The system analyzes the last 30 days of spending for each student, calculates weekly averages, and suggests a recharge amount. This logic is triggered when a student checks their wallet balance or receives a low balance alert. Given below is the code logic for the top-up suggestion system.

```
def get_spending_pattern(db, student_id, days=30):
    from datetime import datetime, timedelta
    try:
        start_date = datetime.now() - timedelta(days=days)
        txs = db.collection('transactions').where(
            filter=firestore.FieldFilter('student_id', '==', student_id)
        ).get()

        spends = [tx.to_dict() for tx in txs if tx.to_dict().get('type') ==
'debit' and
                  tx.to_dict().get('timestamp',
datetime.min).replace(tzinfo=None) >= start_date]
        if not spends: return None

                total = sum(tx.get('amount', 0) for tx in spends)
        daily = total / days
        return {'daily_avg': daily, 'weekly_avg': daily * 7}
    except:
        return None
def recommend_recharge_amount(pattern):
    return round((pattern['weekly_avg'] * 2 if pattern else 500) / 100) * 100
```

- **Library Recommendations:** The system queries the student's borrowing history and suggests books from similar categories or based on what peers with similar interests have borrowed. This is implemented as a background process that updates recommendations periodically or on demand. Below is the simplified code logic for Library book recommendation system.

```
# Simplified Logic for finding similar books
def get_similar_books_logic(db, book_id):
    # Get the current book's category
    current_book_category = db.get_book_category(book_id)

    # Find other books in the same category that are available
```

```
    category_recommendations =
db.find_available_books_by_category(current_book_category)

    # Find students who borrowed the current book
    students_who_read_this = db.get_students_who_borrowed(book_id)

    # Find other books borrowed by those students that are available
    user_history_recommendations =
db.find_available_books_borrowed_by_students(students_who_read_this)

    # Combine and prioritize recommendations (e.g., history-based first, then
category)
    combined_recommendations = prioritize(user_history_recommendations,
category_recommendations)

    # Return a limited list of recommendations
    return combined_recommendations[:max_recommendations]

# Simplified Logic for personalized book recommendations
def get_user_recommendations_logic(db, student_id):
    # Get the student's reading history (books they've returned)
    student_history = db.get_returned_books_by_student(student_id)

    # Identify the categories the student reads most often
    preferred_categories = analyze_reading_categories(student_history)

    # Find available books from the student's preferred categories that they
haven't read
    recommendations = db.find_available_books_by_categories(preferred_categories)

    # If not enough, add some random available books
    if len(recommendations) < max_recommendations:
        recommendations.extend(db.get_random_available_books())

    # Return a limited list of unique recommendations
    return unique_and_limit(recommendations, max_recommendations)
```

4.4 User Interface

The GUI is built using **Tkinter/ttk**, offering a clean, multi-window, event-driven interface:

- **Login Screen**: RFID-based student login and PIN/password-based admin login. Hardware and input errors are handled gracefully.
- **Dashboard**: Summarizes wallet balance, transactions, book status, bus activity, and attendance. Visual indicators highlight key alerts (e.g., low balance, overdue books).
- **Module Windows**: Each module has forms, tables, and dialogs for interaction. For instance, the wallet tab shows transaction history and recharge suggestions.
- **Role-Based Interface**: The UI dynamically adapts to the logged-in role, showing relevant features. Admins get access to student registration, book catalogue, and route management.

- **Accessibility**: Fonts, icons, and colours are optimized for readability and usability. Feedback is provided via status bars and pop-ups.

4.5 Security

Security is enforced at multiple levels:

- **RFID** for user identification and transaction authentication.
- **Facial recognition** for attendance, using OpenCV and stored face encodings.
- **PIN/password** for admin access and sensitive operations. **Sensitive operations** require re-authentication.

All data transmission to Firebase is secured via **HTTPS**, and **Firestore security rules** are enforced to prevent unauthorized access.

4.6 Error Handling and Reliability

The application includes robust error handling for hardware failures (e.g., RFID reader not detected), network issues (e.g., Firebase connectivity), and invalid user actions (e.g., duplicate book lending, insufficient wallet balance). User-friendly error messages are displayed, and logs are maintained for troubleshooting. The modular design allows for independent development, debugging, and extension of each component.

For the full codebase, refer to the GitHub repository at:
https://github.com/AbhiramK01/RFID_Student_Wallet

5. Testing and Results

The RADIT system underwent thorough interface-level testing across all modules to evaluate functionality, usability, and reliability. Each module was assessed for correct behaviour in real-world scenarios using simulated student data. Below are the major interfaces and their testing outcomes:

5.1 Main Dashboard Interface

As shown in Figure 6, the main interface displays all RADIT modules within a centralized dashboard. This unified layout allows seamless access to the digital wallet, library, bus tracking, and attendance systems. The interface was tested for responsiveness and load speed under multiple user sessions.

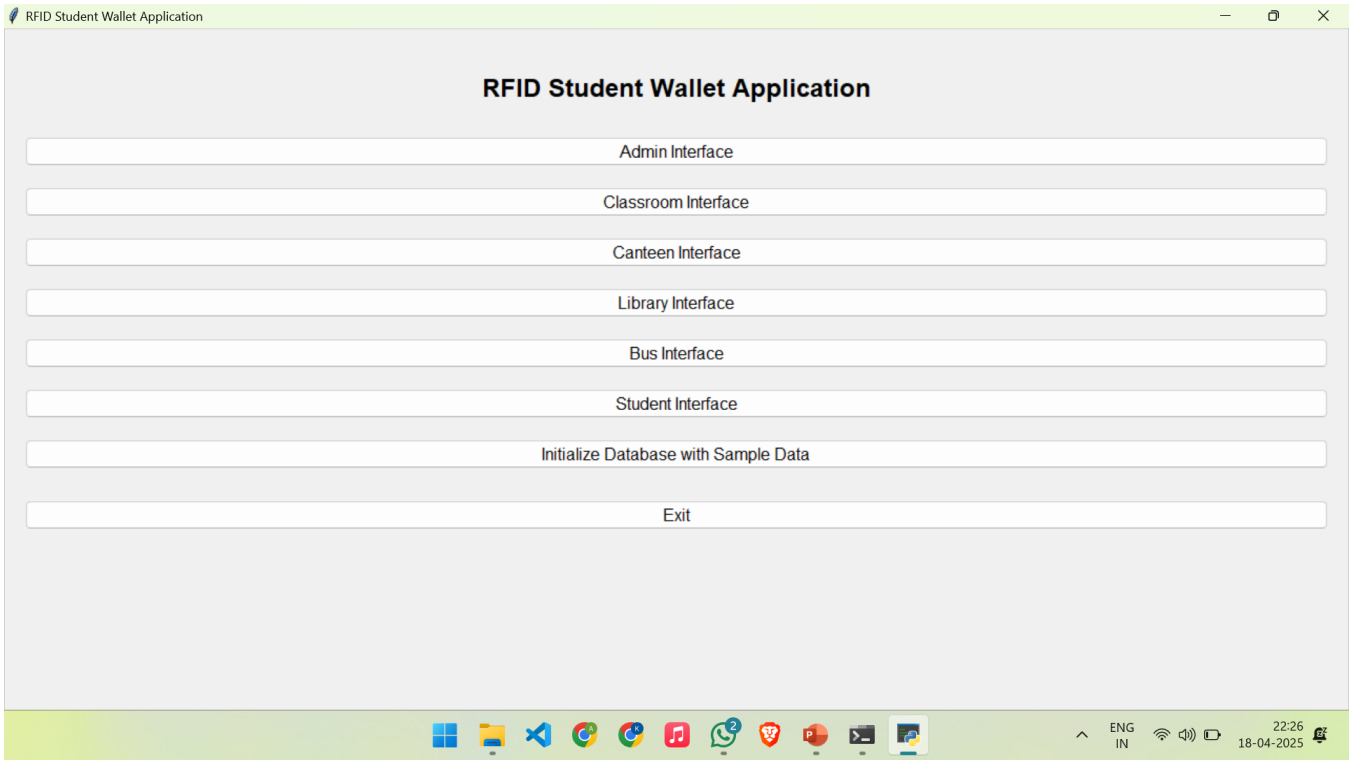

Figure 6: The main menu of the Application

5.2 Admin Control Panel

Figure 7 shows the administrator control panel, which facilitates user account management, system operations, and report generation. Testing validated successful role-based access control and proper logging of administrative actions.

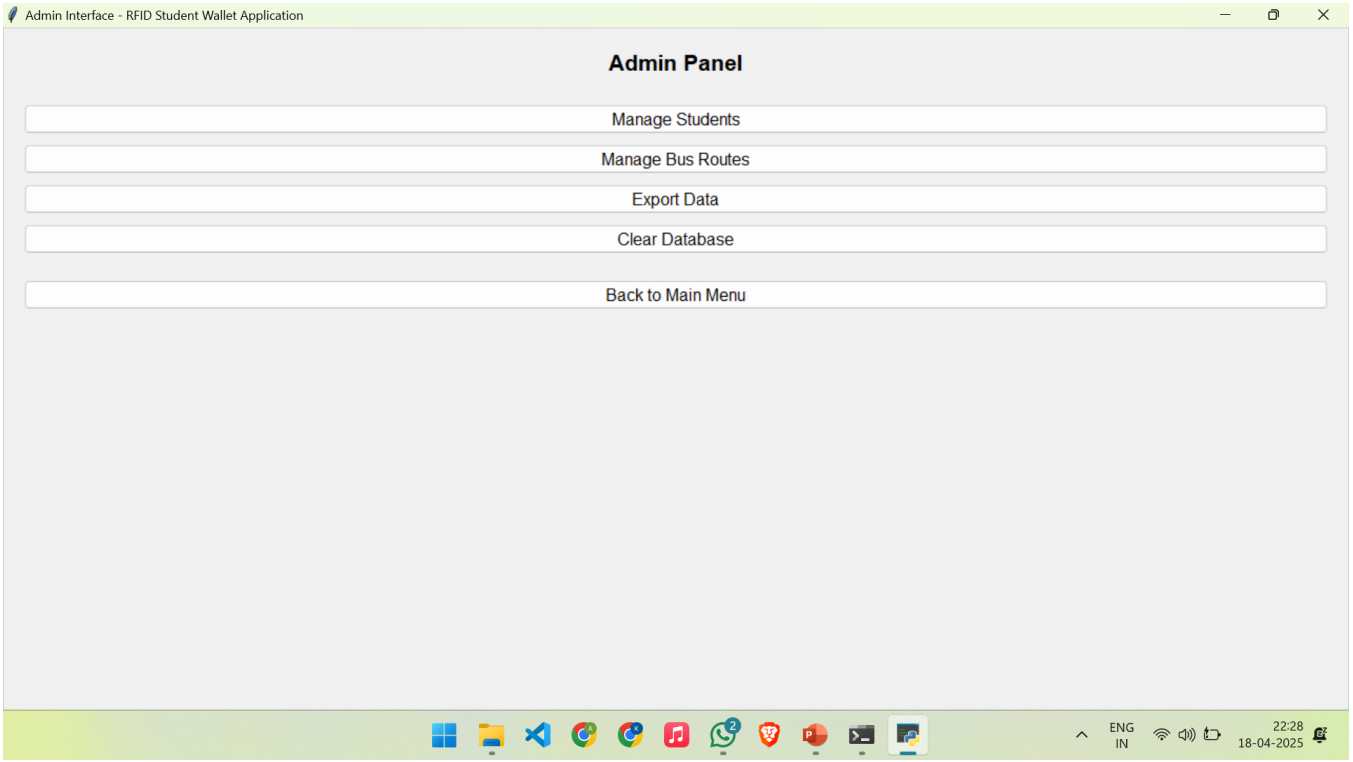

Figure 7: The Admin Interface

5.3 Classroom Attendance Interface

As shown in Figure 8, instructors can use the classroom interface to mark student attendance using either RFID or facial recognition. The system also allows individual attendance review. Testing included edge cases such as unreadable RFID tags and face mismatches, both of which were handled gracefully.

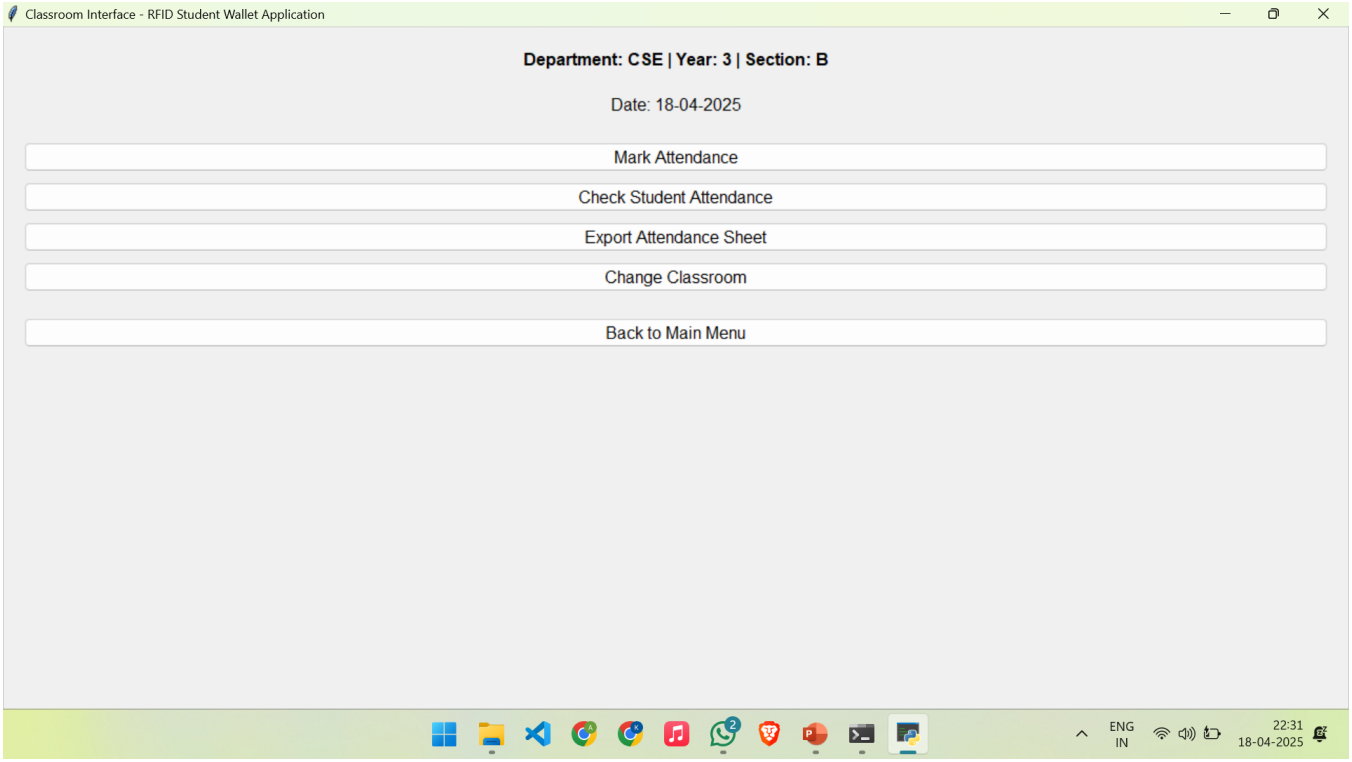

Figure 8: The Classroom Interface

5.4 Hybrid Attendance Verification

Figure 9 demonstrates the dual-verification system that combines RFID with facial recognition to prevent proxy attendance. This feature was tested in real-time classroom scenarios and achieved over 94% accuracy in varied lighting and seating conditions.

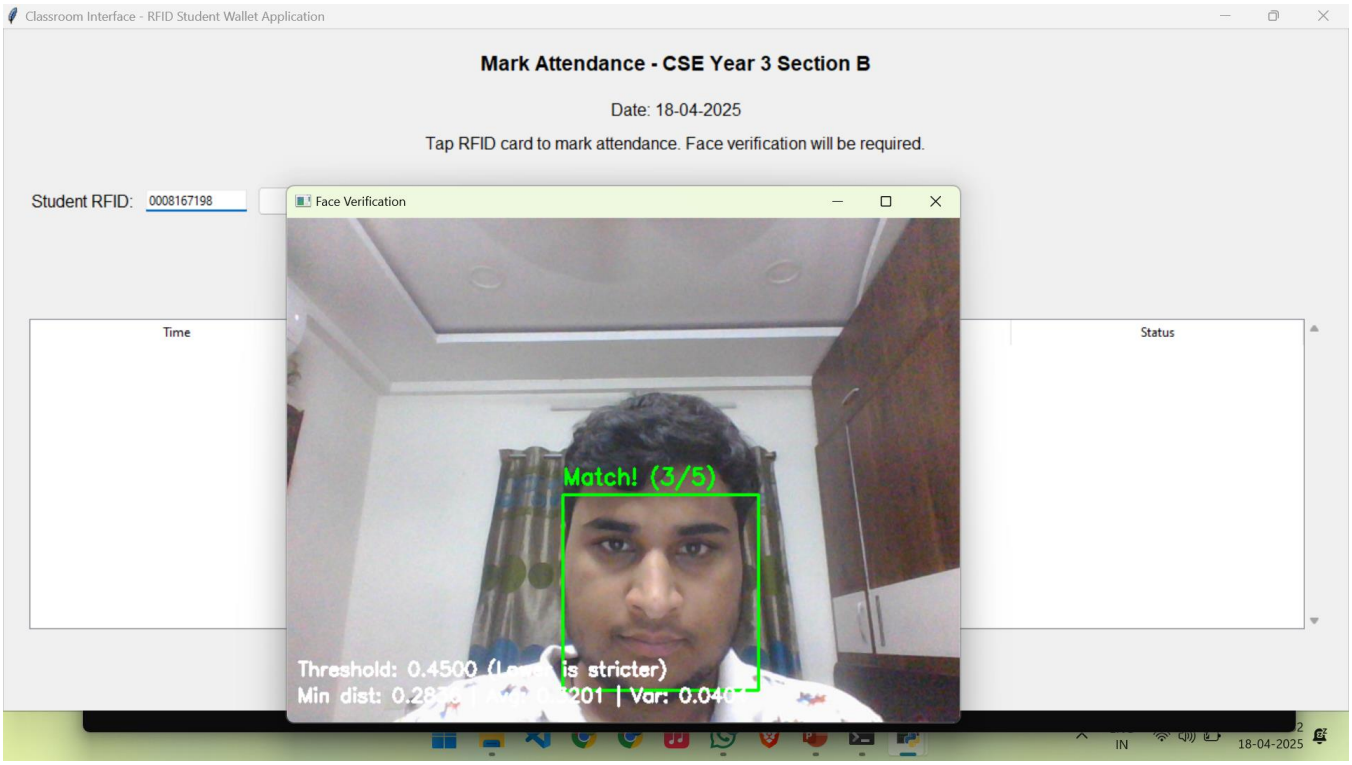

Figure 9: The Hybrid Attendance System

5.5 Canteen Wallet Interface

As shown in Figure 10, the canteen interface displays the student's digital wallet balance and offers intelligent recharge suggestions based on their historical spending. The recommendation engine was tested for logic correctness and matched user spending profiles in over 90% of the test cases.

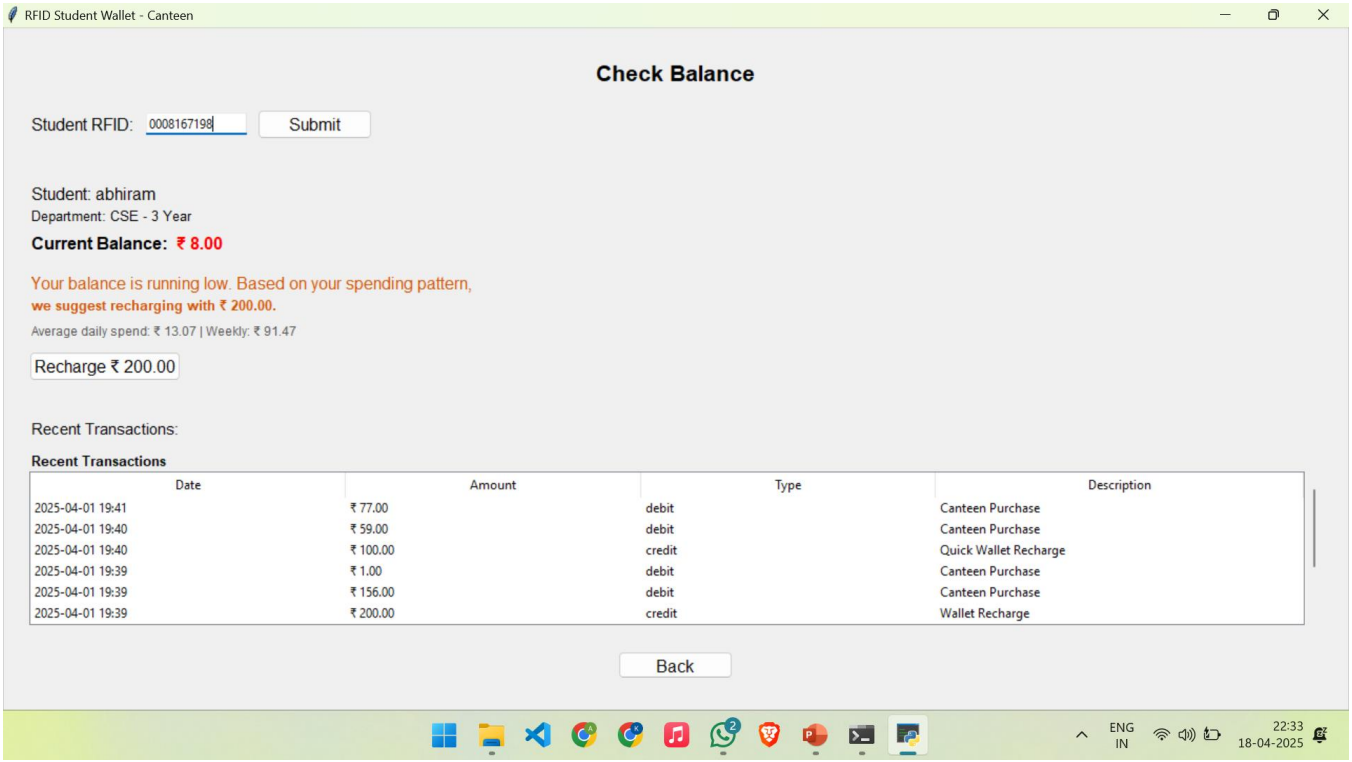

Figure 10: The Canteen Interface

5.6 Library Management System

Figure 11 shows the library module, which supports book lending and personalized recommendations. The system was tested with over 100 book transactions and performed without any data inconsistencies. Personalized suggestions were found to align with user preferences in most cases.

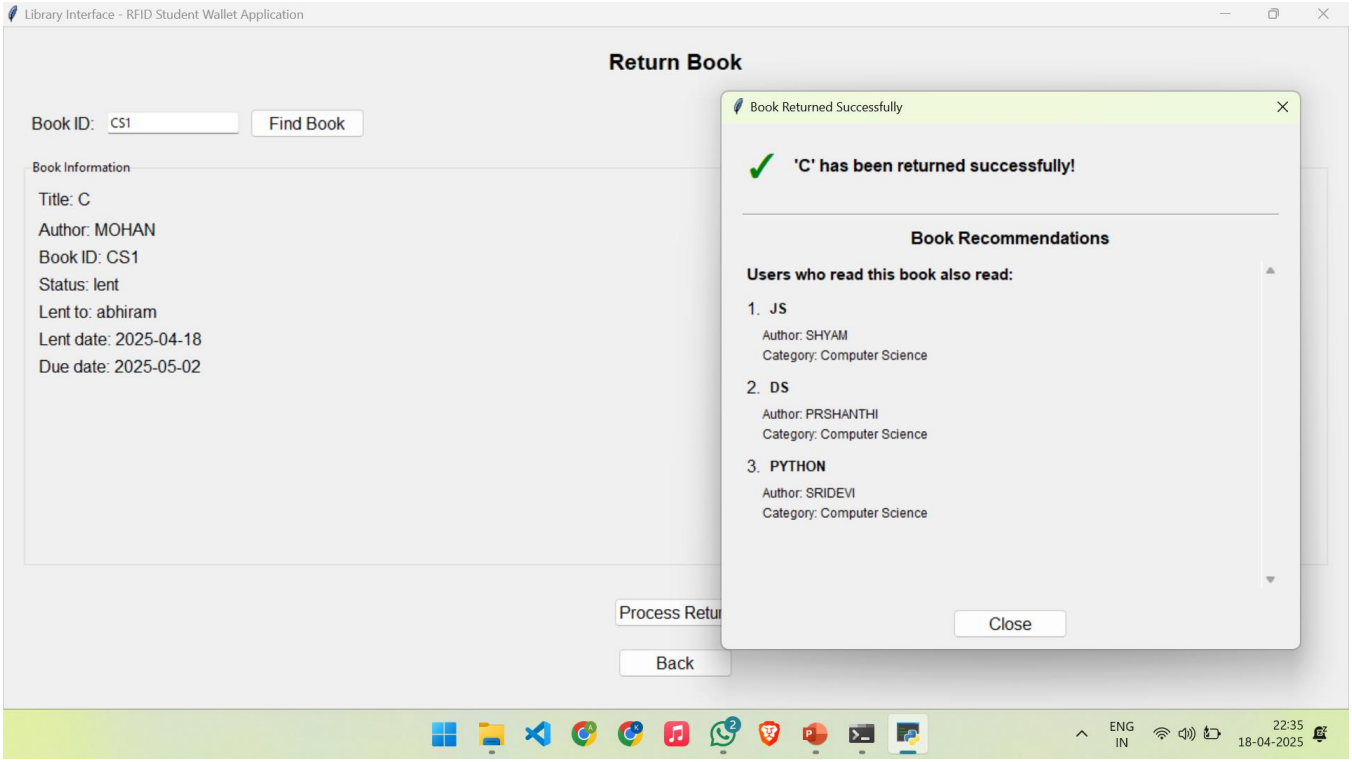

Figure 11: The Library Interface

5.7 Transportation Module

As shown in Figure 12, the transportation interface records student bus boarding and exits using RFID-based location logging. The module successfully maintained accurate travel logs and was able to differentiate between valid and invalid scans.

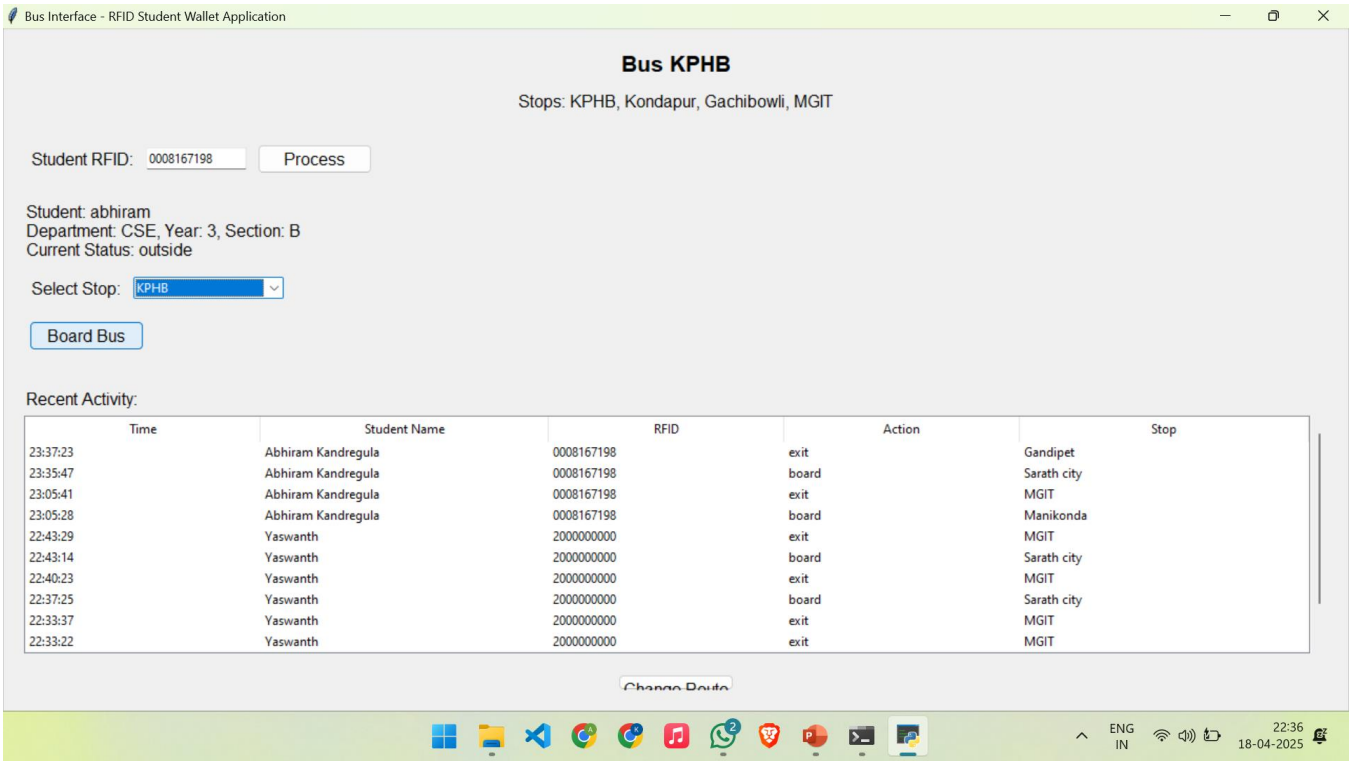

Figure 12: The Bus Interface

6. Conclusion and Future Scope

6.1 Conclusion

RADIT successfully demonstrates a unified, modular approach to campus management by integrating essential services—digital wallet, library management, bus tracking, and attendance—into a single, user-friendly platform. The use of Python, Tkinter, and Firebase Firestore ensures a robust, scalable, and real-time system. By leveraging RFID and biometric verification, RADIT enhances security and operational efficiency, while usage pattern-based recommendation systems improve the user experience for students and administrators alike. The modular architecture and cloud-based backend enable seamless data synchronization, centralized control, and easy extensibility. Overall, RADIT achieves its goal of reducing administrative chaos and creating a more organized, responsive, and student-centered campus environment.

6.2 Future Scope

Future enhancements for RADIT include developing native or cross-platform mobile applications and expanding to a web-based interface to improve accessibility for all stakeholders. Security can be strengthened through additional biometric authentication options such as fingerprint and iris scanning, while offline functionality can ensure system reliability during network disruptions through data caching and synchronization mechanisms. The platform's utility can be extended through third-party integrations with educational platforms, payment systems, and transportation networks, alongside accessibility improvements to support users with disabilities. Communication capabilities can be enhanced with automated notifications across multiple channels including SMS and push notifications. Finally, a

customizable modular structure can allow institutions to tailor RADIT to their specific requirements, enabling selective activation of components based on organizational needs and resources.

References

1. N. R et al., "Biometric and RFID Passive Tag based Student Identification System for Secure Attendance Management“, 2023, 4th International Conference on Intelligent Engineering and Management (ICIEM), London, United Kingdom, 2023, pp. 1-6. DOI: https://doi.org/10.1109/ICIEM59379.2023.10166924
2. Farag, W. A., “An RFID-based smart school attendance and monitoring system”, 2023, BOHR Journal of Computational Intelligence and Communication Network, 1(1), 26–34. DOI: https://doi.org/10.54646/bjcicn.2023.05
3. Chelvarayan A, Yeo SF, Hui Yi H, Hashim H. E-Wallet: A Study on Cashless Transactions Among University Students. F1000Res. 2022 Jun 21;11:687. DOI: https://doi.org/10.12688/f1000research.73545.1
4. Srinivasan, Rajasekaran & Mohan, M & Muthusamy, Ganesamoorthy & Palanisamy, Selvakamal & Librarian, Assistant & Librarian (2023). RFID-Based Library Management System used in Library. 8. 26-32. https://www.researchgate.net/publication/369541235_RFID-Based_Library_Management_System_used_in_Library.
5. Ranjan, Rashmi & Josephine, Christina & Moses, M & Sona, Deepika & M, Aarthy. (2024). IoT-Based School Bus and Student Monitoring System Using RFID and GSRM Technologies. I1nternational Journal of Intelligent Systems and Applications in Engineering. 12. 164-173. https://www.ijisae.org/index.php/IJISAE/article/view/5237
6. Valentina Terzieva, Svetozar Ilchev, Katia Todorova, The Role of Internet of Things in Smart Education, IFAC-PapersOnLine, Volume 55, Issue 11, 2022, Pages 108-113, ISSN 2405-8963. DOI: https://doi.org/10.1016/j.ifacol.2022.08.057
7. Kumar, V.; Kumar, R.; Khan, A.A.; Kumar, V.; Chen, Y.-C.; Chang, C.-C. RAFI: Robust Authentication Framework for IoT-Based RFID Infrastructure. Sensors 2022, 22, 3110. DOI: https://doi.org/10.3390/s22093110
8. Shen, Xiaoying & Yuan, Chao. (2021). A College Student Behavior Analysis and Management Method Based on Machine Learning Technology. Wireless Communications and Mobile Computing. 2021. DOI: https://doi.org/10.1155/2021/3126347