Report on Driver Prototype Application Testing

Introduction

This report evaluates the performance and functionality of a prototype application designed to manage RFID-based student card verification, timestamp updates, and eligibility constraints. The system was tested using randomized constraints such as recent bus ride history and fee payment status. The dataset consisted of over 400 student records uploaded to Firestore, and performance tests were conducted on five randomized student records to measure the app's response under different scenarios. Three versions of the application were tested under both Wi-Fi and mobile data conditions.

Test Setup

1. **Data Initialization**:
    - Over 400 student records were uploaded to Firestore. Each record included fields for:
        - **Fee Paid Flag**: Indicates whether the student has paid their fee.
        - **Last Ride Timestamp**: The last recorded bus ride of the student.
    - Data values were randomized to simulate real-world variability.
2. **Eligibility Constraints**:
    - **Fee Payment Status**: Cards were invalidated if fees were unpaid.
    - **Recent Ride Restriction**: Students who had ridden the bus within the last 2 hours were restrained from another ride.
    - These constraints were enforced in real-time during the testing process.
3. **Test Cases**: Performance tests focused on five student records under randomized scenarios.
4. **Network Conditions**: Tests were conducted using both Wi-Fi and mobile data to assess performance.

Results

1. **Version 1**: **Basic Card Verification**
    - **Functionality**: Verified cards for fee payment and recent ride restrictions but did not update last ride timestamps.
    - **Performance**:
        - Wi-Fi: **0.75 seconds**
        - Mobile Data: **0.64 seconds**
    - **Observation**: This version was the fastest but lacked critical functionality, such as timestamp updates.
2. **Version 2**: **Integrated Verification and Timestamp Update**
    - **Functionality**: Verified cards and updated last ride timestamps in a single operation.
    - **Performance**:
        - Wi-Fi: **0.82 seconds**
        - Mobile Data: **1.04 seconds**
    - **Observation**: Combining verification and updates decreased response times.
3. **Version 3**: **Decoupled Verification and Timestamp Update via Queue**
    - **Functionality**: Verification was performed immediately, and timestamp updates were handled asynchronously via a queue.
    - **Performance**:
        - Wi-Fi: **0.64 seconds**
        - Mobile Data: **0.72 seconds**
    - **Observation**: By separating operations, this version reduced response times while maintaining full functionality. It was also more consistent across network conditions.

Analysis

- **Randomized Constraints Handling**:
    - The system effectively handled randomized constraints, ensuring valid cards met all conditions:
        - Cards with unpaid fees were correctly invalidated.
        - Students scanned within the last 2 hours were restrained from another ride.
    - All invalid card cases were processed accurately, with appropriate error messages displayed.
- **Performance Trends**:
    - Version 1 was the fastest due to its limited functionality.
    - Version 2 introduced necessary features but reduced the response time.
    - Version 3 optimized the workflow by decoupling operations, resulting in significant improvements in response time and reliability.

Conclusion

The prototype application was tested under realistic conditions, including randomized eligibility constraints and varied network environments. The results show a clear evolution across the three versions:

- **Version 1** provided basic functionality but lacked essential features, such as timestamp updates.
- **Version 2** integrated verification and timestamp updates but faced efficiency challenges.
- **Version 3** offered the best balance between functionality and performance, making it the most reliable and efficient version.

Recommendation: Version 3 is the ideal solution for deployment. Its queue-based approach ensures quicker response times and robust handling of eligibility constraints, providing a seamless experience for end-users.