UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Comunicación y Artes Contemporáneas

Liebre: A Ridesharing System for College Campuses

Joel Benjamín del Castillo Baquero

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Liebre: A Ride-Sharing System for College Campuses

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ABSTRACT

This project proposes the development of a digital ride-sharing platform designed for university students based on the “Design for Trust” approach to prioritize increased user confidence, hospitality, risk mitigation, and sustainable community growth. The platform aims to improve student mobility, reduce transportation costs, reduce carbon footprint, and integrate with existing university (Universidad San Francisco de Quito) infrastructure. Through a cross-platform mobile application, students will be connected with available rides, carpooling will be promoted, and reliance on single-occupancy vehicles will be reduced. This research will explore integrating existing university transportation systems and current ride-sharing platforms. Additionally, the project will address critical structural challenges commonly faced by such platforms, including unreliable users due to unregulated fares, lack of user reputation ratings, absence of reward systems to incentivize participation, and the need for secure student verification through integrated authentication systems. By addressing these issues, the project will establish a safe, reliable, and structured ecosystem, specifically for the university community.

Keywords: Ridesharing, Carpool, College Campus, Mobile App

RESUMEN

Este proyecto propone el desarrollo de una plataforma digital de compartir viajes diseñada para estudiantes universitarios, basada en el enfoque de "Diseño para la Confianza" con el objetivo de priorizar el aumento de la confianza de los usuarios, la hospitalidad, la mitigación de riesgos y el crecimiento sostenible de la comunidad. La plataforma tiene como objetivo mejorar la movilidad estudiantil, reducir los costos de transporte, disminuir la huella de carbono e integrarse con la infraestructura universitaria existente (Universidad San Francisco de Quito). A través de una aplicación móvil multiplataforma, los estudiantes se conectarán con viajes disponibles, se promoverá el uso compartido de vehículos y se reducirá la dependencia de vehículos con un solo ocupante. Esta investigación explorará la integración de los sistemas de transporte universitarios existentes y las plataformas actuales de compartir viajes. Además, el proyecto abordará desafíos estructurales críticos comúnmente enfrentados por tales plataformas, como usuarios no confiables debido a tarifas no reguladas, falta de calificaciones de reputación de los usuarios, ausencia de sistemas de recompensas para incentivar la participación y la necesidad de una verificación segura de los estudiantes mediante sistemas de autenticación integrados. Al abordar estos problemas, el proyecto establecerá un ecosistema seguro, confiable y estructurado, específicamente para la comunidad universitaria.

Palabras clave: Compartir viajes, Campus universitario, Aplicación móvil.

TABLE OF CONTENTS

INTRODUCTION

Universities worldwide face mounting transportation challenges, mainly as student populations grow and campuses become more congested. At Universidad San Francisco de Quito (USFQ), the current transportation reflects these issues, with students often relying on single-occupancy vehicles or inconsistent public transportation options for distant commutes that can’t benefit from the current university infrastructure. These trends contribute to more significant traffic congestion, increased student transportation expenses, and a larger carbon footprint. A study by Ochoa-Herrera in 2019 [1] Highlighted that the USFQ community emitted 6,225.4 tons of CO_2, with land mobility being the primary contributor, accounting for 68% of the total emissions.

While existing ridesharing platforms can address some of these issues, they are not optimized for university-specific needs. Critical structural problems such as unreliable user participation, unregulated fares, lack of user reputation systems, and insufficient student verification measures hinder trust and consistent engagement on such platforms. Without mechanisms to ensure security, transparency, and reliability, students hesitate to embrace ridesharing as a dependable transportation option.

The rise of the digital sharing economy has significantly transformed these commerce and social interaction models. This shift is demonstrated through platforms like Uber and Airbnb, which facilitate direct transactions between individuals, referred to as peer-to-peer interactions. At the heart of this ecosystem is the essential concept of reputation management. This mechanism is crucial for building confidence among users who typically enter these transactions as strangers, ideally enabling similar behaviors among college students.

This project proposes a targeted solution: a university-specific, trust-focused ride-sharing platform designed exclusively for the USFQ student and faculty body. By emphasizing "Design for Trust" principles, this platform will address the shortcomings of existing solutions and prioritize user confidence, hospitality, and risk mitigation.

The development process will leverage React Native Expo, a robust front-end framework for efficient, cross-platform application development. This will ensure a coherent user experience on iOS and Android devices. The application will also integrate a serverless backend powered by Google Cloud Firebase, providing robust data management, real-time updates, and enhanced security features.

Through this initiative, we aim to redefine the ride-sharing experience at USFQ and set a new standard for safety and reliability within the campus community, contributing to a more cohesive and environmentally responsible campus community.

STATE OF THE ART

The rise of a "digital sharing economy," characterized by platforms like Uber, Airbnb, and TaskRabbit, has promoted a new marketplace of peer-to-peer transactions. Within this framework, reputation management studied in [2], becomes paramount, as trust is essential for facilitating interactions between strangers. Prior research [3] on trust in online marketplaces emphasizes the role of reputation systems, which aggregate user feedback and ratings to assess an individual's trustworthiness. However, recent scholarship [4] delves deeper into three different trust systems: institution-based trust, trusting beliefs, and trust-related behaviours. It explores the interplay between social influence, network effects, and the design of these reputation systems in shaping user trust.

Rooted in informal carpooling arrangements, ridesharing has transformed with the rise of mobile technology. Previous research [5] The early iterations of this carpooling dynamic focused on connecting riders with spare carpool seats as a shared mobility method facilitated by community organizations. Mitropoulos et al. [6] refer to this concept as an “innovative on-demand transport service that aims to promote sustainable transport, reduce car utilization, increase vehicle occupancy and public transport ridership.” Collaborative consumption like this promotes the rise of "micro-entrepreneurship," [7] They empower individuals to leverage underutilized assets and generate income. Beyond economic benefits, through collaborative consumption and using these platforms, Silk and Hunks claim that replacing all bus and car trips with these new modes would result in 62% reduced carbon emissions.

Uber's success in facilitating peer-to-peer car-sharing shows the potential of collaborative consumption. This social and economic model [8] Uses online social connections to facilitate the exchange of services in the physical world. This platform presents a unique opportunity to bridge the gap between online trust and offline interactions, promoting collaboration between strangers. However, Chowdhurry and Jamal [9] argue that this type of service is not preferable for students due to its high rates and lack of institutional security.

The emergence of such platforms in South America, like Ryde and DragonPool, revolutionized college ridesharing by leveraging smartphones for real-time ride-matching and electronic payments at a low cost for students. While offering benefits like convenience, reduced traffic congestion, and lower costs, these platforms still present significant challenges. Concerns persist regarding passenger safety, data privacy, and the potential disruption of driver and rider commitment to the service. As ridesharing platforms evolve, ongoing research [6] focuses on optimizing matching algorithms, mitigating safety risks, and developing sustainable business [10] Models that balance innovation with responsible integration into existing transportation. In contrast, Send and Ang [11] propose a crowdsourcing method for carpooling arrangements, where participants are selected on short notice, with rider journeys often formed dynamically.

Crowdsourcing methodologies [12] Prove well-suited to facilitate driver-rider matching within these dynamic scenarios, although various challenges remain to be addressed.

For all methods, reputation management mentioned in [13] plays a crucial role within these platforms as a robust reputation system, where positive past interactions increase the likelihood of better rates or service providers, incentivize user participation, and promote a culture of hospitality. However, designing effective reputation mechanisms resistant to manipulation or bias [14] requires careful consideration.

Design for Trust, a new user-design-centric field of research, [15] investigates methods to cultivate user confidence in peer-to-peer interactions through user interfaces crafted to empower informed decision-making, allowing users to readily assess the trustworthiness of potential partners through detailed profiles, verified information, and clear communication channels in a secure and transparent environment. This approach [14] encompasses a holistic design philosophy prioritizing transparency, user control, and robust security protocols.

METHODOLOGY

This user research project will employ a multi-method approach to understand student needs and concerns regarding trust.

1. User Research

To begin with, a comprehensive literature review will be conducted to analyze and synthesize existing research on trust issues related to ride-sharing. This will be complemented by focus group discussions involving a diverse range of students to gather qualitative insights on their perceptions and experiences with trust in ride-sharing services.

Following this, we will develop detailed user personas representing various student demographics, including different backgrounds, preferences, and usage patterns, to ensure a well-rounded understanding of the target audience.

Next, we will conduct direct observations at key transportation hubs, such as bus stations and university drop-off points, to gather real-time data on student behaviour and interactions with informal and formal ride-sharing options. In-depth interviews will also be conducted to delve deeper into individual experiences, focusing on what factors foster or hinder trust in these services.

To evaluate current ride-sharing platforms, we will perform a benchmarking analysis highlighting their existing trust-building features and analyzing how they establish reliability, safety, and rapport with users. Subsequently, we will map user journeys to identify critical touchpoints where trust is established or eroded throughout the ride-sharing experience. This will involve visualizing user interactions from the initial booking phase through to the completion of the ride, focusing on moments that significantly impact user confidence and satisfaction.

Lastly, the user personas will be refined based on the insights gathered from previous research activities, ensuring they accurately reflect students' nuanced needs and concerns. We will host a facilitated brainstorming workshop to generate solutions.

2. **Iterative Product Design**

The development process transitions into an iterative design phase, informed by comprehensive user research findings. This phase is pivotal for aligning the product with user needs and expectations. During this stage, we will create low-fidelity prototypes, such as wireframes and mockups, visually representing the proposed user interface.

We will conduct user testing sessions to ensure these prototypes effectively address user requirements. In these experiments, we aim to gather qualitative and quantitative feedback from participants, allowing us to refine aspects of both the user interface (UI) and the overall user experience (UX).

This continuous user feedback loop is essential for identifying usability issues and areas for improvement throughout the development cycle. Usability testing is particularly critical, ensuring the platform is intuitive, user-friendly, and efficient in meeting user goals. Observing real users as they interact with the prototypes can pinpoint specific pain points and gather insights into their behaviours and preferences.

In addition to usability testing, we will implement A/B testing for crucial features. This method involves comparing two design variants to determine which performs better based on user interactions and engagement metrics. Such data-driven optimizations enable us to make informed decisions that enhance critical features, reinforcing our commitment to a Trust-Centric approach

3. **Cross-Platform Development**

With a user-tested design established, the development process is poised to transition into cross-platform development. The project leverages frameworks facilitating deployment across multiple operating systems, particularly iOS and Android. For this reason, we will utilize React Native, a robust framework that empowers developers to create a unified application logic and user interface that can serve both platforms simultaneously. React Native’s component-based architecture promotes reusability, significantly allowing us to streamline the development process. To further enrich the application, we plan to integrate the Expo framework, pre-built functionalities and tools designed to expedite the development process. By leveraging Expo, we gain access to a wide range of components and libraries that eliminate the need for redundant coding, ultimately speeding up the deployment timeline.

A critical aspect of our approach is rigorous testing. We will employ a combination of emulators and accurate device testing to ensure that the application performs seamlessly across both platforms. This includes verifying user interactions, responsiveness, and performance metrics to identify and rectify potential issues before publishing the application. Through this comprehensive strategy, we optimize development time and costs while delivering a high-quality mobile application that offers a consistent and enjoyable user experience across both iOS and Android platforms.

4. Serverless Architecture and Cloud Computing

The system will utilize Google Cloud Platform (GCP) for its scalable backend infrastructure, ensuring high availability and security. At the core of the data management, Firebase Firestore will be employed as a NoSQL database to efficiently manage user data, ride requests, and trip details, benefiting from real-time data synchronization and retrieval capabilities.

For user-generated content, such as images and videos, Google Cloud Storage will provide a secure and reliable storage solution, facilitating quick access and easy management of multimedia files.

Firebase Cloud Functions will automate backend processes, including notifications and trigger functions. This serverless architecture allows seamless code execution in response to events, enhancing the system’s responsiveness and efficiency.

User authentication will be designed to integrate smoothly with existing college single sign-on (SSO) systems. This integration will streamline the user experience, enabling quick and secure access to the platform using familiar credentials.

Lastly, Firebase Security Rules will be implemented to safeguard user privacy and maintain data integrity. These rules will define granular data access permissions, ensuring that users can only access information relevant to them while protecting sensitive data from unauthorized access.

USER RESEARCH

This section relies on user research to develop comprehensive features that help to understand user needs, preferences, and behaviours. This approach is crucial for bridging the gap between the end-user perspective and the application development process.

We designed two experiments to gather information to understand the public's needs in this problem space. The first experiment aimed to evaluate USFQ students' tendency in social media towards the current ridesharing apps in the university. The second experiment focused on collecting qualitative data to identify students' specific needs related to their commuting behavior.

Each experiment is described in detail below.

Experimental 1: Social Media Platform Opinions

Social media platforms provide valuable insights into user experiences, mainly when anonymity allows individuals to share honest feedback without fear of repercussions. This experiment focuses on observing and analyzing student sentiments expressed through anonymous public confession accounts on platforms like Instagram, specifically through the account @usfqrushes, widely used across the Universidad San Francisco de Quito (USFQ) student population, specifically regarding existing ride-sharing services popular among students.

This study seeks to extract and analyze qualitative data from these public posts to identify the critical pain points and expectations of USFQ students for ride-sharing services. By examining complaints, frustrations, and recommendations shared in these forums, we aim to gather authentic insights that may not emerge through traditional surveys or interviews.

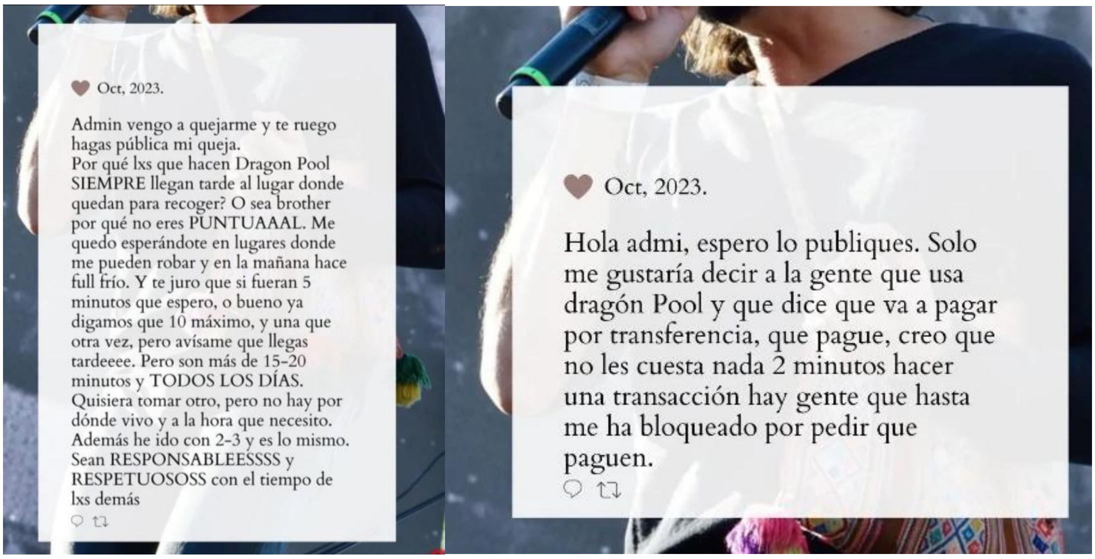

Fig 1. Social Media posts regarding existing ridesharing services at USFQ.

Observation:

In October 2023, prominent user dissatisfaction with the punctuality, payment transactions, and reliability of drivers of the existing ridesharing platforms at USFQ was reported. Students frequently report being left waiting in unsafe or uncomfortable conditions, particularly during early morning hours when temperatures are low and the risk of theft is perceived to be higher. This unreliability is further exacerbated by consistent delays, often ranging from 15 to 20 minutes, which impact students' schedules and create frustration.

Moreover, more alternative ride-sharing options must be available that service specific locations and times, limiting students' flexibility in finding a dependable solution. Attempts to use different drivers do not appear to resolve the issue, as similar behaviors are observed across multiple drivers. The feedback calls for increased responsibility and respect for passengers' time, reflecting an intense desire among students for improved service standards and a more accountable system.

Moreover, users need help completing payment transactions after committing to pay by transfer. The post highlights that some passengers either delay payments or avoid them altogether, to the extent that they block the drivers when reminded about outstanding balances. This behavior creates a trust deficit and financial insecurity for drivers, who rely on timely payments to sustain their service.

These observations underline a need for more accountability and structured payment protocols within the existing ride-sharing platform, pointing to a more reliable and transparent payment system. Such improvements would enhance trust and fairness.

Experimental Design 2: Smaller Focus Groups on Campus

This experiment employs focus groups and qualitative research methods to identify students' specific needs related to commuting behaviours.

Selection of Smaller Student Groups:

- Randomly select diverse smaller student groups based on factors such as academic majors and extracurricular interests.
- Ensure representation from various demographic backgrounds to capture various perspectives.

Qualitative Research Phase:

- Conduct focus group discussions within each selected student group to explore their experiences, challenges, and expectations regarding social inclusion and event awareness.
- Use open-ended questions to encourage participants to express their thoughts freely.

Research Questions:

General Questions / Current Transportation Methods

- What do you study?
- How do you currently travel to and from the university?
- How long does your typical commute take?
- What difficulties do you face with your current mode of transportation?

Interest in Ridesharing

- Have you ever used ride-sharing services like Uber or Lyft? If so, what was your experience?

- What do you like or dislike about these services?
- What features would make a university-specific ride-sharing platform appealing to you?
- How vital are cost savings in using a ride-sharing service?

FOR DRIVERS / Driving Patterns / Carpooling Experience

- How often do you drive to the university?
- Do you usually drive alone or with passengers?
- Have you ever carpooled with other students? If so, how was your experience?
- What challenges have you encountered while carpooling?

Interest in Being a Ride-Sharing Driver

- How important is earning extra income in your decision to drive for this platform?
- Have you ever driven for ride-sharing services like Uber or Lyft? If so, what was your experience like?

Trust and Safety Concerns

- What safety features are most important to you in a ride-sharing service?
- Would a verification system ensuring only university students can use the platform make you feel safer?
- How important are user ratings and reviews for you?
- What other measures would help you feel confident using the service?

Preferences and Features

- What features do you consider essential in a ride-sharing app (e.g., fare transparency, user ratings, real-time tracking)?
- What incentives or rewards would encourage you to use the platform regularly?

Results

To qualitatively assess the social inclusion and event awareness of the Universidad San Francisco students, 20 undergraduate students participated in this experiment. Participants were predominantly in their first and second year of studies and ranged from various ethnicities, including seven exchange students. These focus groupsled to the following results.

- **Trust and Payment Reliability:** The recurring issue of unreliable payments among users emphasizes the need for a secure and automated payment system. An integrated payment feature could enforce transactions, ensure drivers receive compensation, and reduce friction between drivers and passengers.

- **Safety and Student-Only Verification:** Security is perceived positively due to measures like taking a photo of a student ID card and using the university's learning platform (D2L) for verification. However, the community implements these measures manually and lacks formal platform support. Safety is a core concern for both drivers and passengers. The preference for a student-exclusive platform with university-based verification highlights the need for a robust authentication system. This could involve automatic verification using university credentials, such as student IDs, to restrict access only to the USFQ community.
- **Incentives for Drivers and Passengers:** Drivers are motivated by the potential for additional income, but the lack of formal incentives and the cost of operating (fuel, parking) are barriers. Implementing structured incentives, such as parking discounts for frequent drivers or points-based rewards, would likely increase participation and satisfaction. From the driver's perspective, convenience is critical; drivers prioritize pick-up and drop-off locations that align with their routes. Passengers benefit from low costs, which was noted as a positive aspect, but issues with payment reliability were raised. There is no mechanism enforcing payment, which often leaves drivers unpaid.
- **Improved Coordination Tools:** The reliance on group chats for ride coordination is inefficient and often overwhelming for users. An in-app scheduling and route-sharing feature would streamline the coordination process, allowing drivers to post routes and times in advance and enabling passengers to join rides with minimal back-and-forth communication. A system for publicly posting complete routes and letting passengers choose specific pick-up points was highlighted as a desirable feature, suggesting limitations in flexible route coordination.
- **Fare Transparency and Flexible Pricing:** A standardized fare structure is essential to passengers and drivers, as it establishes clear expectations and minimizes disagreements over pricing. Additionally, pricing options for varying distances and group sizes provide flexibility and fairness.
- **Social Aspect and Community Building:** Students value the social aspect of ride-sharing, as it allows them to connect with friends during commutes. This suggests that the platform could benefit from community-building features, such as the option to create friend groups, which could enhance user engagement and build a stronger sense of trust and community.

The front-end design of the social network app should be aligned with the previous product vision, supporting the app's goals and values while providing a seamless and enjoyable user experience. By prioritizing usability, accessibility, and aesthetics, the design can help create a platform ensuring that users can easily navigate the app and find the needed features.

The Trip System comprises three interrelated components: Routes, Schedules, and Requests. Each component is designed to provide clarity, convenience, and flexibility for drivers and riders, improving the overall commuting experience on campus.

1. **Routes**: Routes are pre-defined paths created by drivers that outline the general trajectory of a trip from a starting point to a destination. The system enables drivers to establish specific routes based on popular commuting corridors, connecting major residential areas with the university campus and other significant locations. The Route feature also provides:
    - Visual Mapping: A map-based interface shows the route with potential pick-up and drop-off points. This visual aid allows passengers to understand and evaluate route suitability at a glance.
    - Route Personalization: Drivers can customize the route to accommodate frequent pick-up points or adjust based on real-time traffic conditions, enhancing flexibility.
    - Distance-Based Price Tiers: The system calculates suggested fares by dividing travel distances into set price brackets (e.g., 1–5 km, 6–10 km, etc.). Each tier corresponds to a specific price range, which increases proportionally to distance. Serves as a recommendation rather than an enforced rate, allowing drivers to set their prices within the suggested range based on factors like car occupancy, fuel costs, and convenience while being transparent and consistent pricing for passengers:

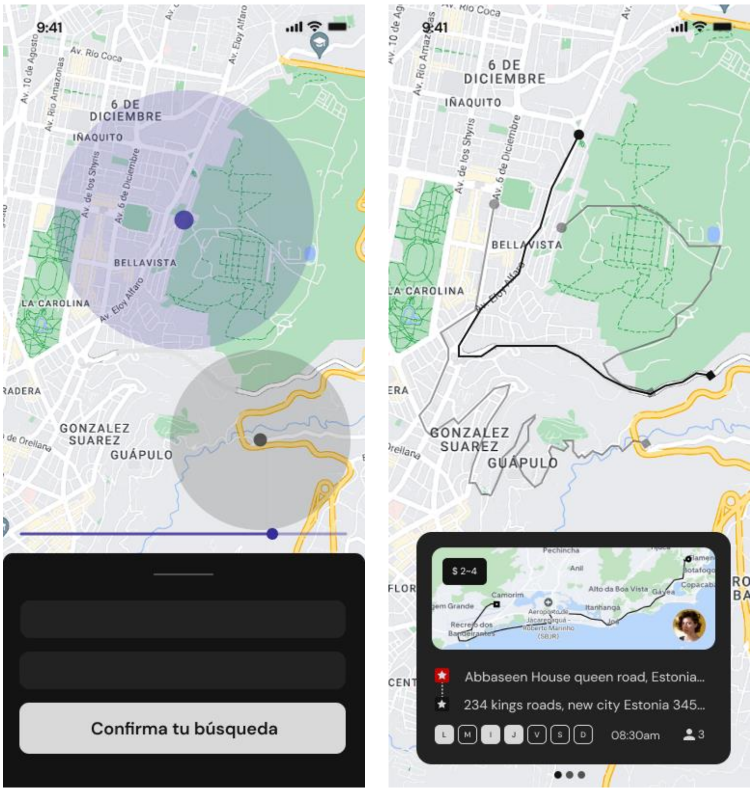

Fig. 2. Weekly Routes with visual routing, distance-based price, and personalization.

2. **Schedules**: Schedules represent fixed times associated with each Route, giving structure to the commuting experience and ensuring that trips occur at predictable intervals. Each Route can have multiple Schedules to accommodate various commuting needs throughout the day. The Schedule feature provides:

    - Time-Defined Trips: Users can view specific departure times, allowing them to plan their trips around their class or work schedules with certainty.
    - Recurring Availability: Drivers can set recurring schedules (e.g., daily at 8:30 AM), creating a reliable timetable that passengers can depend on, particularly for routine commutes.
    - Demand Responsiveness: The platform can adjust schedules based on demand data, adding or adjusting departure times for high-demand routes during peak periods, such as mornings and late afternoons.

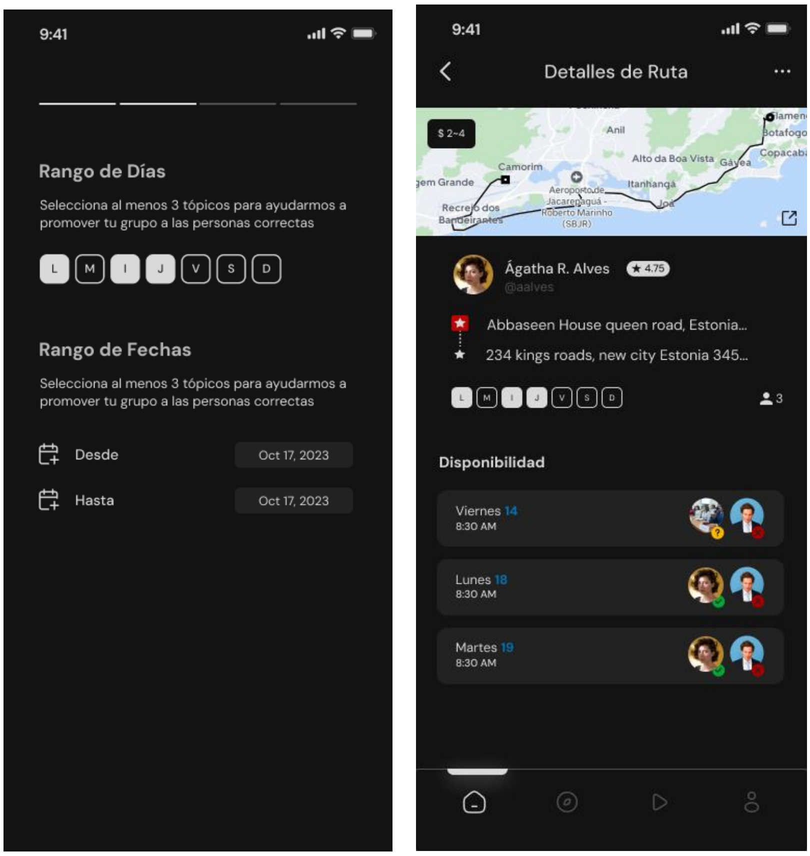

Fig. 3. Time-defined routes are divided into specific trips with recurring availability and current demand.

3. **Requests**: The Request system allows passengers to join a specific Schedule within a Route, giving drivers visibility into the expected number of passengers and aiding in trip planning. Requests are an efficient reservation mechanism, reducing wait times and optimizing vehicle occupancy. Key aspects of the Request feature include:
   - Reservation Confirmation: Once a passenger submits a request, they receive a confirmation, ensuring their place on the scheduled ride and reducing uncertainty.
   - Seat Management: Drivers can limit the number of requests per Schedule, ensuring vehicle capacity is not exceeded. This also allows passengers to view seat availability and make informed decisions.
   - Notification System: Passengers receive notifications regarding changes to their requested Schedule, such as delays or route adjustments, and get directed to the driver's messages.

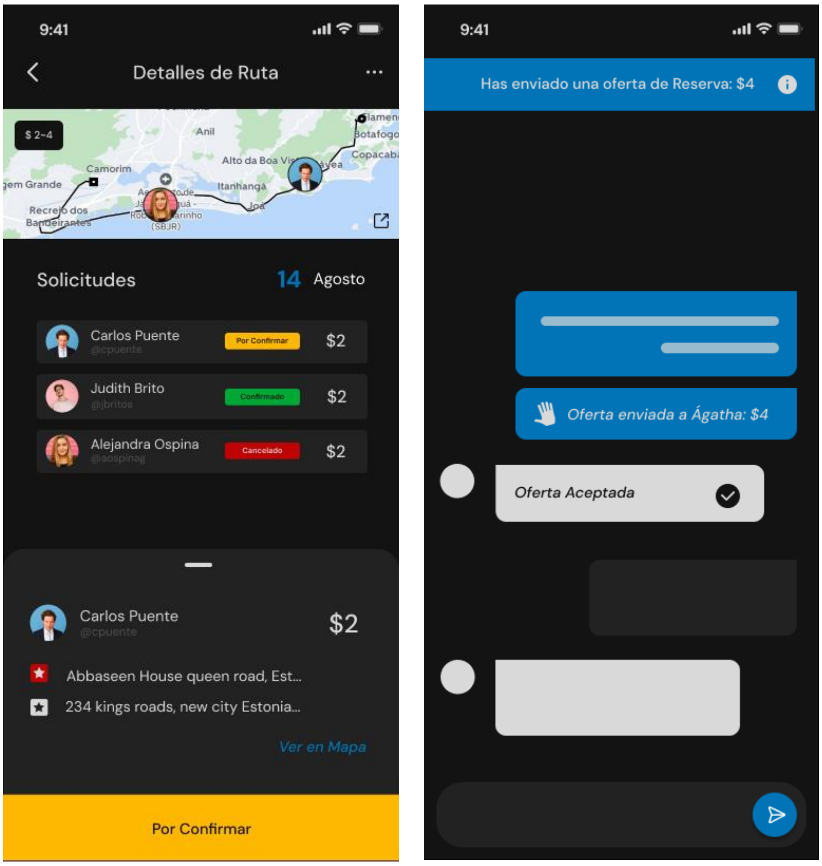

Fig. 4. Trip Request based on availability for a specific date and chat with the driver after reservation.

BACKEND ARCHITECTURE

The architecture leverages Microsoft and Google Cloud technologies to enable seamless authentication, caching, data synchronization, and real-time interaction. The architecture components are specifically chosen to ensure optimal performance, data security, and integration with USFQ's existing digital ecosystem.

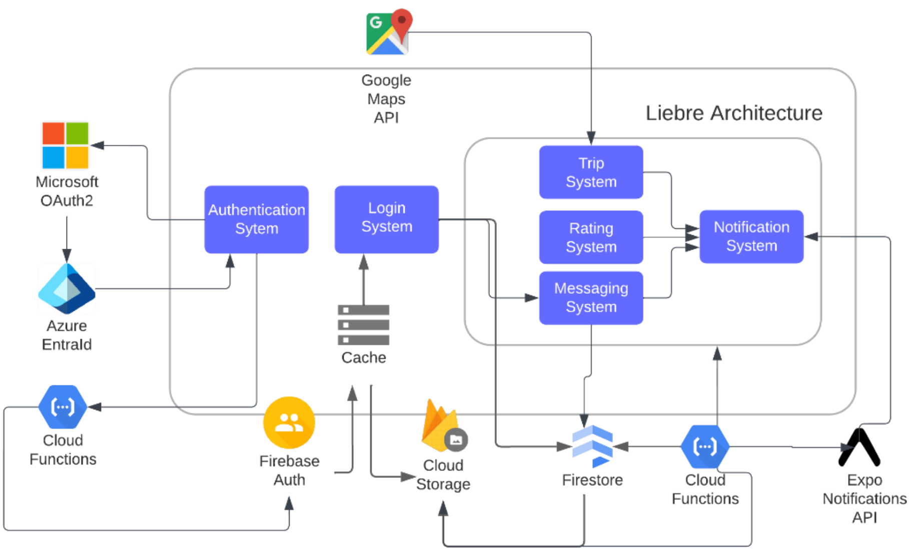

Fig. 5. Liebre's Feature Ecosystem

Authentication and Session Management

To ensure the platform is accessible only to verified USFQ students, Microsoft OAuth is utilized for authentication. Integrating Microsoft OAuth through Azure Entra ID (formerly Azure Active Directory) enforces a custom sign-in process that verifies users against the university's directory. This way, only users with valid USFQ student accounts can access the platform, ensuring a safe, closed network for students.

After the initial sign-in, a login system handles session management. This system caches the authentication certificates, allowing the platform to manage future sessions efficiently. By storing authentication tokens in the session cache, the platform minimizes the need for repeated logins, improving user experience while maintaining secure access.

Data Storage and Caching with Google Cloud Firestore

Google Cloud Firestore is the primary database for its scalability and real-time data synchronization capabilities. Firestore stores the platform's core data, including trips, users, notifications, chats, schedules, and requests, using a structured and nested dictionary format that suits the platform's needs for hierarchical data management.

To optimize performance and reduce latency, data from Firestore is cached locally in the session cache and asynchronously in a broader system cache. This dual caching strategy allows the backend to simulate Firestore's real-time behavior within the cache, ensuring swift data retrieval and updates. By mirroring Firestore's nested structure within the system cache, the platform minimizes round-trip latency to the database, enhancing the user experience with near-instant access to frequently used data.

Geolocation and Route Management

The platform integrates the Google Maps Geocoding API and Google Maps Directions API to manage geolocation and route mapping. When users enter addresses or coordinates, the Geocoding API decodes these inputs into precise locations, which are then used to calculate optimal routes. The Directions API processes this location data, providing route details that enhance the platform's ability to display accurate trip paths, estimate travel times, and support navigation.

Real-Time Chat and Notification System

The backend incorporates a chat system embedded within a notification system to support in-platform communication. This lets users receive real-time updates about trips and messages, fostering active engagement and efficient communication between drivers and passengers. The chat system is nested, with conversations containing individual messages to simulate real-time behavior. Notifications trigger updates within the chat, ensuring that users remain informed about the latest developments related to their trips and can coordinate with each other easily.

Trip Completion and Rating System

A Rating System is implemented to ensure quality control and user accountability. After a trip is completed, a cloud function is triggered, prompting the driver and passengers to rate each other. This rating system is essential for building trust on the platform and providing feedback on user behavior, reliability, and punctuality. By handling ratings through cloud functions, the system ensures that the feedback process is consistent, automated, and seamlessly integrated with the ride-sharing experience.

DATABASE DESIGN

In designing the database architecture for the application, Firestore was chosen as a non-relational database due to its scalability, performance, and ability to handle complex data structures. This approach allows for the creation of nested collections, which, while adding some complexity in managing duplicated documents, minimizes data retrieval costs over time. Firebase's NoSQL nature supports flexible schema evolution, enabling easy integration of new features like notification types and trip-related fields. Its real-time capabilities provide instant updates essential for a ride-sharing application, facilitating seamless communication through chats and immediate feedback on ride requests.

Firebase's built-in authentication and Security Rules ensure secure user access and data protection. This Firebase schema is designed for a ride-sharing application with several core entities, each capturing different functionalities and relationships. The schema uses a hierarchical structure to organize data for users, chat interactions, trips, notifications, and schedules. Here's a high-level summary:

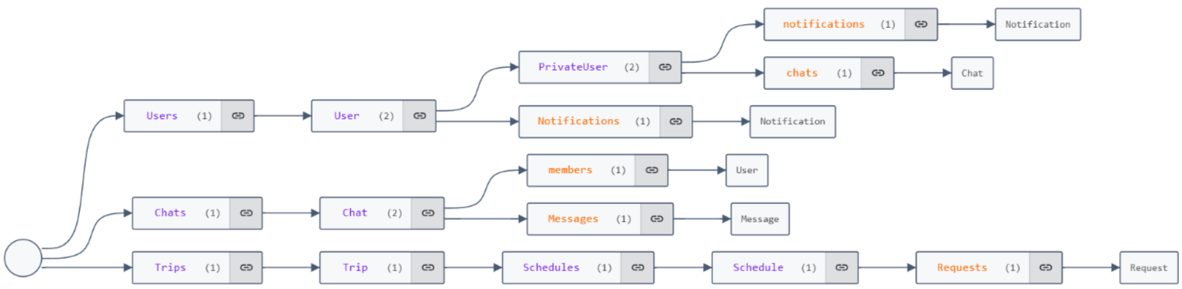

Fig. 6. Simplified Base Schema, showing the relationship between all data.

1. **Users**:

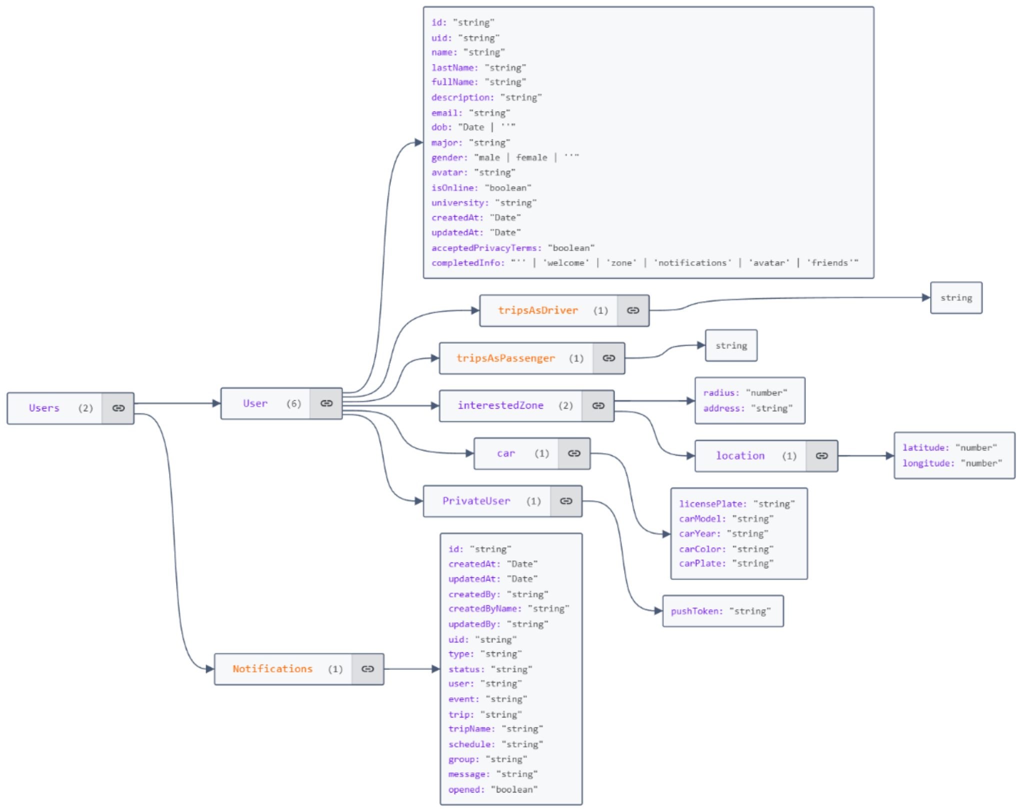

Fig 7. Detailed user database structure with private information and notification collection.

- Users' primary information is stored in a public profile, while sensitive or private data is stored within PrivateUser.
- Notifications are also nested within the User object, keeping all user-related information closely tied to each profile.
- Each user can participate in multiple Chats and receive various notifications related to trips, friend requests, and messages.

2. **Chats**:

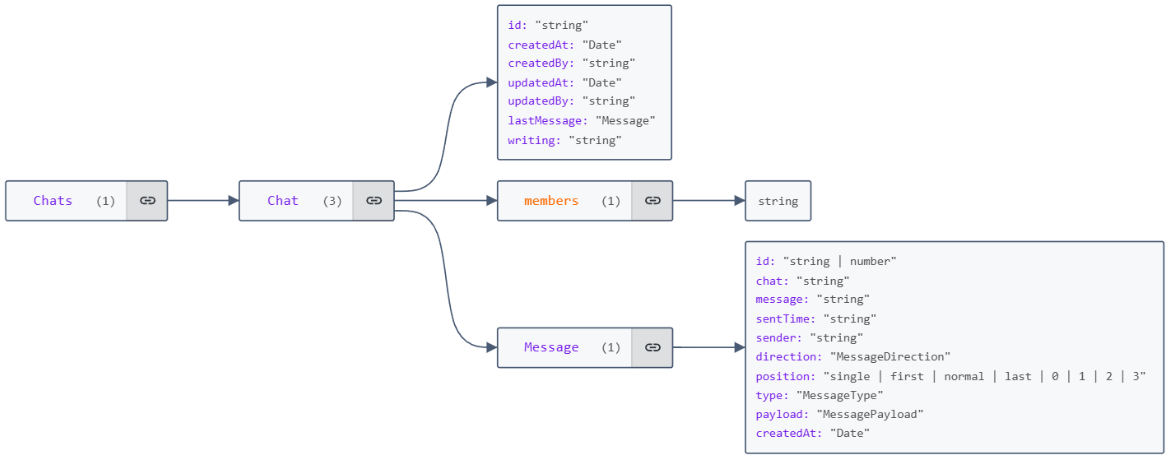

Fig 8. Detailed Chat schema structure with messages sub-collection.

- The Chat structure facilitates direct messaging between users.
- Each Chat includes members (references to users) and stores a list of Messages, allowing for real-time communication between users within the app.

3. **Trips**:

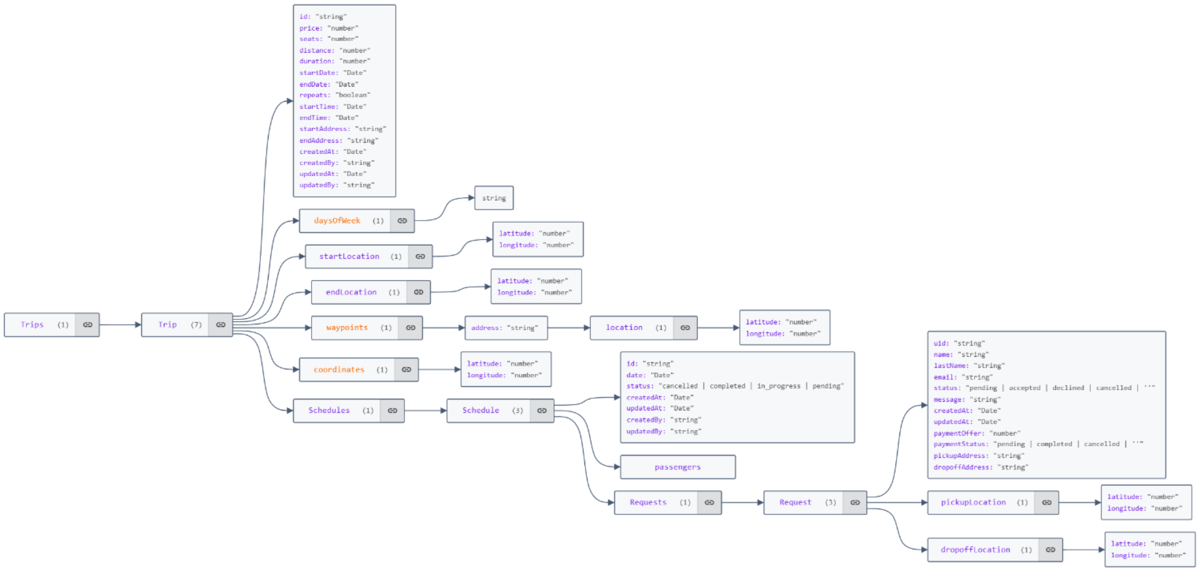

Fig 9. Detailed Trip schema structure with Schedule sub-collection and Requests nested sub-collection.

- Trips are structured as high-level entities that users can join or request access to.
- Each Trip includes nested Schedules, which manage recurring or single-event rides.
- Within each Schedule, there are multiple Requests (ride requests), which capture details about who requested a ride, the status of the request, and relevant payment information.

COSTS

This section summarizes estimated monthly costs associated with deploying and maintaining Liebre alongside key user activity and usage intensity assumptions.

Key Assumptions

- User Base: 1000 monthly active users.
- Usage Intensity: Moderate (e.g., frequent reads/writes but within free-tier limits).
- Development Framework: Expo’s free tier is used for app development and deployment.

Cost Breakdown

1. Firebase: The cost will likely be within the free tier for authentication, storage, and functions. Under moderate use, it could range between $0 and $10/month.

- Authentication:
  - Free tier supports up to 10,000 verifications/month (email, password, phone).
- Cloud Firestore:
  - 50,000 reads, 20,000 writes, and 20,000 monthly deletes are free.
  - Storage costs $0.026/GB per month.
  - Additional usage (reads/writes/deletes) incurs nominal costs.
- Cloud Storage:
  - 1GB free/month. Beyond that, storage costs $0.026/GB, and downloads cost $0.12/GB.
- Cloud Functions:
  - The free tier covers 2 million invocations/month, sufficient for current use.

2. Google Maps API: This is a pay-as-you-go model with a $200 monthly free tier. Under moderate usage, it will likely cost $0–$20/month.

- Maps SDK: $7 per 1,000 requests beyond the free tier.
- Directions API: $5 per 1,000 requests beyond the free tier.
- Geolocation API: $5 per 1,000 requests beyond the free tier.

3. Expo: Provides tools for cross-platform app development and will likely be inside the free tier.

- Managed Workflow (Free Tier): Sufficient for basic builds and deployment.
- EAS Build: Optional faster builds or premium features cost $29/month, though not required at this stage.

4. App Store/Google Play Deployment: Total of $8.25/month

- Apple App Store: $99/year for an Apple Developer account.
- Google Play Store: One-time fee of $25 for a developer account.

Total Estimated Monthly Costs: $20–$50/month.

BUSINESS MODEL

Liebre will adopt a business-to-business (B2B) model, offering the platform at no cost to students. The platform will be funded through institutional licensing, where universities purchase annual or multi-year subscriptions. These licenses cover operational costs, system maintenance, and advanced features such as authentication integration and institutional branding.

CONCLUSIONS

In conclusion, this project presents a comprehensive ride-sharing platform design for the transportation needs of university students, specifically at Universidad San Francisco de Quito (USFQ). Through a creative thinking approach, we developed a solution that prioritizes user-centric design, security, and real-time functionality to address commuting problems to and from campus.

The project's initial phase involved extensive user research to understand the commuting patterns, preferences, and pain points of USFQ students. This included observations of social media platforms, focus groups, and interviews, highlighting issues such as inconsistent payment practices, lack of reliable pick-up times, and safety concerns. By gathering these insights, we could define precise user needs and expectations, forming the foundation for the platform’s feature set and user experience.

An iterative design process ensured that each platform component effectively addressed user needs. Early prototypes allowed us to test key elements such as trip scheduling, route management, and communication features, refining them based on feedback. This iterative approach ensured that the final product would be intuitive and efficient, balancing usability and functionality.

The backend architecture was designed to support secure, scalable, and responsive operations. By integrating Microsoft OAuth through Azure Entra ID, we enabled a custom authentication system exclusive to USFQ students, enhancing platform security and ensuring a trusted user community. Google Cloud Firestore managed user data, trips, and notifications, allowing for structured and nested data storage. Combined with local and asynchronous caching, this database choice optimizes data retrieval speed and simulates real-time behavior, creating a responsive user experience even at scale.

To support route planning and location accuracy, we incorporated Google Maps Geocoding and Directions APIs, which process address and coordinate data to generate optimal routes and travel times. Furthermore, the chat and notification system enables real-time communication, allowing students to coordinate pick-ups, receive updates, and foster community. Lastly, the rating system, triggered upon trip completion, adds a layer of accountability and trust, reinforcing positive user behavior and reliability on the platform.

The system addresses the logistical challenges of university commuting and promotes a safer, more reliable, and cost-effective transportation alternative for students. Through rigorous research, iterative refinement, and careful architectural planning, this platform provides a viable model for university-specific ride-sharing solutions with the potential to scale and adapt to similar campus environments globally.

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