LessGo: Smart Carpooling Matching Platform

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ABSTRACT

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Ridesharing services have become increasingly popular in urban settings, enabling customers to quickly and easily book rides to their preferred destinations. In a similar vein, carpooling systems enable co-workers or users with similar destinations to ride together, saving on transportation costs. Corporate carpooling has become a trend for many companies to address parking shortages and reduce their carbon footprint. Another method is the use of public transportation, which provides a low-cost alternative to travel.

There is no current example of an affordable, student-specific carpooling platform. Due to the decline of carpooling during the COVID-19 pandemic and the shift to remote work, students who need to commute for in-person classes can be in a tough situation if they do not have a car. Public transportation, like buses and trains, can be unreliable with variable schedules and may require additional connections. Furthermore, stops can be scarce as we move away from urban centers. In contrast, standard rideshare services are more direct but costly, especially with many popular services implementing surge pricing and concerns about unknown drivers.

In this project, we propose a student-centered ride-sharing platform that implements carpooling features. Our proposed solution enables student-specific systems that can match students while considering their class schedules, timetables, and route overlaps. This platform aims to address the cost concerns by providing a system in which students can determine fair pricing, as well as

splitting the cost with their fellow riders. Additionally, it will allow students the option to select drivers according to preference, for ease of mind.

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Chapter 1. Project Overview

Introduction

LessGo is a safe, smart, and cost-saving carpooling platform designed to improve the daily commute experience for university students by reducing parking congestion, travel stress, and transportation costs. The project focuses on leveraging overlapping student schedules and routes to enable efficient ride sharing between drivers and riders traveling to and from campus. By emphasizing safety, fairness, and usability, LessGo aims to complement existing transportation options with a community-driven alternative that scales with campus growth.

The platform introduces a structured approach to campus carpooling through intelligent rider–driver matching, transparent pricing, and integrated safety mechanisms. Key design goals include ensuring that riders never pay more than an initially quoted maximum fare, accounting for detours and route changes when allocating costs, and continuously monitoring trips for anomalies such as route deviations or abnormal stops. Together, these capabilities position LessGo as a robust, privacy-aware, and student-centric solution to ongoing commuting and parking challenges in university environments.

Proposed Areas of Study and Academic Contribution

LessGo contributes to several active research areas in intelligent transportation systems, including dynamic carpool matching, fair cost-sharing mechanisms, and privacy-preserving mobility services. The platform builds on prior work in static and dynamic carpooling, candidate-set pruning, and route optimization, and extends these ideas with a microservice-based architecture that integrates grouping, route optimization, cost calculation, safety monitoring, and payments into a unified system tailored to a university setting. By focusing specifically on recurring campus commutes and peak-time congestion, LessGo provides a concrete case study of how these techniques can be adapted and constrained to a well-defined, high-density mobility corridor.

From an academic standpoint, the project proposes to study and evaluate: (1) machine-learning–enhanced grouping that reduces candidate sets while maintaining high-quality rider–driver matches, (2) detour-aware, monotonic cost allocation algorithms that ensure “quote never increases” pricing while preserving driver incentives, and (3) anomaly-based safety validation that monitors route deviations and triggers silent checks and alerts. These areas offer opportunities to empirically compare different matching heuristics, quantify fairness and transparency in cost-sharing under real-world constraints, and assess how privacy techniques like homomorphic encryption can be integrated into routing and safety pipelines without degrading usability.

The expected academic contributions include a domain-specific architecture and data model for campus carpooling platforms, experimental results on grouping and pricing performance under simulated campus loads, and design guidelines for incorporating safety and privacy requirements directly into ride-sharing system design. Additionally, the project can contribute a reusable set of user stories, non-functional requirements, and QA/performance benchmarks for future student teams working on mobility, transportation optimization, or microservice-based cyber-physical systems.

Current State of the Art

In the current industry, two popular ridesharing systems exist: Uber and Lyft. Both of these systems optimize for single parties with multi-rider trips as a secondary focus. These ridesharing services involve simple pricing calculations depending on distance and time, with small detour adjustments. This pricing system is also very opaque and difficult to determine if a fair price is being calculated. Our smart carpool matching platform builds upon preexisting ridesharing systems by focusing on three concepts.

Safety Validation System

- Using anomaly detection algorithms, we plan to implement a real-time safety check of active trips. These safety checks allow riders to feel safer during their trip.

ML Enhanced Grouping Systems

- Utilizing machine learning techniques to reduce the size of candidate sets allows for quicker and higher-quality groupings between riders and drivers.

Fair Cost Allocation Algorithms

- Incorporating detours and disruptions to routes allows for a fairer estimate of cost per rider.
- We also would like to implement multi-factor considerations when estimating cost to be fair for drivers as well (Car MPG, estimated wear, etc.)

Privacy using Encryption

- Homomorphic encryption (HE) is used to improve privacy throughout the system, using addition and multiplication to protect data.
- 3 main types of HE:
    - Partial homomorphic encryption, which allows either multiplication or addition, but not both at the same time

- Somewhat homomorphic encryption, which allows both but limits the number of times they can be performed
- Fully homomorphic encryption, which allows both addition and multiplication an unlimited number of times

Chapter 2. Project Architecture

Introduction

Figure 1 shows a system architecture of the proposed system, called "LessGo". We opted for a microservice architecture with each functional aspect of our project broken down into its own service. This allows us scalability and independence across features.

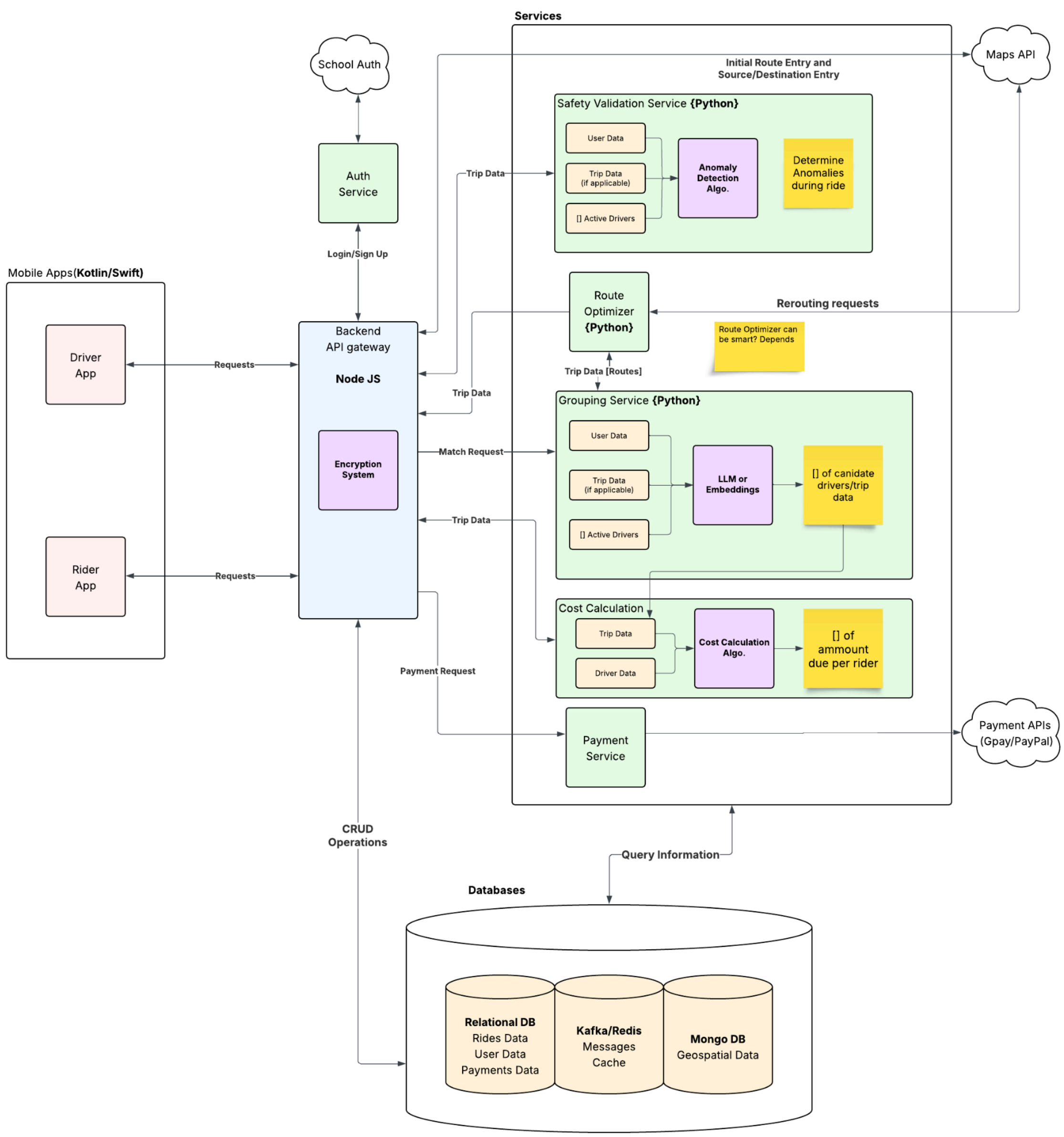

Figure 1. A System Architecture of our carpooling platform

Architecture Subsystems

Our services are described below.

- API Gateway:
  - Acts as a central entry point for both the rider and driver apps.
  - Directs incoming requests to the relevant microservice and manages database operations.
- Authentication Service:
  - Handles Logins, Sign Ups, and verification with the school authentication system.
  - Ensures only verified members (e.g., students) access the platform, boosting trust and campus security.
  - Manage user session security and access control.
- Grouping Service:
  - Takes in a match request and uses information from users and active drivers with their respective trip data to make an optimized list of candidates.
  - Uses user (ex., based on class schedule), driver, and trip data to optimize candidate lists for carpooling, aiming for best-fit matches.
- Safety Service:
  - Monitors the ride activity to check if they deviate too much from the optimal route.
  - Sends silent alerts for the riders to respond to.
  - Sends a report to their emergency contacts if the rider does not respond within a set time.
- Route Optimization Service:
  - Takes in trip data and produces optimal routes using an algorithm that can be smart (A* algorithm) or non-smart (Dijkstra).
  - Minimizes total detours and travel time for all users in the carpool, which is crucial on crowded campuses.

- Cost Calculation Service:
    - Takes in the Trip data and info about the driver to calculate the respective cost of each rider in the trip.
    - Addresses the need for transparency and equity in fare splitting, which is lacking in most large platforms.
- Payment Service
    - Integrates with payment APIs like PayPal, Stripe, etc.
    - Securely handles fund transfers between riders and drivers.

Glossary

Ridesharing and Carpooling

- **Ridesharing:** On-demand transportation service where passengers book rides with drivers via a platform (e.g., apps like Uber or Lyft).
- **Carpooling:** Shared travel arrangement where multiple riders with similar destinations share a single vehicle to reduce cost and resource usage.
- **Corporate carpooling:** Employer- or campus-backed carpooling programs aimed at reducing parking demand and carbon footprint.
- **Surge pricing:** Dynamic fare adjustment where ride prices increase in periods of high demand.

LessGo Platform Concepts

- **Smart carpooling matching platform:** A system that intelligently pairs riders and drivers based on routes, schedules, and preferences to form carpools.
- **Student-centered ride-sharing platform:** Ridesharing system designed specifically for students, integrating campus constraints like class times and locations.
- **Route overlap:** The portion of two or more users' travel paths that coincide, used to decide efficient carpool groupings.
- **Fair pricing / fair cost allocation:** Pricing approach that accounts for distance, time, and detours so each rider pays a reasonable share of trip cost while compensating drivers appropriately.

Architecture and Services

- **Microservice architecture:** System design that decomposes the application into small, independently deployable services, each focused on a specific business capability.

- **API Gateway:** Single entry point service that receives external requests, forwards them to appropriate microservices, and often centralizes authentication, routing, and rate limiting.
- **Authentication service:** Component responsible for user registration, login, integration with school SSO, and ensuring only verified users access the platform.
- **Grouping service:** Service that processes rider match requests and constructs optimized candidate sets by combining user, driver, and trip data.
- **Safety service:** Component that monitors active trips for abnormal behavior, triggers silent rider checks, and notifies emergency contacts if needed.
- **Route optimization service:** Service that computes efficient trip paths for carpools to minimize travel time and detours across all participants.
- **Cost calculation service:** Service that computes per-rider fares using trip details, detours, and driver-specific factors such as fuel efficiency.
- **Payment service:** Service that integrates with third-party payment providers to securely transfer funds between riders and drivers.

Algorithms and Techniques

- **Anomaly detection:** Class of algorithms that identify unusual patterns or deviations from expected behavior, here used to detect unsafe or suspicious trip activity in real time.
- **Machine learning (ML):** Set of techniques that learn patterns from data to make predictions or decisions, used here to improve rider–driver grouping quality and speed.
- **Candidate Set (for grouping):** The filtered list of potential rider–driver combinations considered by the grouping system before final match selection.
- **A* algorithm:** Heuristic graph search algorithm that finds cost-optimal paths efficiently using a combination of actual distance and estimated remaining cost.
- **Dijkstra's algorithm:** Classic shortest-path algorithm that finds the minimum-cost route in a weighted graph without heuristic guidance.

Security and Privacy

- **Safety validation system:** Mechanism that continuously evaluates trip safety using anomaly detection and route monitoring.
- **Homomorphic encryption (HE):** Encryption scheme that allows certain computations (such as addition and multiplication) to be performed directly on encrypted data without decrypting it.
- **Partial homomorphic encryption:** HE variant that supports either repeated additions or repeated multiplications, but not both operations in arbitrary sequences.
- **Somewhat homomorphic encryption:** HE variant that supports both addition and multiplication but only a limited number of operations before noise makes decryption unreliable.
- **Fully homomorphic encryption:** HE scheme that supports unlimited additions and multiplications on ciphertexts, enabling arbitrary computations over encrypted data.
- **Session security:** Measures that protect active user sessions (e.g., tokens, timeouts) against hijacking and unauthorized use.
- **Access control:** Mechanisms that ensure users can only perform actions and access resources allowed by their roles and permissions.

Transportation and Cost Factors

- **Detour:** Deviation from the shortest or most direct route taken to pick up or drop off additional riders in a carpool.
- **Trip data:** Collected information about a ride such as origin, destination, waypoints, timestamps, and assigned users, used by grouping, routing, and cost services.
- **Car MPG:** Miles per gallon; measure of a vehicle’s fuel efficiency, used to approximate fuel cost contribution in pricing.
- **Wear (vehicle wear):** Approximate long-term cost of vehicle usage, including maintenance and depreciation, considered when compensating drivers.

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Appendices

Appendix A. Literature Search Table

The literature search table organizes prior work on ridesharing into key thematic buckets (cost/pricing, matching/routing, and safety/privacy) and captures how each paper informs your project, along with gaps they leave open.