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EcoPool: A Carpooling App for Urban Commutes

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Abstract
EcoPool is the new web based carpooling site that links the drivers with empty seats with the riders seeking convenient, cheap and environmental friendly mode of transport. It was created with Tailwind CSS and Firebase, and it provides real-time user authentication, interactive maps, which display routes, and clever functions that will pair up riders with appropriate drivers.The platform is more concerned with the privacy of the users, such as the safety options available to women, emergency contacts, or real-time tracking of the trips. Accessibility is also in the priority order and access to visually challenged users is provided, although the webpage is compatible with the use of a screen-reader and a voice-activated AI assistant to use hands-free.
EcoPool is a working prototype, as well as a physical representation of smart ride-sharing concepts of the present-day research in the transportation system online. It aims to contribute to lessening the traffic in cities, reduction of individual costs on travel, and promotion of more reasonable commutation.

Keywords: Carpooling, Ride-Sharing, Smart Transportation, Sustainable Mobility, Firebase, Leaflet Maps, Real-Time Tracking, Route Optimization, User Safety, Voice AI Assistant.

1. Introduction

EcoPool is a very innovative and web based carpooling service that is intelligent to match unsold seats on cars to riders seeking a convenient, low-cost and environmentally-neutral way to commute. It is based on a responsive design developed with Tailwind CSS and a scalable implementation with Firebase ensuring that the experience works well on desktops and tablets besides mobile devices.
EcoPool is based on Firebase Authentication and Firestore to verify users in real time and manage their data. This facilitates safe account creation, real-time data exchange, and ride times. The site also incorporates Leaflet to create interactive maps where users can view their routes, pickup locations and destinations on the map. It also has intelligent matching features that scan such factors as shared paths, time, and ratings of users to match drivers and riders in the most optimal manner.The interest in user safety and inclusivity is one of the primary assets of EcoPools.
It includes certain women safety features, such as an option of emergency contacts and real-time tracking of their trips, making sure that users can share the information about their trips with someone trusted. The features assist in creating a sense of trust as this is one of the fundamental requirements to make individuals feel safe on shared means of transport.EcoPools design also plays a large role of accessibility.

The site is compatible with screen readers, so that the user with visual impairments can work with it and it adheres to the principles of inclusive design. On top of that, a beta of a voice AI assistant, which allows search and interaction without typing, makes the platform more accessible and user-friendly to rides, confirm, and navigate through the interface, using voice commands, which makes the site more applicable in a real-world, on-the-fly situation.

Technologically, EcoPool proves the practice of the latest web development and cloud architecture. The real-time feature of Firebase services, provision of scalability and secure data manipulation, and the application of Leaflet contribute to its geographic interaction. The application is easy to maintain and extend in the future, characterized by its modular structure, which ensures it can be used as a prototype as well as as the basis of other systems creation, producing a system that will be ready to use later.

Other than functionality, EcoPool matches with the greater sustainability objectives. The platform will help decrease the number of vehicles on the road by promoting shared transportation and so reducing traffic jams, fuel usage and carbon emissions. It is also economically beneficial as it divides the traveling costs between users, thus commuting is more affordable to the individual.

Essentially, using EcoPool goes beyond a carpooling application. It is an all round example of how smart systems, focus on people, and eco-friendly thought processes can come together to solve contemporary mobility issues in urban settings. It echoes the tendencies in modern studies about collective transport and poses a prospective resolution, intended to develop more intelligent, safe, and environmentally friendly commuting.

2. Literature Review

Digital carpooling and ride-sharing websites have significantly transformed modern transportation systems and become effective due to their ability to reduce urban traffic and transportation costs, as well as curb the environmental influence. Studies such as the smart carpooling simulation study in the Bacau region reveal that organised carpooling can be a serious way of reducing fuel consumption and greenhouse gas emission.

But these studies are largely theoretical and have not been implemented in real life or based on the user considerations.The fact that there are already real-time carpooling applications that are based on Android, indicating that GPS tracking, posting of rides, and the booking of seat can be used to offer end-to-end solutions. They however, do not have good user safety, good verification and intelligent matching with people with special needs. A more general search through carpooling research literature identifies trust, privacy and psychological comfort as some of the biggest contributors to non-use of such services and thus more all-encompassing user-friendly designs to platform needs to be implemented.

Based on these results and the shortcomings of the earlier studies, EcoPool was developed as an operational and a fully-functional carpooling system. It addresses these challenges with intelligent ride-matching algorithms, safety, not only accessibility, but also an AI voice assistant providing an all-embracing, comprehensive, and human-centric solution to the problem of modern urban commuters.

2.1 Literature Survey

1. Intelligent Carpooling System - Case Study (Bacau Area)

Morar, I., & Codreanu, M. (2022)

In this paper, an intelligent carpooling model is introduced, constructed on real transport data in the Bacau area, containing the information about routes, stops, traffic and speed of vehicles. Using this data, the researchers experimented with various carpooling conditions and quantified the amount of fuel that would

be saved and the reduction of greenhouse gases. The findings indicated that carpooling could increase efficiency of the established transportation systems significantly without necessarily having to build new infrastructure.Nevertheless, the model was a pure simulation and lacked real world application, user interface and user experience. This identified one of the main issues that EcoPool is determined to address. The paper also limited its scope to a smaller region, and failed to address issues of user safety, inclusivity, and comfort, which demonstrated the necessity of a viable platform that would ensure environmental benefits are evident to people. EcoPool improves on that by providing live ride matching and real-time carbon saving dashboard that assists commuters to make more informed decisions.

2. Real Time Smart Car Pooling and Ride Sharing System (Android)

Kumar, R., et al. (2021)

The paper describes how an Android-based carpooling application was developed with its features including the GPS, Google Maps, user registration, postings of ride and ride search, seat booking, and update. It demonstrates that it is possible to ride share in real time and provides a good glimpse of how a car sharing system should be developed.Nonetheless, the app had certain problems, such as a lack of basic security, simple matching on routes and time only, and lack of support of people with special needs. These concerns influenced the design of EcoPools. Compared to this Android-only application, EcoPool is a web-based application that allows it to create secure logins with Firebase, interactive maps with Leaflet and incorporates safety options such as emergency contacts and role-based access, making it more secure and accessible to a broader group of users.

3. A Literature Survey on Carpooling

Agatz, N., et al. (2022)

This paper presents an extensive survey of the carpooling literature including corresponding techniques, incentive systems, environmental impact and platform architecture. It is a key reference due to its large scope in comprehending the present state of the field. It goes on also to observe that social and psychological barriers such as trust, privacy and flexibility are significant barriers to adoption, that in current systems are scarcely addressed.This conclusion impacted EcoPools design. The platform is designed to be comfortable and convenient with a modern and smooth user interface. Details such as the ability to switch roles between rider and driver easily, robust Firebase-driven log-in, and a voice assist as a hands-free option demonstrate a concern to reduce the barriers to carpooling that this survey found.

4. What Influences People to Choose Ridesharing? An Overview of the Literature

Lavieri, P. S., & Bhat, C. R. (2019)

This paper will review the literature on this topic examining aspects of why people prefer to rideshare, such as cost, travel time, safety, trust, social comfort, and convenience. It offers valuable information used to determine where to design a carpooling platform, particularly creating trust and a sense of security and comfort. However, the questionnaire does not provide precise designs of the systems and makes emotional and social comfort the aspect that can be installed on the platform. EcoPool considers these factors with verifiable community access via schools and businesses, rating system, explicit safety measures inside the application, and equivalent, which takes into account comfort, time, and cost as well.

5. Human Satisfaction as the Ultimate Goal in Ridesharing

Lesmana, N., et al. (2019)

The present paper presents a neural network design decision model which predicts user satisfaction during carpool rides and applies the predictions to enhance ride sharing. It demonstrates that user satisfaction and its emphasis rather than efficiency can make people happier without significantly influencing the

performance. This is in favor of a humanistic platform design.Although the structure was tested on a simulator and trained on small situations, it lacked safety and inclusivity. EcoPool will adhere to this vision by collecting post-ride comfort and safety feedback, and applying it to matching and develop a better user experience.

6. How to Develop a Carpooling App: Features, Steps and Technology Developers

Digest (2023)

This article defines the key points and technical aspects of a car driving app, including user registration, ride posting, matching, tracking, payments, and ratings. It is a guiding book to create a simple platform. However, it does not elaborate on state-of-the-art protection features, accessibility features, and environmental monitoring. This opens the door to platforms providing additional offerings to the basic version. Ecopool contains all the main features and provides additional functionality, such as verified user profile, emergency contacts, category of rides called Women and Children, and carbon savings tracker, which is beyond a typical template.

3. Methodology

EcoPool was created in a systematic web-based design with full-stack data handling and ride-matching decision-making algorithm.

3.1 User Data Collection

The initial is the collection of the required information needed in the delivery of ride-sharing services. The data that is collected by the system is as follows:

- Name, email, and password are registered using Firebase Authentication.
- The details inputted by drivers such as source, destination, route, number of seats on the ride, and time.
- Ride requests that are placed by riders who have a pickup/dropoff point.
- The latitudes and longitudes (latitude and longitude) chosen on the interactive map.
- Information in the database about user profiles.

This data assists the system to know the destination level that people desire to reach and drivers at their disposal.

3.2 Data Storage and Management

After gathering the data, it must be gathered safely and systematically prepared. The system goes through the following steps:

- Users are authenticated by Firebase Authentication in Javascript.
- Saves Firebase Firestore ride listings, ride requests and driver routes.
- Sorts information in groups and records to access it effectively.
- Allows updating live so that the users will instantly see what new rides and available seats are.

The step makes sure that there is synchronization of ride information throughout the application.

3.3 Frontend Interface and Navigation

It has a self-interactive user interface allowing users to search and offer rides, as well as, bookings. The application uses:

- React 18 to create a Single Page Application (SPA) to interact quickly and efficiently.
- Vite as the programming language, compile tool to build faster projects.
- React Router DOM to control page navigation including: login, home, ride search, ride offering, and safety options.

- Tailwind CSS to design the interface and develop a clean and responsive one.

This enables the users to freely navigate through various sections of the platform without having to reload pages.

3.4 Map Integration and Location Selection

Positioning data is needed to match the ride and visualize the route. The system employs the following:

- Interactive map visualisation: Leaflet and React-Leaflet.
- Gives users the option of a pickup and drop-off point to pick directly on the map.
- Shows graphically routes driven by fans and location of rides.
- Benefits from the use of the geographic coordinates to aid distance calculations, and route algorithms.

This enables users to have a clear vision of the routes and pick ups.

3.5 Ride Matching and Distance Filtering

The system initially limits the distance of drivers to get suitable drivers to the rider. The system uses:

- Haversine Formula to estimate distance between the position of the rider and the people around him.
- Latitude and longitude of the map.
- Distance limit to remove the drivers too far apart.

3.6 Nearest Driver Identification

Once it has filtered nearby drivers, the system finds the nearest drivers to match. The system uses:

- K-Nearest Neighbors algorithm (KNN).
- Distance between points using the Haversine Formula.
- Ordering of drivers in terms of distance to the rider.

This will make sure that the most suitable drivers are firstly watched on ride matching.

3.7 Route Optimization

After identifying potential drivers, the system then computes the route that is the most optimal one. The system uses:

- The Dijkstra Algorithm used to calculate the shortest path between the source and destination of the rider.
- OpenStreetmap (OSM) data of road network.
- Assessment of health (route cost) to figure out the extent to which a driver would have to deviate in order to pick a rider.

This makes sure that routes are efficient coupled with drivers and the passengers.

3.8 Testing and Deployment

The system should be deployed and tested prior to use by the users. Following steps are performed.

- Makes use of the Vite development server to test locally.
- Uses ESLint to ensure the quality and consistency of the code.
- Pushes the production release with the Firebase Hosting or Vercel.

This makes sure that the application is smooth and can be accessed online.

4. Results

The EcoPool platform has become an excellent and innovative platform through which drivers are finding companions to fill the empty seats and riders with an alternative affordable, convenient, and environmental friendly means to reach their destinations. The system integrates various handy functionalities such as user profile, map integrating routes which is easy to understand, intelligent matching of the rides, real time ver-

ification and trip tracking to enable a smooth and easy carpooling experience.
The platform, in addition to providing user profiles, role management, enables users to easily alternate between being a rider or a driver depending on their needs. The Voices AI assistant enables users not to use their hands to interact with the platform, thus making it more accessible and easier to use by everybody. Certain safety considerations, like the use of women safety options and emergency contact tools, enable users to be more confident and secure when exploring.

Comparison with Existing Systems

Although systems discussed in the literature were all valuable sources of insights, none of them did not demonstrate evident drawbacks that EcoPool is to avoid. The comparison between EcoPool and its main dimensions is summarized in the table below:

Feature	Existing Systems	EcoPool
Deployment type	Simulation or basic Android app	Live web application (React + Firebase)
Authentication	Simple login or admin-based	Firebase Authentication with verified profiles
Safety features	Minimal or absent	SOS, emergency contacts, women-only rides
Inclusivity	Not addressed	Women-only and child-friendly ride options
Map integration	GPS or Google Maps (mobile only)	Leaflet-based interactive maps (web)
Accessibility	Standard UI only	Voice AI assistant for hands-free use
User roles	Fixed (driver or rider)	Seamlessly switchable roles
Environmental focus	Planner-level simulation only	User-facing ride activity and eco-friendly matching

Table 1.1: Comparison of EcoPool with Existing Systems.

5. Conclusion

To conclude, EcoPool is an excellent demonstration of how intelligent, web-based carpooling systems can contribute to resolving the growing issues of urban transport networks, traffic congestion and poor driving conduct. The application provides users with a reliable, immediate, and user-friendly experience with all strong technologies, such as Firebase, Tailwind CSS, Leaflet, and smart matching algorithms of rides, to drivers and passengers.
Indication of safety features, features that support individuals with diverse needs, and voice-activated AI assistant make EcoPool a multifaceted and progressive ECG solution that will satisfy the diverse needs of the modern commuters.EcoPool can use future prospects to build on present foundations and enhance their performance. The platform may also introduce such capabilities as payment solutions within the application, ride feedback, carbon emission monitoring, and improved AI-assisted route analysis to enhance it to an even greater degree. The ride-sharing trend, as an alternative to having a car of your own,

is growing in popularity, and EcoPool is a worthy addition toward making city transport systems smarter, eco-friendlier and more connected.

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