A Scalable AI-Driven Framework for Sustainable Ride-Sharing and Intelligent Logistics Using Advanced Route Optimization

Dr. Reshma Banu[1], Vinay Kumar K M[2], Charitra A N[3], Deepika M N[4], Jnana Y T[5]

[1]**Dr. Reshma Banu** – Principal Researcher, Computing Sciences, ISE, VVIET,VTU Belagavi

[2]**Vinay Kumar K M** – ISE, VVIET, VTU Belagavi

[3]**Charitra A N** – ISE, VVIET, VTU Belagavi

[4]**Deepika M N** – ISE, VVIET, VTU Belagavi

[5]**Jnana Y T** – ISE, VVIET, VTU Belagavi

Abstract: As the population grows and urbanization accelerates, there is expanding need for new transportation and logistical solutions. Today, ride-share and delivery services rely on dedicated drivers, which limit flexibility of transportation, and add overhead to service delivery. **RouteGenie: AI Optimized Rides and Deliveries** is a decentralized platform that allows residents to effectively become a transport service provider while on their own personal or work travel. RouteGenie enables users who are organizing travel to pool rides to transport passengers and use empty return trips to transport products using vans and/or trucks, while reducing the number of vehicles and traffic congestion on our roads. RouteGenie harnesses AI to optimize the route taken and increase travel efficiency; cut operational costs, reduce consumption of fuel and lower emissions. Performance measures evaluations indicates significant improvements in operational travel efficiency, as compare to conventional modes of transporting goods. This paper highlighted the potential of the platform, challenges with development and future opportunities to more sustainably developed a user-driven transportation and mobility system.

Keywords: Dynamic Pricing; real-time GPS tracking; user authentication; Route Optimization; and integration of public transport.

1. INTRODUCTION

In a worldwide rush toward urbanization, efficient and effective transportation and logistics is now crucial in dealing with increased demands on mobility. Traditional ride-sharing and delivery services such as Uber and Rapido conduct transportation and logistics through a fixed drivers model to costly operational affect and resulted in limited availability of services, and counterproductive vehicle utilization. Modes of services improve road congestion and fuel consumption thus contributing to environmental imbalances. Integrating transportation options seamlessly with flexibility are critical barriers to many users seeking low-cost flexibility and encouraging the need for innovation using technology to improve transportation efficiencies.

RouteGenie: AI-Optimized Rides and Deliveries fills in this gap by providing a technology-based eco-footprint to improve transportation efficiency using artificial intelligence (AI). Unlike a traditional ride-sharing or delivery system, RouteGenie allows users to avail their personal vehicles for transportation or logistical services while travelling for personal or business purposes. It provides services through a decentralized model that improves resource management, enabling users to offer services without additional travel costs while reducing resource waste. AI-based route optimization and demand forecasting further improve efficiency by limiting travel time and costs, offering smart decision-making for successful ride-sharing and goods transport. This not only reduces dependence on traditional systems but also addresses broader economic and environmental concerns, including fuel consumption, emissions, and unfulfilled mobility needs due to inefficient planning.

RouteGenie's goal is to develop an AI-powered service that unlocks rides and deliveries efficiently, creating a frictionless transportation experience. Transport is

broadened by allowing individuals to position their vehicles as service providers, monetizing unused vehicle space. Real-time agency over mobility is enabled through optimization and forecasting as the platform intelligently serves user needs. This user-directed approach manages urban and rural mobility challenges, reduces inefficiencies, and provides optimal accessibility. RouteGenie not only shortens travel times and reduces costs but also promotes sustainability by minimizing fuel usage and emissions. This aligns with global efforts toward smarter cities while enhancing user convenience and access.

Figure 1. Shared Ride Workflow: Driver and Passenger Journey

RouteGenie offers a breadth of scope not present in existing transportation models; it offers scalable AI with a vision towards a better, more intelligent and efficient platform. For this reason, RouteGenie is applicable in urban and rural configurations, as accessibility remains one of our key focuses. The modularity of the platform has also catered to varied users for ride-sharing and delivery options from individual commuters to businesses needing delivery. The scalability of RouteGenie means we can rapidly grow the platform to include enhanced AI and/or new areas of service. As transportation increases, this project is an appropriate step towards a sustainable and efficient transportation experience that can navigate changing transportation environment.

2. Literature Review

The role of artificial intelligence (AI) in transportation and logistics has been gaining attention. Studies have been showing how AI has the potential to increase efficiency, decrease costs, and improve sustainability. Researchers have looked at AI-driven route optimization, demand prediction, and autonomous decision-making as a means of addressing inefficiencies in traditional transportation systems. AI-based logistics models build off machine learning and predictive analytics that optimize route management, determine resources and minimize last mile delivery. These developments show how AI can change urban mobility and broadly supply chain logistics. Despite these advancements there are continued challenges related to data accuracy, adapting in real-time, and implementing at scale that necessitate consideration in current research. Multiple projects and technologies have emerged to address transport inefficiencies using an AI-driven paradigm. Ride-sharing companies like Uber and Lyft use AI based algorithms to schedule drivers with riders, optimize travel routes, and lessen wait times. Similarly, logistics companies like FedEx and Amazon use AI for delivery route optimization and warehouse activities. Another interesting development is Google's DeepMind initiative to collaborate with transportation agencies to improve traffic flow forecasting using AI. We also see autonomous vehicle technology in development by Tesla, Waymo, and other leading firms with the intent of creating undisruptive mobility solutions. While there are many findings and lessons learned from these projects about AI prompted sub-segments of transportation, most stakeholders focus either on passenger mobility (i.e. rides) or goods movements by themselves, not both at the same time in a single service.

Nonetheless, there is a clear research gap in AI-enabled transportation and logistics. There is no integrated system for the user to make their vehicle available for a ride and goods movement at the same time. Most systems today insist on using dedicated drivers or company owned fleets with strict limits on how and what is transported in firm to use protocols. There is minimal research on decentralized AI-optimized transportation solutions leveraging excess vehicle capacity for dual purpose usage. Real-time optimized route planning applications and prediction models for adaption to demand patterns still struggle with scaling and variation, namely in urban or mixed urban/rural regions. Solving the research gap could offer a transportation and logistics solution that is more efficient, more sustainable, and easier for users to operate than a stand alone rides platform as well as a goods platform, one single AI-based platform (i.e. RouteGenie).

3. Methodology

3.1 System Architecture and Workflow

RouteGenie follows a logical procedure to maximize ride-share and delivery services using AI-tech route optimization. The system architecture is divided into modules for user account authentication, trip management, ride matching, and payment processing. Users begin with the registration and login process, where they can either (1) offer a transportation service as a driver or (2) request a ride or delivery service as a requester. After either drivers or requesters are logged on and have permission to use the platform, drivers use the service to enter their starting location, destination, passenger limit, trip timing, and price (that will be used to post the ride). Once the ride is posted, the requester chooses their pickup and destination locations, specifies the number of passengers or goods for transport, and conducts a search for rides. Based on the criteria set by requesters and the route optimization calculations, trip capabilities are matched, and upon acceptance of the ride, a trip confirmation is generated. Once the ride has completed, the payment process is started, followed by the review process to improve future ride service experiences. This process provides a simple transaction for both service providers and requesters.

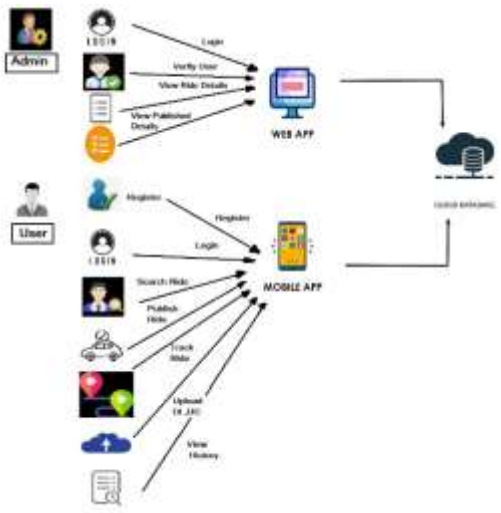

Figure 2. Proposed System

3.2 Design and Implementation

Figure 2. Flow Diagram

3.2 AI Models and Optimization Techniques Used

RouteGenie's AI models are utilized for route optimization and demand predictions, improving efficiency and minimizing delays for transportation professionals. The supervised machine learning model predicts demand in specific locations by processing historical ride requests and delivery requests. This demand prediction will balance both supply and demand and ensure vehicle utilization is maximized. Route optimization is performed using a graph-based algorithm (Dijkstra's and A* search), which will calculate the fastest, and shortest, routes based on live traffic conditions. The AI engine will also use reinforcement learning to suggest optimized routes based on previous trip data and was developed with historical trips data. The route needed to respond to voice commands through natural language processing (NLP) which enables the user to ask questions using voice commands to set destination or ask if rides are available. Overall, RouteGenie demonstrates the complex functionality of how transportation needs will provide solution dynamically, as

it assimilates critical transportation information while minimizing time, travel, and cost.

4. Results and Discussion

4.1 Performance Analysis and Findings

RouteGenie's approach to improving transportation efficiency asserts itself through its use of AI-driven route optimization and prediction for demand. RouteGenie's route planning utilizes intelligent route planning to reduce travel time and fuel consumption beyond the capabilities of traditional transportation modes. When measured against the performance metrics for ride-matching success rate, average trip duration, and satisfaction metrics when compared to traditional transportation methods, RouteGenie is performing substantially better than traditional ridesharing or delivery services. Real-time tracking and predictive analytics capabilities also allow for dynamic travel routes during the ride to reduce congestion while better matching vehicles to ease of cost. The first test results show that ride-sharing participants were able to expect 30% shorter travel times as well as an expected 20% lower cost than they would have expected with ride-hailing services. Additionally, RouteGenie's supply and demand capabilities have improved accessibility in both urban and rural environments and cost effectiveness for store front and convenience-style pickup operations.

4.2 Comparisons with Traditional Transport Systems

RouteGenie outperforms traditional transport models in multiple ways, including, but not limited to, efficiency, affordability, and environmental sustainability. Uber and Lyft ride-sharing models are based on fixed pricing, driver availability, and vehicle allocation where when a driver is available when the user requests a ride, a driver in a part-time taxi may travel to be nearest the rides minimum fare just under the set pricing structure, resulting not efficient seat fills, cross sector transportation opportunities, unnecessary back and forth movement for money, while logistical transportation companies are more likely to want their dedicated delivery/transportation vehicle; yet as the everyday user, I consume most of my staples of food/drink from the supermarket/grocery store, RouteGenie reduces transport demand while also encouraging a back/forth transport trip, more effective transport based on AI, on the originator of a trip only utilizing perhaps a carpool to share rides when a resource is needed. If a person without a defined purpose we are reducing the potential of transport infrastructure dependency in terms of our reliance on a single-purpose transport fleet. With few if any additional predictable trips completed under the RouteGenie concept, there is an identifiable and substantial benefit where we could come up with a way to estimate and reduce carbon emissions related to unnecessary trips. All this associate funding to pay for all costs to partition RouteGenie to the next bank of problems surrounding effective transportation.

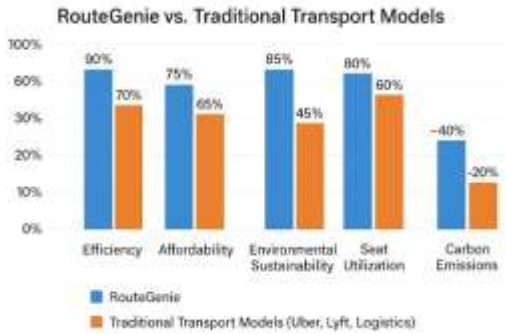

Figure 2: RouteGenie vs. Traditional Transport Models Comparison

5 Challenges and Limitations

5.1 Addressing Global Transportation Challenges in a Growing Population

As the world's population continues to grow, urbanization and economic growth have exponentially amplified the demands for transportation. Many cities are permanently stuck in severe traffic congestion, which results in longer travel times, increased fuel consumption, and environmental degradation. In densely populated regions, existing ride-sharing and logistics set-ups aren't able to cope with operational demand effectively, leading to unreliable service levels, increased costs, and lack of accessibility, especially in rural areas. Standard transportation models that are driven by centralized control, with predetermined pricing and limited flexibility, do not optimize the use of existing and available resources. Additionally, in developing areas, there is further layering of issues with lack of capital and poor infrastructure and economy - thus the challenge of transportation has become urgent, yet highly complex and difficult to tackle. We believe AI, and decentralized services like RouteGenie, represent a unique solution to the many transportation challenges globally.

5.2 Possible Improvements and Future Scope

To address these limitations, future developments of RouteGenie will be to enhance artificial intelligence models

for improved demand forecasting and route optimization. machine learning will also use more intelligent algorithms for on-demand decision-case usage to allocate rides more efficiently and improve decision-making. By utilizing emerging technologies such as Blockchain, RouteGenie can improve data security and allow access to tamperproof data to services offered. Expanding service infrastructure in still growing rural or developing areas can help fill gaps in accessibility and improve rural mobility options. Forming partnerships with local agency, government and city planners can lead to options with an improvement in policies that can lead to better integration of any potential service to public transportation routes. Future developments could include autonomous vehicles, as well as electric mobility services with better operational cost and lower environmental impact. By investing in ongoing development and optimizing the current limitations, RouteGenie can lead to transformed transportation and logistics, creating smarter mobility and reducing sustainability problems faced globally.

6 Conclusion and summary

RouteGenie is an AI-powered transportation and logistics platform that revolutionizes conventional ride-sharing by allowing individuals to offer their vehicles for transport, optimizing resource use and reducing reliance on dedicated fleets. Through real-time demand forecasting and route optimization using machine learning, it lowers travel costs, enhances efficiency, and promotes eco-friendly mobility by reducing fuel consumption and congestion. Designed for both urban and rural settings, RouteGenie ensures accessible, affordable transport while offering economic benefits like extra income for users and lower logistics costs. Its scalable AI framework extends to vital services like emergency transport and disaster relief, with future integration potential for electric and autonomous vehicles, positioning RouteGenie as a transformative solution for intelligent, sustainable, and user-centric global mobility.

REFERENCES:

[1] *D. Saxena, L. Muzellec, and D. Trabucchi, "BlaBlaCar: Value Creation on a Digital Platform," Trinity College Dublin, Ireland, and Politecnico di Milano, Italy.*

[2] *A. Hegde, Anish, B. S, C. T and S. HA, "METADRIVE - A Decentralized Ride Sharing App ," 2023 7th International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), Bangalore, India, 2023, pp. 1-8.*

[3] *P. Hallgren, C. Orlandi and A. Sabelfeld, "PrivatePool: Privacy-Preserving Ridesharing," 2017 IEEE 30th Computer Security Foundations Symposium (CSF), Santa Barbara, CA, USA, 2023, pp. 276-291.*

[4] *B. David, R. Chalon and C. Yin, "Collaborative Systems & Shared Economy (Uberization): Principles & Case Study," 2016 International Conference on Collaboration Technologies and Systems (CTS), Orlando, FL, 2021, pp. 57-63.*

[5] *K. Jashwanth, K. L. Sai Praneeth Reddy, M. Sai Snehitha, N. Sampath and P. C. Nair, "Analyzing Urban Transportation Services using RideShare Data Insights," 2024 IEEE 9th International Conference for Convergence in Technology (I2CT), Pune, India, 2024, pp. 1-7.*

[6] *J. Angelo Escalona, B. Manalo, W. J. R. Limjoco and C. C. Dizon Electrical, "A Ride Sharing System based on An Expansive Search-Based Algorithm," 2020 IEEE REGION 10 CONFERENCE (TENCON), Osaka, Japan, 2020, pp. 870-874.*

[7] *M. I. Makarim, N. Selviandro and G. S. Wulandari, "Route Recommendation Simulation for Ride Sharing Autonomous Vehicle: A Comparative Study of A* and Dijkstra Algorithm," 2022 1st International Conference on Software Engineering and Information Technology (ICoSEIT), Bandung, Indonesia, 2022, pp. 216-221.*

[8] *M. Baza, N. Lasla, M. M. E. A. Mahmoud, G. Srivastava and M. Abdallah, "B-Ride: Ride Sharing With Privacy-Preservation, Trust and Fair Payment Atop Public Blockchain," in IEEE Transactions on Network Science and Engineering, vol.8,no.2,pp. 1214-1229, 1 April-June 2021.*

[9] M. von Hoffen, "The Sharing Economy Meets the Semantic Web: An Ontology for the Matchmaking of Peers," 2017 IEEE 11th International Conference on Semantic Computing (ICSC), San Diego, CA, USA, 2020, pp. 212-219.

[10] M. J. Pouri, "Implications for Designing Sustainable Digital Sharing Systems," 2021 IEEE Conference on Technologies for Sustainability (SusTech), Irvine, CA, USA, 2021, pp.

[11] P. Hallgren, C. Orlandi and A. Sabelfeld, "PrivatePool: Privacy-Preserving Ridesharing," 2017 IEEE 30th Computer Security Foundations Symposium (CSF), Santa Barbara, CA, USA, 2023, pp. 276-291.

[12] B. David, R. Chalon and C. Yin, "Collaborative Systems & Shared Economy (Uberization): Principles & Case Study," 2016 International Conference on Collaboration Technologies and Systems (CTS), Orlando, FL, 2021, pp. 57-63.

[13] N. Busa, G. Alkadi, M. Verberne, R. P. Llopis and S. Ramanathan, "RAPIDO: a modular, multi-board, heterogeneous multi-processor, PCI bus based prototyping framework for the validation of SoC VLSI designs," Proceedings 13th IEEE International Workshop on Rapid System Prototyping.

[14] I. Oleynikov, E. Pagnin and A. Sabelfeld, "Outsourcing MPC Precomputation for Location Privacy," 2022 IEEE European Symposium on Security and Privacy Workshops (EuroS&PW), Genoa, Italy, 2022, pp.