

A Literature Survey on Carpooling

Krushna Jaybhaye¹, Aniket Chavan², Aneesh Wath³, Omkar Sherkar⁴, Sheetal Kapse⁵

Department of Computer Engineering^{1,2,3,4,5}

Smt. Kashibai Navale College of Engineering, Pune, Maharashtra, India

Savitribai Phule Pune University, Pune, India

Abstract: *This paper embarks on an exploratory journey through a collection of diverse studies, shedding light on the multifaceted world of carpooling. These papers collectively underscore the compelling advantages of carpooling, from economic benefits to addressing traffic congestion and pollution, highlighting its potential to reshape urban commuting and contribute to sustainability. Simultaneously, these studies address inherent carpooling challenges, proposing solutions that encompass logistical considerations and social barriers. We also witness the evolution of carpooling design and technology, from dedicated lanes to advanced matching algorithms, emphasizing innovation at its core. These papers collectively provide valuable insights into carpooling's multifaceted world, illuminating its transformative potential and resilience in the face of urban challenges. This paper provides an overview of the existing research related to the carpooling concept.*

Keywords: Carpooling, Ride-sharing, Sustainable Urban Transportation, Traffic Congestion

I. INTRODUCTION

In the bustling urban landscapes of the 21st century, the concept of carpooling has risen to prominence as a transformative solution to the multifaceted challenges of modern transportation. As we stand at the crossroads of burgeoning population growth, escalating traffic congestion, environmental concerns, and evolving cost dynamics, carpooling emerges as a beacon of hope. It is within this context that this report embarks on a comprehensive exploration of a myriad of research papers, collectively focusing on various aspects of carpooling technology.

Our journey through these papers traverses the expansive landscape of carpooling, beginning with a closer examination of its undeniable advantages. From the economic dividends accrued through fuel cost savings to its pivotal role in alleviating traffic congestion and combating pollution, these advantages offer a compelling vision of carpooling as a sustainable and pragmatic mode of transportation. The cumulative findings within these papers provide a comprehensive understanding of carpooling's potential to reshape urban transportation. Our exploration also delves into the challenges it confronts and the ingenious solutions it beckons. These research papers collectively guide us through a multifaceted world, providing insights, solutions, and innovations that redefine our understanding of carpooling and, in turn, the future of urban transportation. This paper tries to present an overview of all these papers.

II. BACKGROUND AND AIM OF STUDY

Our world is experiencing rapid urbanization, with an ever-growing population flocking to urban areas. This trend is accompanied by a surge in the number of vehicles, while the physical space available for roads remains constant. This situation results in pervasive traffic congestion and escalating pollution. Carpooling is an indispensable solution to a multitude of pressing needs in our modern world. It seems to directly address the pervasive issue of traffic congestion in urban areas, alleviating lost productivity and the stress of long commutes. Additionally, it plays a crucial role in reducing carbon emissions and mitigating air pollution, contributing significantly to environmental sustainability. Beyond its environmental benefits, carpooling optimizes resource usage, including fuel and infrastructure, promoting efficient resource conservation.

The study aims to enhance our understanding of carpooling, including its necessity, benefits, challenges, and impacts. It investigates the need for carpooling and its advantages, addressing challenges and economic/environmental benefits. Additionally, the study explores logistical, social, and infrastructure barriers to adoption and innovative solutions like carpool lanes and matching algorithms. The research highlights carpooling's impact on congestion, air quality,

sustainability, employee satisfaction, and organizational sustainability. It also examines proposed enhancements through incentives, policies, and user experience improvements, emphasizing carpooling's dynamic role in sustainable urban transportation. This study seeks to significantly advance our comprehension of carpooling.

III. METHODOLOGY

For our study, we started collecting research papers relevant to Carpooling. We did extensive research on the topic both online and offline. These papers were studied, grouped based on their content and finally analyzed thoroughly. The detailed steps are given below:

- Defining scope and goals: The goals for the study were first established. Various aspects when it comes to the study of carpooling were finalized.
- Literature Search Strategy: The research for this survey report was conducted through a comprehensive search across various academic platforms and databases. A preliminary search was performed on Google to identify initial sources. The online databases and platforms include IEEE Xplore, Google Scholar, Google Scholar and Scienedirect.
- Inclusion and Exclusion Criteria: Research papers and articles were selected based on their relevance to the survey report's focus on summarizing and analyzing academic papers and articles. Preference was given to recent and peer-reviewed publications.
- Data Collection and Analysis: Identified papers and articles were reviewed to extract key information such as publication date, authorship, title, abstract, methodology, results, and conclusions.
- Data Synthesis and Report Compilation: The extracted information from the selected papers was synthesized, and key points, summaries, and conclusions were documented.
- Citations and References: Proper citations and references were provided for each paper or article included in the report, ensuring academic integrity and acknowledgment of the original authors' work.

It's important to note that the search for papers and articles was limited to accessible online resources and primarily in the English language. This may introduce a degree of selection bias and could exclude valuable research not available through these channels. By following this methodology, a diverse and relevant set of research papers and articles were identified and analyzed to create a comprehensive survey report on the chosen topic. This methodology ensures the rigor and credibility of the report by emphasizing peer-reviewed and credible sources while respecting ethical considerations in research.

IV. LITERATURE SURVEY

Contribution of Carpool towards Sustainable Urban Transportation – A Study of Ahmedabad City

Padiya & et al... [1] provide a study of the impact of and awareness about carpooling in Ahmedabad city. The objectives of the study include identifying motivating factors for carpooling, major hindrances and impact of carpooling. The researchers gathered data and surveyed carpooling users and non-users throughout the city. The study found that the average car occupancy rate in Ahmedabad can be increased from 1.97 to about 3 to 4 and traffic can be reduced by 34.42%. The majority of the carpooling users were from the income group of Rs. 3 to 5 lacs. The study also highlighted the importance of various features in carpool applications. Security-related features like brief profile of Car owner/ Co-traveler, Verification of Information about car owner by App and driving experience were considered most important while factors like caste, education and social media profile were not considered important. Things like ratings, age group, type of vehicle, gender and occupation were found to be moderately important. The study concludes that carpooling has the potential to significantly reduce vehicle density and pollution. Users consider pollution reduction and cost saving as two main reasons to opt for carpooling. Still, lack of flexibility and privacy are some of the main hindrances when it comes to carpooling. It also concludes that awareness campaigns and connectivity with trusted car users can significantly boost carpooling in India.

Potential of carpool for network traffic management

Yu (Marco) & et al... [2] examine the impact of carpooling on network traffic in a highly idealized futuristic world. They consider a world where all travellers are willing to participate in carpooling. The study focuses on building a

carpool model while considering trade-offs between travel cost saving and inconvenience. The study makes some key assumptions like considering the congestion effect to be negligible. Authors then consider models for one Origin-Destination (O-D) pair and cross O-D pairs. The study finds that for one O-D pair, when the inconvenience cost is less than the median trip valuation of a rider, the platform could always achieve an almost perfect match while maximizing commuters' welfare. It still yields positive results even when the inconvenience cost is too high though the perfect match may not be possible. The cross O-D matching, however, incurs higher inconvenience costs and traffic congestion. While the study provides some very good findings it also highlights its limitations. Firstly it makes some key assumptions that don't directly reflect real-world scenarios. Secondly, the network considered in the study has a special topology. The study also needs to consider real-world features like traffic dynamics and one-to-many matching.

Carpooling and the economics of self-driving cars

Ostrovsky & et al... [3] study the interplay between autonomous transportation, carpooling, and road pricing. They try to find a way to achieve efficient outcomes in transportation markets while taking into account the cost of driving, commute preferences and road capacity. The study highlights how self-driving cars can boost carpooling systems and provide many advantages. It proposes a market-based solution for designing an efficient transportation system, with road prices set at market-clearing levels by regulators and free coalition-formation markets for carpooling. It makes some assumptions like assuming that as long as the number of cars on a road segment is below the segment's capacity, the speed of the flow does not depend on the number of cars. While their model allows for time-varying demand for transportation and accommodates time-sensitive tolls, it assumes that demand fluctuations are known. Work needs to be done to incorporate real-world uncertainties in the model and improve it.

What encourages people to carpool? A conceptual framework of carpooling psychological factors and research propositions.

Julagasigorn & et al... [4] provide an overview of the psychological factors that motivate people to carpool. The paper identifies 18 psychological factors that motivate individuals to carpool, 11 of which were not previously included in research reviews. These factors can be categorized into those common for both drivers and passengers and those specific to each group. These psychological factors play a significant role in carpooling decisions. The paper presents a multidisciplinary conceptual framework for future research, incorporating theories from Social Psychology, Marketing, Sociology, and Information Systems. The paper highlights the practical implications of these factors for researchers, carpooling platforms, and policymakers, suggesting that these insights can be used to promote carpooling and improve the quality of carpooling service. This framework is expected to enhance the understanding of carpooling decision-making mechanisms.

Carpooling Systems for Commuting among Teachers: An Expert Panel Analysis of Their Barriers and Incentives.

Rey-Merchán MDC & et al... [5] examine the attitudes and preferences of teachers regarding carpooling as a mode of transportation. The study assesses the factors that motivate or discourage teachers from participating in carpooling and identifies key findings related to the incentives and barriers they face. The study also discusses potential solutions and strategies for promoting carpooling among teachers in a specific region of Spain, Andalusia. Authors conclude that cost savings related to fuel consumption are a significant incentive for carpooling among teachers. However, the importance of cost savings diminishes for shorter commutes. Female teachers expressed greater concerns about barriers related to gender, particularly when it comes to sharing rides with male co-workers. Finally, the study suggests that allocating some vehicles exclusively for women could reduce this barrier. The study recommends the development of an institutional carpooling program for teachers. Such a program would improve matching possibilities and reduce barriers related to meeting points, commute times, and gender preferences.

Company-Wide Carpooling for Long Distance Commuting in South Korea and Its Effects on Reducing Transportation Problems

Lee & et al... [6] study a unique carpooling program by the Korea Land & Housing Institute, focusing on its suitability for long-distance commuting. The analysis of carpooling satisfaction surveys and three years of usage logs reveals that carpooling is more popular among employees in their 40s and 50s for daily commuting. While many carpool less than twice a month, about 30% carpool three or more times monthly. Over three years, driver participants averaged 11.8 carpool trips, with all carpoolers expressing satisfaction. Notably, there were twice as many passenger participants, demonstrating that carpooling can be a versatile solution when public transport is inconvenient. Increased carpool use suggests that encouraging carpooling through traffic management policies can ease congestion and reduce emissions and energy consumption.

Smart peer car pooling system

R. Hasan & et al... [7] propose a solution tailored to meet the intricate challenges of contemporary urban mobility. By effectively connecting travellers heading in the same direction, it significantly reduces the prevalence of single-occupancy vehicles on the road, leading to a considerable drop in traffic congestion and environmental consequences. The incorporation of features like real-time ride-matching, geolocation services, and secure payment options enhances the user experience, making carpooling a convenient and budget-friendly choice for urban travel. The accessibility of this technology through mobile applications and web platforms further boosts the overall convenience and accessibility of urban mobility.

Real-time carpooling and ride-sharing: Position paper on design concepts, distribution and cloud computing strategies

D. Dimitrijević & et al... [8] offer an optimized Real-Time Carpooling system with a user-friendly interface. They have designed a straightforward route request system, integrated with digital maps for a seamless travel experience. The system is highly reliable, featuring automatic route searching and backup systems for unforeseen events. If carpooling options aren't available, it will suggest the nearest public transport routes. User profiles contain all necessary travel information. Interactive credit systems gauge public opinion, and police cooperation ensures member safety. Unlike other projects, it comprehensively addresses carpooling aspects while considering past shortcomings. It utilizes the latest technology, particularly mobile phones, for universal accessibility.

Ucarpooling: Decongesting Traffic through Carpooling using Automatic Pairings

A. Lugo & et al... [9] present a dynamic concept that emphasizes shared car journeys to reduce traffic congestion and environmental impact. It leverages the power of smartphone apps and web platforms, allowing users to seamlessly connect and share rides with fellow commuters heading in the same direction. Ucarpooling is not only user-friendly but also cost-effective, with financial benefits stemming from the shared cost of travel. With real-time tracking and secure payment options, these systems enhance the overall experience, emphasizing safety, transparency, and convenience. Furthermore, user ratings and feedback mechanisms foster trust and accountability within the community of passengers and drivers. As cities worldwide grapple with urban mobility challenges, this solution offers a sustainable solution that promotes eco-friendly practices, curbing greenhouse gas emissions and energy consumption. By optimizing vehicle occupancy and encouraging shared rides, Their solution can play a pivotal role in reshaping the urban transportation landscape for a smarter, greener, and more interconnected future.

An Intelligent Carpooling App for a green social solution to traffic and parking congestions,

O. Dakroub & et al... [10] discuss a Real-Time Carpooling System with a server, client, and scheduler. The system allows multiple origins and destinations for carpooling. The server runs a carpooling scheduler and stores user and ride information, communicating rides to drivers and passengers. The client side is a smartphone application for user interaction. The scheduler aims to ensure that all users secure a ride by minimizing the number of operating cars, assigning roles of drivers and passengers, and finding the least-cost route for rides. The paper uses a genetic algorithm for carpooling optimization, with customized operators, and presents simulation results using real user data. The system

introduced combines a customized Genetic Algorithm with a structured initial solution that factors in carpoolers' preferences. A preliminary test and a survey were conducted to evaluate the model's efficiency in various scenarios. The simulation results, using actual data, demonstrate that the model delivers high-quality solutions within a reasonable timeframe. Their survey of users also further emphasizes this point.

Various other papers focus on optimizations for carpooling systems. **X. Xia & et al...** [11] delve into a unique carpooling challenge known as the Common Departure (CCD) problem, which aims to identify optimal matchings for carpooling with the least global travel cost. This problem is particularly relevant for facilitating carpooling among employees in large corporations. Such an approach has the potential to yield substantial societal and environmental advantages, including energy conservation and alleviating traffic congestion. **M. Anas & et al...** [12] employ a machine learning (ML) model in this study to categorize customers based on their personality types, using their tweets, and then group them with others who share similar personalities for carpooling. The goal is to eliminate the potential discomfort that can arise when traveling with individuals of differing personalities. **Y. Duan & et al...** [13] focus on eliminating the rigid capacity constraint for vehicles. Their approach enables vehicles to transport more passengers than their designated capacity by allowing passenger turnover during the journey. The paper introduces a greedy method rooted in multi-round matching and enhances it by leveraging geometric properties. The paper claims that the algorithms are put to the test using both simulated and real-world datasets, and the experimental findings demonstrate that our approach outperforms existing methods.

V. CONCLUSION

In conclusion, this paper provides an overview of the literature that delves into the multifaceted world of carpooling, shedding light on its numerous advantages, including economic benefits, traffic congestion reduction, and pollution mitigation. These also address the inherent challenges of carpooling and proposed innovative solutions, considering both logistical and social aspects. The evolution of carpooling technology and design, featuring advanced matching algorithms and dedicated lanes, has been highlighted as a testament to the innovation driving this transportation approach. These collective insights underscore the transformative potential of carpooling in urban environments and its resilience in the face of various challenges. Carpooling has proven itself adaptable, paving the way for a more sustainable and efficient future in urban transportation. As cities continue to grapple with issues of congestion, pollution, and resource allocation, the findings presented in this paper offer a compelling case for the continued exploration and implementation of carpooling as a key component of urban transportation systems, ultimately contributing to more sustainable and resilient cities.

ACKNOWLEDGMENT

The authors wish to express their sincere gratitude to all the researchers and scholars whose invaluable contributions and insights in the existing literature greatly informed and enriched this paper. Your work has been an essential foundation for our research, and we acknowledge your dedication to advancing knowledge in the field.

REFERENCES

- [1]. Padiya, Jasmin and Bantwa, Ashok, Contribution of Carpool towards Sustainable Urban Transportation – A Study of Ahmedabad City (November 22, 2020).ISSN 2046-0430
- [2]. Yu (Marco) Nie a and Ruijie Li b, Potential of carpool for network traffic management (June 2022)
- [3]. Ostrovsky, Michael & Schwarz, Michael. (2019). Carpooling and the Economics of Self-Driving Cars. EC '19: Proceedings of the 2019 ACM Conference on Economics and Computation. 581-582. 10.1145/3328526.3329625.
- [4]. Julagasigorn, Puthipong & Banomyong, Ruth & Grant, David & Varadejsatitwong, Paitoon. (2021). What encourages people to carpool? A conceptual framework of carpooling psychological factors and research propositions. Transportation Research Interdisciplinary Perspectives. 12. 100493. 10.1016/j.trip.2021.100493.

- [5]. Rey-Merchán MDC, López-Arquillos A, Pires Rosa M. Carpooling Systems for Commuting among Teachers: An Expert Panel Analysis of Their Barriers and Incentives. *Int J Environ Res Public Health*. 2022 Jul 12;19(14):8533
- [6]. Lee, JB. Company-Wide Carpooling for Long Distance Commuting in South Korea and Its Effects on Reducing Transportation Problems. *KSCE J Civ Eng* 26, 3226–3234 (2022).
- [7]. R. Hasan, A. H. Bhatti, M. S. Hayat, H. M. Gebreyohannes, S. I. Ali and A. J. Syed, "Smart peer car pooling system," 2016 3rd MEC International Conference on Big Data and Smart City (ICBDSC), Muscat, Oman, 2016, pp. 1-6, doi: 10.1109/ICBDSC.2016.7460384.
- [8]. D. Dimitrijević, N. Nedić and V. Dimitrieski, "Real-time carpooling and ride-sharing: Position paper on design concepts, distribution and cloud computing strategies," 2013 Federated Conference on Computer Science and Information Systems, Krakow, Poland, 2013, pp. 781-786
- [9]. A. Lugo, N. Aquino, M. González, L. Cernuzzi and R. Chenú-Abente, "Ucarpooling: Decongesting Traffic through Carpooling using Automatic Pairings," 2020 XLVI Latin American Computing Conference (CLEI), Loja, Ecuador, 2020, pp. 358-366, doi:10.1109/CLEI52000.2020.00048.
- [10]. O. Dakroub, C. M. Boukhater, F. Lahoud, M. Awad and H. Artail, "An intelligent carpooling app for a green social solution to traffic and parking congestions," 16th International IEEE Conference on Intelligent Transportation Systems (ITSC 2013), The Hague, Netherlands, 2013, pp. 2401-2408, doi: 10.1109/ITSC.2013.6728586.
- [11]. X. Xia, H. Liu, J. Li, X. Liu, R. Zhu and C. Zong, "Carpooling Algorithm with the Common Departure," 2019 IEEE International Conferences on Ubiquitous Computing & Communications (IUCC) and Data Science and Computational Intelligence (DSCI) and Smart Computing, Networking and Services (SmartCNS), Shenyang, China, 2019, pp. 513-520, doi: 10.1109/IUCC/DSCI/SmartCNS.2019.00111
- [12]. M. Anas, G. C and K. G, "Machine Learning Based Personality Classification for Carpooling Application," 2023 International Conference on Intelligent Systems for Communication, IoT and Security (ICISCoIS), Coimbatore, India, 2023, pp. 77-82, doi: 10.1109/ICISCoIS56541.2023.10100353.
- [13]. Y. Duan, T. Mosharraf, J. Wu and H. Zheng, "Optimizing Carpool Scheduling Algorithm through Partition Merging," 2018 IEEE International Conference on Communications (ICC), Kansas City, MO, USA, 2018, pp. 1-6, doi: 10.1109/ICC.2018.8422976.