**Evaluating graph algorithms for optimal ride sharing solutions**

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Abstract

*Since the start of the 21st century an exponential increase of interest has sprouted in the study of ride sharing methods for a multitude of reasons. It is the aim of this paper to understand the discoveries in the field as well as possible claims of finding optimized algorithms for a sample of objectives and to simulate one.*

**Keywords**: Ride sharing, route, minimum cost, algorithm, simulation

**Introduction**  
As interest in large projects such as hyper loops increase and increases in Electronic Vehicle (EV) manufacturing occur, additional focus on optimizing human travel continues to be at the forefront of study by public and private organizations. As shown by Martins et al in their paper *Optimizing ride-sharing operations in smart sustainable cities: Challenges and the need for agile algorithms* they show the exponential increase of terms such as “ride-sharing”, “car-sharing” and “carpooling” occurring in cited research from 2008 to 2019 with 0 to over 4000 citations, respectively. Understanding the general state of this body of research and the questions that have been asked, answered and unsolved is necessary to understand what topics might be useful to further the research in this wide field. This article attempts to understand the possible topics in the study of graph algorithms to solve optimization problems for objectives in ridesharing such as minimum cost to the driver or riders and minimum distance traveled, explore possible solutions proposed, and simulate the results of one of the compared algorithms.  
**Preliminary Review of Literature**

By first reviewing Martins’ paper, a researcher in car-sharing optimization can understand the breadth of possible topics and possible objectives worthy to be studied. The organization of the paper breaks down the possible objectives into several categories, covering 86 different research papers from a collection of 1,355 gathered. They first generalize car-pooling and ride-sharing with the term “car-sharing” and cite specific objectives for car-pooling, such as route optimization from source to destination, as opposed to ride-sharing, which has a higher tolerance for detours for additional passengers. They also discuss and categorize the methodology of each study into three main categories: exact, heuristic or metaheuristic, and other. But more importantly to Martins, as the title highlights, is the identification of algorithmic methods that employ metaheuristic elements in addition to simulation. This is well illustrated with figure 8 in the paper where the authors attempt to display the tradeoffs of the collection of algorithms examined into rankings across categories Dynamism, Optimality, Speed, Flexibility, Scalability, Uncertainty, and Scalability (Martins et al., 2021).

The rapid expansion of the field of this study can be validated further by examining Di Febbraro et al’s research in one of the earliest suggestions of a dynamic ridesharing system from 2013 (A. Di Febbraro et al., 2013). Their proposal suggests three objectives and proposes using mixed continuous-integer linear programming. While pioneers in adding simulation to their research, as additional papers were studied, the complexity of the systems increased significantly over time, as evident in Martins, as did the quantity and types of objectives.

Two objectives Martins et al highlight from a user’s perspective are the mixed type of travel possible, such as mixing ride shares and public transportation, and privacy users demand when using a dynamic system. Using a modified heuristic as introduced in pShare, by Huang et al, it can be understood why the exact methodology must be abandoned in favor of more metaheuristic solutions (Huang et al., 2022). Martins supplies a list of metaheuristics that includes genetic algorithms, tabu search, and greedy randomized adaptive search procedures. Interestingly, tabu search appears often in cited works. One example is the research by Ben Cheikh-Graiet et al in “*A Tabu Search based metaheuristic for dynamic carpooling optimization”* (Ben Cheikh-Graiet et al., 2020)*.*

While it is tempting to believe more complicated algorithms are superior to something such as linear programming, history shows favor to simplicity. As this research paper develops it is the goal to find a candidate for simulation and reperform the algorithm on a new dataset to simulate the example.

A. Di Febbraro, E. Gattorna, & N. Sacco. (2013). *Optimization of Dynamic Ridesharing Systems*. <https://doi.org/10.3141/2359-06> This article was useful to get a picture of what possible types of systems were studied in the past.

Ben Cheikh-Graiet, S., Dotoli, M., & Hammadi, S. (2020). A Tabu Search based metaheuristic for dynamic carpooling optimization. *Computers and Industrial Engineering*, *140*. <https://doi.org/10.1016/j.cie.2019.106217> This artilce was used to understand the functionality of Tabu Seach.

Huang, J., Luo, Y., Xu, M., Hu, B., & Long, J. (2022). pShare: Privacy-Preserving Ride-Sharing System with Minimum-Detouring Route. *Applied Sciences (Switzerland)*, *12*(2). <https://doi.org/10.3390/app12020842> This article gives an example of how research is implementing adjusted algorithms in integrate user privacy

Martins, L. do C., de la Torre, R., Corlu, C. G., Juan, A. A., & Masmoudi, M. A. (2021). Optimizing ride-sharing operations in smart sustainable cities: Challenges and the need for agile algorithms. *Computers and Industrial Engineering*, *153*. <https://doi.org/10.1016/j.cie.2020.107080> This article is used as a basis for understanding the general state of research in the field of ride-sharing study.

Possible additional research articles:

[**https://towardsdatascience.com/assigning-fastest-pick-ups-to-uber-drivers-with-linear-programming-8f8bd3c44c9a**](https://towardsdatascience.com/assigning-fastest-pick-ups-to-uber-drivers-with-linear-programming-8f8bd3c44c9a)