Title
Dynamic Routing to Improve the Efficiency of Ride-Sharing

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RESEARCH BRIEF

Dynamic Routing to Improve the Efficiency of Ride-Sharing

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Research Question

Traffic congestion causes significant economic costs, wasted time, and public health risks. According to the 2021 Urban Mobility Report, the total cost of congestion in 2019 was $190 billion in the U.S. and the total amount of delayed time was 8.7 billion hours with an extra usage of 3.5 billion gallons of fuel. The Harvard Center for Risk Analysis found that traffic congestion led to 4,000 premature deaths with a public health cost of around $31 billion in 2000 across 83 urban areas.

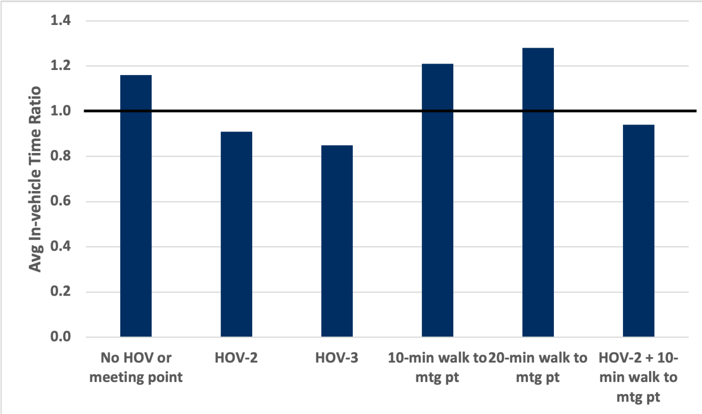
Ride-sharing, defined as a joint trip of more than two participants who share a vehicle that requires coordination among itineraries, has the potential to help mitigate congestion. Although this idea dates back to the 1940s, widespread adoption of the internet, the Global Positioning System (GPS), and wireless communications greatly expands the potential adoption rate of ride-sharing. A good ride-sharing system should provide quick response to passenger requests while identifying routes with minimum travel time. This is not an easy task, especially with dynamic passenger requests, variable request times, and cancelations of existing requests. One way to mitigate the effect of these uncertainties is to allow passengers to walk to a designated pick-up spot while waiting for the drivers, which can improve the system's efficiency. Taking advantage of ride-sharing incentives such as High Occupancy Vehicle (HOV) lanes can also reduce travel time and make ride-sharing more appealing.

Researchers at the University of Southern California developed a two-stage algorithm to solve the routing problem in real-time within a context where ride-sharing drivers are traveling toward their own destinations while making detours to serve passengers with flexible pickup and drop-off locations. This two-stage algorithm consists of an insertion heuristic to solve the pickup and delivery problem and a second-stage algorithm that can solve the meeting points problem optimally in polynomial time. The researchers also simulated operation of a ride-sharing system with and without HOV lanes and passenger meeting points, to determine the impact of these two factors on the operation of the system.

Key Research Findings

The use of HOV lanes improves the performance of the ride-sharing system. Using HOV lanes decreases the average in-vehicle time ratio—the ratio between the actual in-vehicle time and what the direct travel time would be without ride-sharing—compared to simulations with no HOV lanes (Figure 1, left). This is because HOV lanes increase driving speed. They also increase the percentage of requests that are served in the system (Figure 1, right), since the time saved by using HOV lanes can be used to serve more requests, and serving more requests, in turn, increases the possibility of using the HOV lanes.

The use of meeting points increases the use of the ride-sharing system. Passengers who congregate at designated meeting spots can be served more efficiently, resulting in fewer empty vehicles. The use of meeting points vs. no meeting points increases the use of the ridesharing system by 10.7%, which in turn leads to a 4.2% increase in the time spent by drivers in the ridesharing system and 4.3% increase in the average in-vehicle time ratio.



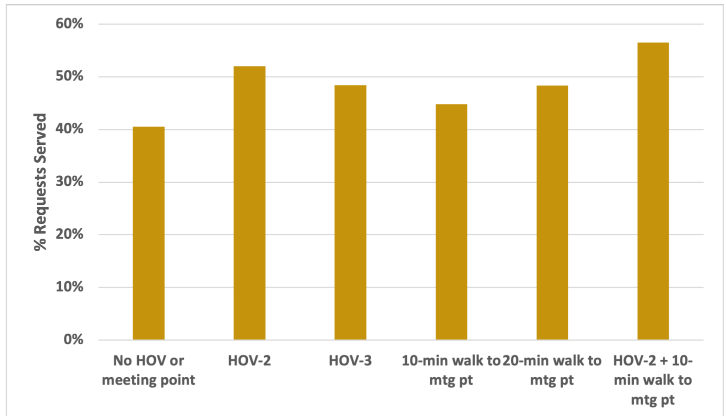


Figure 1. The performance of simulations with different combinations of HOV lane use and passengers walking to a shared meeting point with regard to average in-vehicle time ratio (left graph) and the percentage of ride requests served (right graph) in a ride-sharing system.

Combining meeting points and HOV lane access produces the greatest efficiency improvements. When the ride-sharing system allows a maximum walking time of 10 minutes to reach meeting points and allows vehicles with 2+ persons to use HOV lanes, the system can serve 39% more passenger requests while reducing the average in-vehicle time ratio by 19% as compared to simulations in which the ride-sharing system includes neither meeting points nor HOV lanes (Figure 1).

Research Implications

These results indicate that both HOV lanes and meeting points can increase the efficiency of a dynamic ride-sharing system. A good combination of HOV lanes and meeting points can provide passengers with lower commuting costs and a faster commuting experience. These results can inform policy makers and planners when making decisions about HOV lanes to support ride-sharing behavior.

More Information

This research brief is drawn from "Dynamic Routing with Ride-Sharing," a research report from the National Center for Sustainable Transportation, authored by Shichun Hu and Maged M. Dessouky of the University of Southern California. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/dynamic-routing-ridesharing.

For more information about the findings presented in this brief, contact Maged M. Dessouky at maged@usc.edu.

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