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National Center for Sustainable Transportation

RESEARCH BRIEF

Congestion Reduction via Personalized Incentives

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Research Question

Rapid population growth and development in cities across the globe have fueled an inescapable urban burden: traffic congestion. Congestion causes huge economic losses and increased vehicle emissions, which contribute to poor air quality. Over the past several decades traffic engineers have tried various strategies to reduce congestion, ranging from increasing roadway capacity to transportation demand management programs. Among the latter strategies is road pricing, which involves charging a fee for driving on a particular road or within a defined area. While promising for relieving congestion, road pricing proposals have faced equity concerns and low public acceptance.

An alternative travel demand management approach that has garnered less attention is the use of positive incentive programs—rewarding desirable behavior rather than penalizing undesirable behavior—to reduce congestion. Recent technological advances, including road sensors that provide real-time traffic information and widespread public access to smartphones with GPS technology, make positive incentive programs feasible. Thus, drivers have an efficient platform to continually communicate with a central transportation planner in order to find an optimal routing to avoid congestion. Using real-time traffic information, a central planner could then influence each driver's routing decision by providing incentives to encourage a socially optimized outcome such as minimization of greenhouse gas emissions, total travel time, or congestion (Figure 1).

Researchers at the University of Southern California developed a real-time, distributed

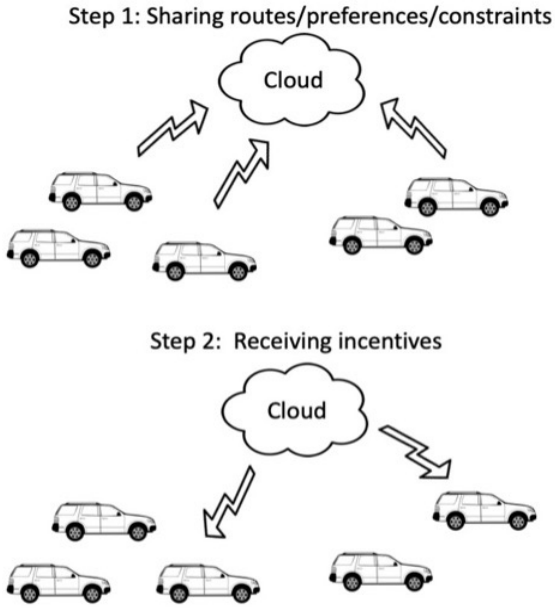

Figure 1. Framework for offering incentives

algorithm for offering personalized incentives to individual drivers to make socially optimal routing decisions. The methodology relies on online and historical traffic data as well as individual preferences and routing options from drivers' origins and destinations to estimate both the traffic condition and the drivers' responses to the provided incentives. The algorithm is designed to avoid creating new congestion in other parts of the network. The researchers also developed a simulation model to evaluate the performance of the proposed method using data from five southern California counties stored in the University of Southern California's Archived Data Management System.

Key Findings

The proposed mechanism allows for drivers' smartphones to be used for computing the optimal incentives. The optimization problem is large and complex to be solved in

real time. Using drivers' mobile devices can distribute the computational burden.

Offering incentives to optimize total travel time savings across the system can reduce carbon dioxide (CO_2) emissions by up to 27% during Los Angeles rush hour times. This approach to optimize system benefits may lead to congestion in parts of the network but is much more effective in simulations than uniformly reducing congestion across different road segments in the network. The latter approach rarely reduced the network's CO_2 emissions by more than 10% in simulations.

Even providing a small incentive to 10% of vehicles can reduce CO_2 emissions in the road network. The simulations for morning rush hour times showed that even offering a monetary incentive of $1.50 on average to 10% of the vehicles can reduce CO_2 emissions by 5%–6%. Incentivizing 50% of the drivers with an average of $2–$3 per driver can reduce CO_2 emissions by more than 20%.

Increasing the budget available for incentives can further reduce travel time and emissions, up to a point. Simulations showed a diminishing return from increasing the budget. In some experiments, increasing the budget from $1,000 to $10,000 enhanced CO_2 reductions by almost a factor of four, while increasing the budget further to $100,000 led to only slight improvements.

Research Implications

This work shows that offering incentives for drivers to take alternate routes holds promise for reducing traffic congestion and emissions. However, the model only offers incentives to alter drivers' routing decisions. Future work should also consider the effects of offering incentives for travelers to change the time or even the mode of their trips. These options will bring additional flexibility to the model, which in turn will result in further congestion and emissions reduction.

More Information

This research brief is drawn from "Congestion Reduction via Personalized Incentives," a report from the National Center for Sustainable Transportation, authored by Ali Ghafelebashi, Meisam Razaviyayn, and Maged Dessouky of the University of Southern California. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/congestion-reduction-personalized-incentives.

For more information about the findings presented in this brief, contact Meisam Razaviyayn at razaviya@usc.edu.

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