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CHANGING WHAT'S POSSIBLE

A INCENTIVIZING INDIVIDUAL TRAVEL BEHAVIOR CHANGES FOR SYSTEM-LEVEL ENERGY SAVINGS

Updated: January 13, 2018

TITLE: Integrated, Personalized, Real-Time Traveler Information and Incentive Technology for Optimizing Energy Efficiency in Multimodal Transportation Systems

PROGRAM: Traveler Response Architecture using Novel Signaling for Network Efficiency in Transportation (TRANSNET)

AWARD: $3,780,000

TEAM: University of Maryland, Arizona State University, North Carolina State University, and University of Michigan

TERM: November 2015 – August 2018

PRINCIPAL INVESTIGATOR (PI): Lei Zhang

MOTIVATION

The transportation sector accounts for over 25% of total energy use in the United States. Significant energy savings could be realized in personal transportation by improving vehicle occupancy, correcting poor driving styles, and reducing congestion. Occupancy is only 40% of nominal capacity for passenger vehicles,[1] poor driving styles (e.g. rapid acceleration) contribute to a 45% reduction in on-road fuel economy per driver,[2] and congestion (which is related to non-optimal route choice) increases the energy used by up to 33%.[3] Better use of modes of transportation, including public transit and rideshare programs, can reduce overall energy use by increasing vehicle occupancy and mitigating traffic. A 1% reduction in overall energy use in the United States could be achieved by a relatively small number of travelers adjusting their current travel choices and driving style. The challenge is how to show the right travelers the right incentives delivered at the right time, for maximum energy savings.

TECHNICAL OPPORTUNITY

Widespread smartphone and location-based technologies enable researchers to reach individual travelers with a smartphone app and/or technology APIs (application programming interfaces) that are integrated into existing private-sector apps and government-operated commuter service platforms. Existing travel guidance and planning tools focus on helping individuals make travel choices optimized at the user level for objectives often unrelated to energy. Incentives through status-quo technologies are often static and impersonal, and consequently not always effective. Recent advances in the fields of large-scale transportation system modeling, agent-based simulation in transportation, dynamic network optimization, data analytics, cloud-based computing, and artificial intelligence applications in behavioral sciences have enabled the development and implementation of architectures that can deliver dynamic, personalized, and optimized incentives to travelers in a multimodal transportation system and at the metropolitan scale.

1 The National Highway Transportation Survey reports average occupancy of 1.67 persons over all types of trips. The average number of seats is assumed to be 4.

2 Sivak, M. & Schoettle, B."Eco-driving: Strategic, tactical, and operational decisions of the driver that influence vehicle fuel economy", Transport Policy 22 (2012) 96–99. See also LeBlanc, D., Sivak, M., and Bogard, S. "Using Naturalistic Driving Data to Assess Variations in Fuel Efficiency among Individual Drivers" University of Michigan Report UMTRI-2010-34, December 2010.

3 This is an approximation of the maximum effect. See Roughgarden, T., "The Price of Anarchy in Games of Incomplete Information", http://theory.stanford.edu/~tim/papers/inc.pdf.

INNOVATION DEMONSTRATION

The University of Maryland (UMD) project seeks to optimize monetary and non-monetary incentives to gain maximum energy reduction in the Baltimore-Washington metropolitan area. These incentives will help guide travelers to adjust their travel mode, departure time, route, and driving style for energy efficiency. The UMD project has developed a system model (SM) that utilizes real-time and archived data from the Regional Integrated Transportation Information System (RITIS) hosted at UMD, and consists of integrated dynamic traffic, individual travel behavior, and energy use simulators. RITIS provides real-time data regarding incident, event, detector, probe, weather, transit, and other data including ITS device status. The dynamic traffic simulator uses Intel's multi-core parallel computing technology, the OpenMP, to ensure rapid analysis. The model employs a novel behavioral user equilibrium theory that focuses on actual traveler behavior. The energy use estimator utilizes real-world vehicle trajectories supplemented with in-vehicle powertrain control parameters to enhance accuracy. The SM is integrated with an incentive structure referred to as the incentive/control architecture (IA). The IA was tested and verified via a market adoption survey and incentive framing experiment with more than 2,000 participants in the Baltimore-Washington metro area. An algorithm coupled with a decentralized method for large-scale incentive allocation problems optimally allocates real time and personalized incentives for energy savings.

The integrated SM and IA (named incenTrip, see Figure 1) are capable of simulating all trips of multimodal vehicles in the Baltimore-Washington metro area, covering 5,744 square miles with more than 8.2 million people, for real-time energy use prediction at the trip level and incentive optimization at the user level. For comparison, the traditional travel demand model of a similar network requires about 30 hours of processing time on a high-end workstation. incenTrip works with OpenMP and Spark to process 8 billion data records each day. UMD also successfully developed and tested a new smart phone app to be deployed in the Baltimore-Washington metro area.

IMPACT PATHWAY

Commuter Connections, a regional network of transportation organizations coordinated by the Metropolitan Washington Council of Governments, deployed the incenTrip technology to incentivize departure time shifts. Over 20,000 commuters rely on Commuter Connections for free up-to-the-minute ridesharing information. The project team is collaborating with private sector mobility service partners to deploy incenTrip APIs that enable dynamic and personalized incentives in existing travel services. The incenTrip app, encompassing all new technologies from this ARPA-E project, is ready for deployment and officially launched in Washington, D.C. in early 2018. The project team has established a startup company to take the technology to market, and is exploring how to take the technology to more cities.

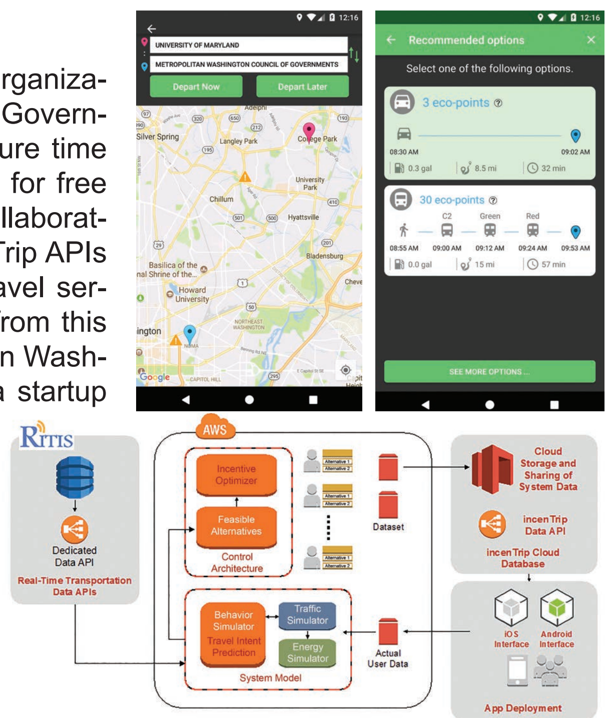

Figure 1: incenTrip Technology Deployment via a Smartphone App (top), incenTrip Technology Overview (bottom).

LONG-TERM IMPACTS

The complex nature of transportation system dynamics means that significant energy savings could be realized with even small behavior adjustments by a few travelers. Connected and automated vehicles will further facilitate the implementation of dynamic trip incentives. Successful demonstration of the incenTrip technology in the Baltimore-Washington metro area could pave the way for long-term energy savings across the United States.

INTELLECTUAL PROPERTY AND PUBLICATIONS

As of November 2017, the UMD team has produced 20 peer-reviewed publications.