Traffic congestion during peak hours, mainly created by solo-driver commuting trips, has become a serious issue around the globe. In the U.S., the ability of public transportation services in shifting commuter mode choice from solo driving to transit has been limited due to transit’s constrained geographical coverage, operational windows, frequency of operation, and etc. Despite their increasing popularity, Transportation Network Companies such as Uber have been shown to create empty miles, adversely affecting traffic congestion. Although Peer-to-Peer (P2P) Ridesharing can present a suitable alternative for serving commuter trips, there are several important obstacles that impede such systems from becoming a viable mode of transportation, including the lack of a guarantee for a ride-back home as well as the difficulty of obtaining a critical mass of participants.

This study addresses these obstacles by introducing a Traveler Incentive Program (TIP) to promote community-based ridesharing to commuters with a ride-back home guarantee. TIP allocates monetary incentives to (i) subsidize a select set of ridesharing rides, and, (ii) encourage a few, carefully selected set of travelers to change their travel behavior (i.e., departure or arrival time). We formulate the underlying ride-matching problem as a budget-constrained min-cost flow problem, and present a Lagrangian Relaxation-based algorithm with a worst-case optimality bound to solve large-scale instances of this problem in polynomial time. We further propose a polynomial-time budget-balanced version of the problem. Numerical experiments on the New York City Taxi dataset suggest that allocating subsidies to change travel behavior is significantly more beneficial than directly subsidizing rides. Furthermore, using a flat tax rate as low as 1% can double the system’s social welfare in the budget-balanced variant of the incentive program.

Figure: Results from Implementing TIP in the Manhattan area. First, most of the trips originate/end form/at the lower Manhattan area. Secondly, those users who start or end their trips in less popular zones are more likely to receive the incentive. Finally, as the popularity of a neighborhood decreases, the trips whose origin and/or destination stations fall into that region should expand their time windows by a larger extent.