



Introduction to the special issue on shared mobility systems

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An increased use of shared mobility systems such as bike sharing, ride sharing or car sharing is evident in recent years. These systems gain popularity as an alternative to using private vehicles since they have the advantage of reducing traffic congestion, parking space shortage, and air pollution. Shared mobility systems serve as a good complementary to mass transit systems, for example, as a convenient solution to the first and last miles of a journey. In addition, members of vehicle sharing programs have a lower tendency to own a private car.

Designing and operating vehicle sharing systems raises many interesting challenges. These problems range from long-term strategic issues to on-line operational decisions. On the strategic end of the spectrum, there are questions such as the economical, technological, and environmental viability of deploying new car or bike-sharing systems in a city. There are various possible modes of operation of vehicle sharing system: it can be station-based or free-float, round-trip or one-way (A to B). Next, the stations' location and capacity should be determined and at a more tactical level, pricing incentives and reservation policies should be set. Finally, at the operational level, vehicles' and stations' maintenance as well as repositioning/rebalancing decisions should be taken on a daily basis and sometimes in real time.

Various tools may be used to solve the above problems: forecasting using statistical and data mining methods, stochastic modeling, simulation and optimization using exact and heuristic methods. Vehicle sharing systems use modern

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information technology and generate large amount of data with many characteristics regarding the state of the system at each moment. This, in turn, may be used as a basis for strategic and tactical decisions. For example, in a bike-sharing system it is possible to react on-line to shortage of bicycles or lockers (docking poles) in a station by a repositioning operation. Moreover, by analyzing historical data it is possible to improve the process of long-term decisions such as determining the capacity (number of lockers) of a station.

While some of the above challenges address topics that are common to many other problems in the transportation and logistics literature, there are unique characteristics that correspond to shared mobility systems, which raise the need to develop new models and solution methods. This special issue contains four papers that contribute to the growing body of knowledge on the topic.

In the paper “Equilibrium design of a bicycle sharing system for Washington D.C.” Nahir and Miller-Hooks developed a model for determining the location of bike-sharing stations. This model is formulated as a bi-level mixed integer program where the upper level problem is setting the location of the stations such that the flow of users in the system is maximized. The lower level problem is minimizing the total travel time of each user by selecting the mode of transportation and the itinerary, given the location of the stations. This problem is solved independently by each user. A heuristic solution approach based on genetic algorithm is developed to solve large instances of the problem. The model is tested using a large dataset for Washington D.C.

Ciari, Weis and Balac take a different approach on the station location problem. In the paper “Evaluating the influence of carsharing stations’ location on potential membership: a Swiss case study”, a statistical model that describes the effect of the availability of round-trip car sharing stations and various demographic characteristics on the demand is developed. The output of the statistical model is used as an input for an optimization model that aims to maximize the carsharing membership. A genetic algorithm to solve this problem is proposed.

In the paper “Pricing in vehicle sharing systems: optimization in queuing networks with product forms” by Waserhole and Jost, a system that is already deployed is considered. The demand curve of each trip is assumed to be known. The vehicle sharing system is modeled as a closed queuing network with infinite buffer capacity and Markovian demands. The goal is to maximize utilization, subject to some constraints, by setting prices and incentives for each possible trip. This problem is solved heuristically using the maximum circulation on the demand graph together with a solution of an integer program obtained by a greedy algorithm. An upper bound on the approximation ratio delivered by this solution method is proved.

Fricker and Gast consider another aspect of influencing the demand with the purpose of balancing a vehicle sharing system. In the paper “Incentives and redistribution in bike-sharing systems with stations of finite capacity” they use a mean-field technique to examine a policy that aims to reduce the number of events in which users are unable to return a bicycle at their destination. According to this policy users are asked to specify two possible destination stations and the system directs them to the least loaded one. It is shown that such a policy can significantly improve the service level provided to the users. Another outcome of the analysis is a

general observation regarding the desired ratio between the number of bicycles and lockers in the system, which should be slightly more than half.

The above contributions demonstrate some of the important topics that arise in designing and operating shared mobility systems. There are many other problems that still need to be addressed. A close collaboration between the operators of shared mobility systems, policy makers and transportation scientists is required. This may assist in focusing the research on practical problems that need to be studied and in translating the contribution of the academic community into actual improvements of decision processes made in these systems.

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