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Using bilateral trading to increase ridership and user permanence in ridesharing systems

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ABSTRACT

One of the main obstacles that has challenged peer-to-peer (P2P) ridesharing systems in operating as stand-alone systems is reaching a critical mass of participants. Toward this goal, we propose what we call the *P2P ride exchange* mechanism to increase matching rate and customer retention in a ridesharing system. This mechanism gives riders the opportunity to purchase other riders' itineraries while it provides suitable alternative rides to the sellers, thus increasing the service rate in a ridesharing system. The proposed mechanism aims to maximize expected user surplus, is robust towards selfish user manipulation, and has very low information requirements. Using numerical experiments, we demonstrate what type of ridesharing systems can benefit the most from P2P ride exchange. Furthermore, we study the impact of customer flexibility on the rate of exchange. If implemented properly, P2P ride exchange can effectively increase the number of served riders and enhance customer loyalty by engaging customers in the ride-matching process.

1. Introduction

Peer-to-peer (P2P) dynamic ridesharing is a shared mobility alternative in which peer drivers and riders (passengers) share the space in the drivers' personal vehicles. The term "P2P" implies that drivers are not hired by companies to transport passengers, but are rather using their personal vehicles to carry out their personal tasks, which makes them peers to riders. The term 'dynamic' highlights the fact that customers can join the system at any point in time and do not have to book their trips in advance.

P2P ridesharing manages to eliminate vehicles from roads by getting people who are traveling in the same direction in the same vehicle. P2P ridesharing benefits drivers, riders, non-users, the transportation infrastructure, and the environment. Drivers receive monetary compensation for the service they provide while following their own daily schedules, and riders are charged less than other transportation alternatives, such as taxis. By reducing the number of traveling vehicles and hence congestion levels, the benefits of P2P ridesharing are extended to the entire community as well as the environment.

Contrary to traditional service businesses where servers belong to the business and their number is proportional to the demand for service, in P2P ridesharing servers are also customers. Therefore, it is important for the system operator to attract the right proportion of riders and drivers. Another feature of P2P ridesharing systems is that drivers typically have specific locations where they start and end their trips, and tight travel time windows to carry out their trips. This limits the level of spatiotemporal coverage of the network by each driver. Therefore, in order to serve a higher number of riders, a ridesharing

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system needs to increase the spatiotemporal coverage of the network by increasing the number of drivers. To motivate, attract and retain a high number of drivers, a high number of riders is necessary. Therefore, the number of customers in a P2P ridesharing system should pass a certain critical mass with a specific proportion of drivers to riders, in order for the system to be able to operate independently and without a need for outsourcing supply.

A ride-matching algorithm is the engine of a P2P ridesharing system, determining how drivers and riders should be paired. Except for very simple and non-efficient ridesharing systems (which we will discuss later), the ride-matching problems are computationally hard to solve. A good ride-matching method is one that can provide the highest number of matches in an attempt to engage the highest number of customers and bypass the critical mass of participants.

Customer experience is another factor that plays a role in the success of a P2P ridesharing system, especially during the initial phases of implementing the system. A customer (rider or driver) may give the system a chance by attempting to use the system a few times, but if he/she is not matched, there is a possibility that such a customer would never return to the system. Therefore, it is essential for a P2P ridesharing system to involve and retain as many customers as possible.

Customers in many transportation systems are served on a first-come, first-served (FCFS) or a similarly pre-ordered basis. For P2P ridesharing, in which customer retention is especially important, considering riders on an FCFS basis is an inefficient use of the very limited available resources (drivers). The FCFS rule, however, is the natural order of serving riders in a dynamic system, where riders announce their trips not long before departure. In addition, dropping the FCFS principle may lead to high solution times for the resulting matching problem, and is therefore not an appropriate implementation strategy for a dynamic real-time system.

In this paper, we introduce what we call *P2P ride exchange*, a mechanism to improve the number of matches in an FCFS-based system. In a system where P2P ride exchange is implemented, riders will still be considered for service on an FCFS basis. Upon joining the system, a rider will be offered the best available itinerary, according to certain criteria which we will discuss later. However, if no match exists, the rider will be given the chance to buy a previously-matched rider's itinerary under specific circumstances. Purchasing an itinerary from a previously-matched rider is in fact reversing the FCFS rule. This exchange of rides is accompanied with an exchange of money through the system. Since the objective of the system from implementing the exchange mechanism is to increase the total number of matched riders, only riders for whom an alternative itinerary is available will receive a proposal to sell their current itineraries.

There are, admittedly, considerable regulatory obstacles to overcome for such P2P exchange or trade schemes to be used in transportation systems. The legal battles faced by ridesourcing firms are now well-known. Transportation supply being considered a public good, any breaking of the traditional FCFS operational paradigms also could face objections based on socio-political arguments of inequity across users. While important, such topics are considered beyond the scope of this paper that focuses only on showing the performance potential of the proposed scheme.

2. Related work

P2P ridesharing systems are a member of the family of shared-use mobility alternatives. There is an abundance of work in the literature on the benefits ridesharing systems offer in terms of reduced direct and indirect cost to the environment and the society (Chan and Shaheen, 2012; Morency, 2007; Heinrich, 2010; Kelly, 2007). Despite these benefits, ridesharing operators have been facing multiple challenges in running ridesharing systems as stand-alone businesses. Furuhata et al. (2013) conduct a thorough survey of different types of ridesharing systems, and discuss some of the challenges that have prevented these systems from reaching their potential, despite the improvements in communication technology, prevalence of GPS-enabled cell-phones, and ease of developing cellphone applications that greatly facilitate participating in ridesharing systems.

Ultimately, for a ridesharing system to operate successfully, it has to attract and maintain a critical mass of customers. An essential challenge practitioners face is finding the most effective way to build this critical mass (Cervero and Griesenbeck, 1988; Brereton and Ghelawat, 2010; Raney, 2010). James Shield of Carma Technology Corporation which develops carpooling applications is quoted in an article by Gaynor (2015) to believe that although there is no definitive answer to this question, attracting a higher number of drivers, increasing marketing efforts, improving the technology, and attempting to use a societal/behavioral approach to engage people and make habits are all valid approaches.

Research in the field of marketing has found customer satisfaction, among other factors, to be a great predictor of customer retention rate (Gustafsson et al., 2005; Ranaweera and Prabhu, 2003; Rust and Zahorik, 1993). A satisfied customer not only has a higher likelihood of returning to the system, but also generates positive word of mouth (WOM) that helps in attracting new customers (Söderlund, 1998). Research has shown that WOM is a more important factor when it comes to deciding on services, rather than goods (Buttle, 1998). In addition, the cost of customer acquisition is about five times the cost of customer retention (Pfeifer, 2005), suggesting that a customer's first few experiences with the system play a central role in its long-term success. In light of these research studies, it is very important for ridesharing systems, especially in their initial stages, to serve as many ride requests at possible. In addition to a high matching rate, the responsiveness of the system to dynamic ride requests could play a role in customer satisfaction. Dynamic systems which try to address requests in real-time score high in this respect.

Encouraging a high number of drivers to participate in the system is another goal of a ridesharing system, albeit not as important as the first one. The reason is that firstly, drivers who participate in ridesharing usually receive a base fare regard-