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1 Introduction

In this paper, we consider the planning of privately owned autonomous vehicles' trips in a ride-sharing application. Emerging challenges, such as the finite oil supplies, rising gas prices and traffic congestion, going in hand with the environmental concerns have increased the interest in ride-sharing applications that can bring together travelers with similar time schedules [1]. Those arising challenges justify the need of new transport innovations, like autonomous (most likely electric) vehicles, which will play a major role in future mobility systems. Regarding autonomous vehicles (AVs), two ways of using AVs in future transportation systems are widely being considered. These are: using autonomous vehicles as a public service and using them as privately owned ones.

As such, this paper considers the use of autonomous vehicles (AV) as privately owned ones and the potential use of such vehicles in a ride-sharing system. The idea is that privately owned AVs can not just bring their owners from their homes to their work locations in the morning and bring them back in the evening while providing ride-sharing opportunities to other users, but they can also serve other users when their owners do not need them (while they are at work for example, see Figure 1).
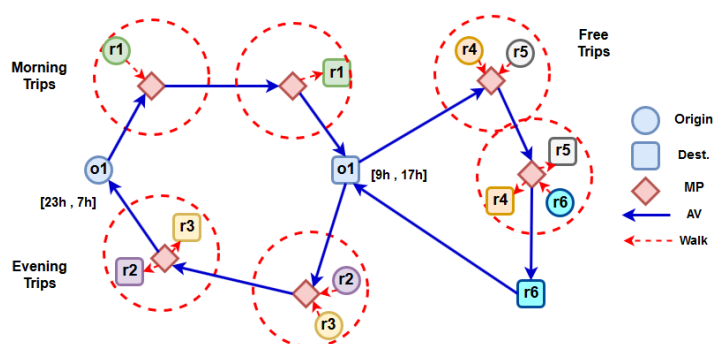

Figure 1: Autonomous Vehicles - Full Day Trips: o1 is the AV owner, r1, r2, r3 ... are riders, the AV brings its owner o1 from his home to his work in the morning and brings him back home in the evening, riders are picked up and dropped off at their home-/destination locations or at feasible meeting points (MPs), the AV can serve riders (r4, r5 and r6) while its owner (o1) is at work and must return to him before he finishes his work.

In this paper, we propose two different approaches for matching different users' trips during different periods of the day in a ride-sharing system with meeting points. The purpose is to evaluate the potential of including AVs in ride-sharing applications.

2 Problem description

In this problem, a set of trip announcements is considered. Every announcement is characterized by: an origin location, a destination location, an earliest departure time and a latest arrival time. The set of announcements is partitioned into two subsets; the set of ride-sharing

offers (including the case where the owner is participating in the trip or where the AV is serving others when its owner does not need it,like in Figure 1: o1 morning trip from home to work, AV round trip while o1 is at work, etc.) and the set of trip announcements by the riders (Figure 1: r3 trip from origin to destination). Every AV owner (like o1 in Figure 1) specifies a maximum trip duration, which indicates how much extra time he can afford to accommodate a shared ride, and the number of available seats. On the other hand, every rider (like r2, r3, etc. in Figure 1) specifies the maximum distance that he is willing to walk to and from a meeting point. A set of meeting point locations is given. A rider can be picked up at his origin or at one of his feasible pickup meeting points and dropped off at his destination or at one of his feasible drop-off meeting points. A feasible meeting point is a point which the rider can reach in an acceptable walking distance (i.e. less than the maximum walking distance that he specified). The distance and the travel time between every two locations are considered.

A match is a combination of an AV ride-sharing offer, a set of riders and a trajectory that indicates the route which the autonomous vehicle will follow. A feasible match must satisfy the capacity constraint of the autonomous vehicle and the time constraints of its participants (owner and riders) and must, at the same time, achieve a distance saving compared to the case of non-shared (individual) trips of both the AV owner and the riders. A match is time feasible if it respects, for all the participants, the earliest departure times from their origins and the latest arrival times at their destinations and, for the owner, the maximum trip time. By solving this problem, the goal is to maximize the number of matched participants.

3 Solution approach

In order to solve this problem, we propose two approaches: a heuristic algorithm and a complete model. The first approach is an extension of the two-phase algorithm introduced in [2]. The two phases are: a preprocessing procedure and a matching method. In the first phase, the preprocessing procedure, we look for feasible matches for every ride-sharing offer recursively and we add them to the matching problem. The matching problem is modeled as a maximum weight bipartite matching problem [2]. In the second approach, we propose a column generation model in which a resource constrained shortest path problem is solved to generate new matches for every AV owner. Both approaches aim at maximizing the number of matched participants.

4 Conclusion

To conclude, the main contribution we intend to achieve in this paper is considering privately owned autonomous vehicles as shared ones bearing in mind that the considered trips can take place during different periods of the day, including the time when their owners do not need them.

References

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