EE364B - Convex Optimization II: Project Proposal

An Energy-Efficient Ride-Sharing Algorithm Using Distributed Convex Optimization

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INTRODUCTION

With a rising need for transporting people from one place to another especially within urban spaces, many mobility-on-demand (MoD) systems like Uber, Lyft and the like have burgeoned to provide swift and efficient mobilty services within just a few taps through our smartphone devices. Although carpooling, an inherently fuel-efficient concept, has penetrated into this market (e.g. Uber Pool, Lyft Line), these ride-sharing algorithms are presently not centered around dispatching vehicles in a manner that optimizes passenger pick-up and drop so as to minimizes fuel use/energy consumption in that phase of travel as well (1). With the rising level of tailpipe CO2 emissions, it is prudent to focus on fuel efficiency to curb climate impact from warming.

In this project, our focus will be on optimizing the fuel/energy use as autonomous taxi agents make decentralized passenger pick-up decisions based on various practical constraints, as part of localized clusters of connected cars. We intend to use distributed convex optimization running on each of these local clusters of networked vehicles, as the backbone for our ride-sharing algorithm that optimally picks-up and drops passengers. This has an objective to minimize fuel used or energy consumed in all phases of travel, thereby making carpooling a completely package of energy-efficient travel.

PROBLEM STATEMENT

We first establish a spatial cluster that spans a certain radius or a fixed number of vehicles that are in a certain proximity. The entire system could be modelled as a graph with multiple connected components (clusters) with an upper bound on the diameter of each connected component taken as individual connected sub-graphs (*Figure 1*). Passengers can spawn arbitrarily at any location on the map and demand a vehicle by establishing a destination. Passengers are mapped to attributes such as pickup location, drop location, time bound and a location buffer. The time bound parameter is an upper bound on the time taken to drop a passenger. The location buffer is a passenger's willingness to be dropped/picked up at a certain buffer distance from the actual pin-point location (2) (this would serve as a relaxation for our problem constraints of pick-up and drop locations). This relaxed constraint enables the vehicle to be fuel efficient as there is an opportunity for minimizing the out-of-the-way distance travelled by the taxi in order to pick-up/drop a passenger. Each taxi that is on the move has attributes such as current path/trajectory, cluster identity and the number of seated passengers (or alternatively, the number of vacant seats - because each vehicle would be capped on the number of passengers it can take). As the taxis move, they will leave one cluster and join another cluster and become a part of another cluster's locally run optimization. Alonso-Mora et. al. have presented a dynamic dispatch procedure that uses Integer Linear Programming to minimize the wait time of the passengers (3). We want to look at an optimization approach to dispatch vehicles in a fuel efficient manner. We expect behaviour of the model to maximize the fuel economy by reducing number of stops and choosing a path such as expressways or freeways where constant speed can be achieved and penalizing inter-neighbourhood path that has traffic signals and stop signs.

REFERENCES

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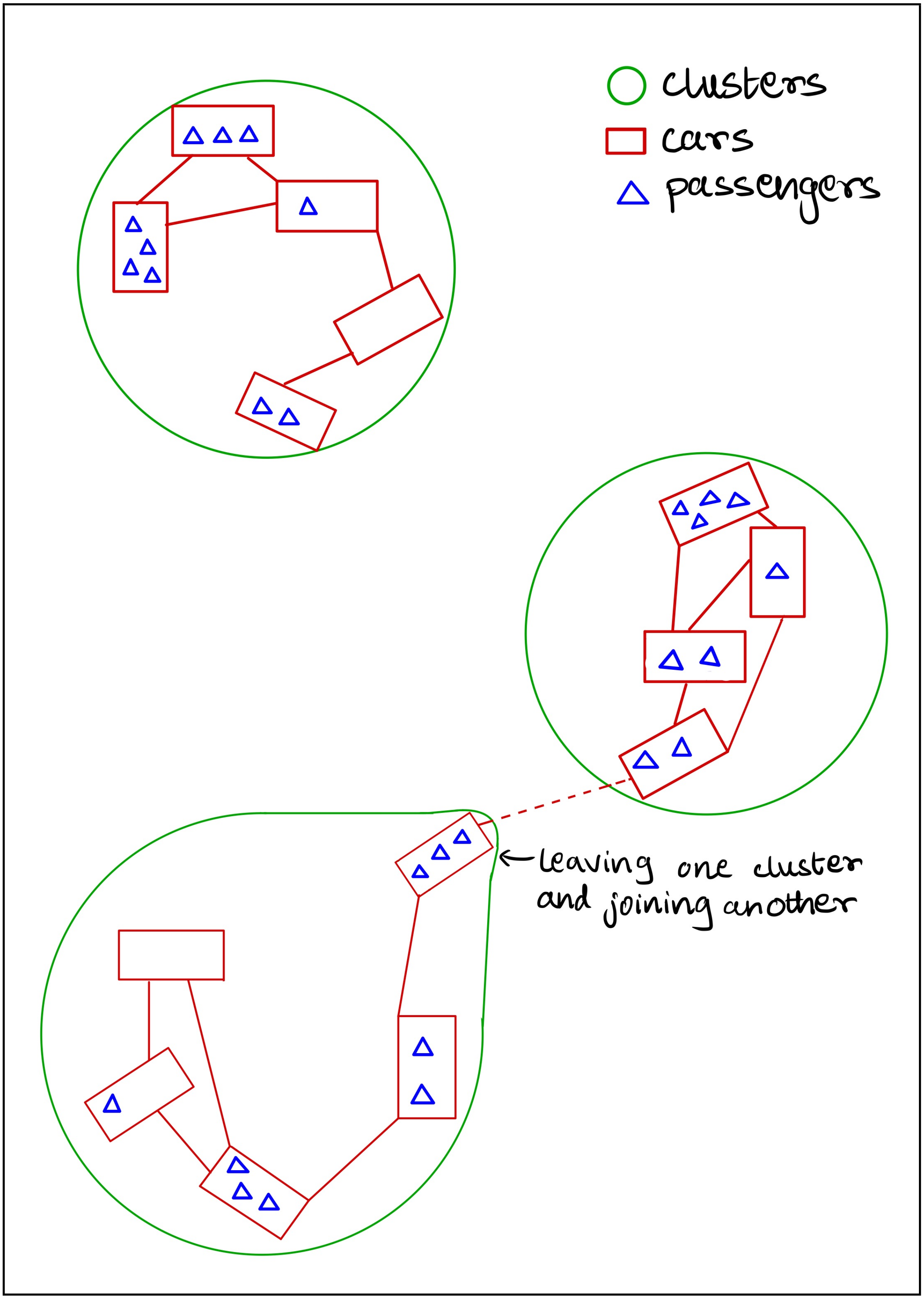

Figure 1: A schematic sketch depicting clusters of autonomous taxis with passengers