Carnegie Mellon University

THE ROBOTICS INSTITUTE

THESIS PROPOSAL

Expressive Real-time Intersection Scheduling: New Methods for Adaptive Traffic Signal Control

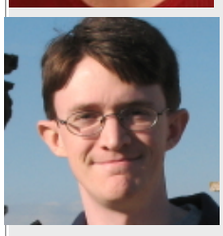
Tuesday, December 3, 2019
6501 Gates Hillman Center
2:30 p.m.

Thesis Committee:

Stephen F. Smith
Chair

Zhen (Sean) Qian

Zachary B. Rubinstein



Gregory J. Barlow
Rapid Flow Technologies

Rick Goldstein

Abstract

Traffic congestion is a widespread problem throughout global metropolitan areas. In this thesis, we consider methods to optimize the performance of traffic signals to reduce congestion. We begin by presenting Expressive Real-time Intersection Scheduling (ERIS), a schedule-driven intersection control strategy that runs independently on each intersection in a traffic network. For each intersection, ERIS maintains separate estimates for each lane approaching a traffic intersection allowing it to more accurately estimate the effects of scheduling decisions than previous schedule-driven approaches. ERIS outperforms a less expressive schedule-driven approach and a fully-actuated control method in a variety of simulated traffic environments.

We examine two limitations to ERIS that prevent it from enacting globally optimal scheduling decisions and discuss methods to improve schedule quality. First, we consider that while each intersection seeks to minimize a local objective based on delay, there will arise situations where global delay is not optimized. We propose CARIC (Centralized Agent Reducing Intersection Congestion), a centralized method that augments ERIS. CARIC generates potential green wave coordination plans, asks individual intersections to score these plans, and selects a plan that minimizes global delay. As a result of coordination, vehicles are able to travel across the network while encountering successive green lights, ultimately reducing delay and fuel usage when compared against a decentralized control strategy.

We then consider the limited planning horizon of ERIS. ERIS enacts decisions that appear to minimize the local delay for the known vehicle clusters, but it does not consider how its decisions may impact the delay of unknown clusters that will arrive in the future. Thus, we examine three modifications to ERIS - adapting the objective function to include a term for schedule makespan, generating expected vehicle clusters based on average arrival rates, and weighting the vehicles travelling each movement (direction) differently to improve the baseline ERIS algorithm. Preliminary work demonstrates that weighting vehicles can lead to a large reduction in delay when tested at a single intersection.

We propose the following areas to further study: (1) Implement an actual traffic network in simulation, using realistic levels of congestion, and run additional simulation experiments; (2) Additional work improving green waves and determining characteristics of when it is worthwhile to utilize green waves; (3) Further investigating the proposed methods that consider ERIS' limited planning horizon.