Traffic Signal Control Simulation and Optimization

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Goal

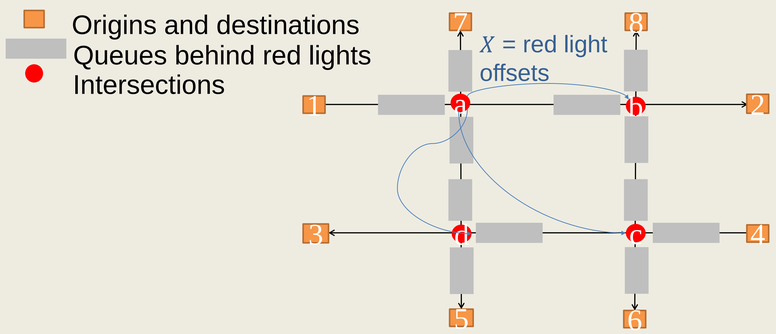
- We want to add multiple different problems in SimOpt library so that we can compare the solver's performance effectively and accurately

Modelling

- Inspired by Manhattan's grid with a few long two-way vertical arterial roads and a number of one-way crossing streets with alternating directions
- Generate origin and destination pairs and time of arrival for each car entering the system based on the arrival rate in each street and randomly generated probabilities for each destination
- Generate each car's route to their destination by Floyd–Warshall algorithm

[Objective function = average cycle time]

$$\min_{X} F(X; \xi \sim \exp(\lambda_i, i = 1,4,5 \dots, 8), \ell: \text{length of red and green lights})$$

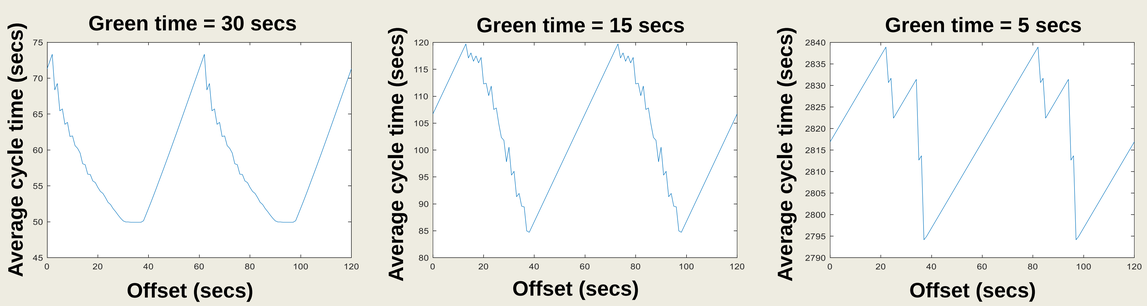


2 × 2 grid network example

Characteristic of Traffic signal control problem

- Sample path is non-smooth, non-convex function. In case of two intersections problem, the sample-path objective function shows two characteristics.
  1. periodic behavior;
  2. zig-zagging decline but sharp increase after reaching minimum value

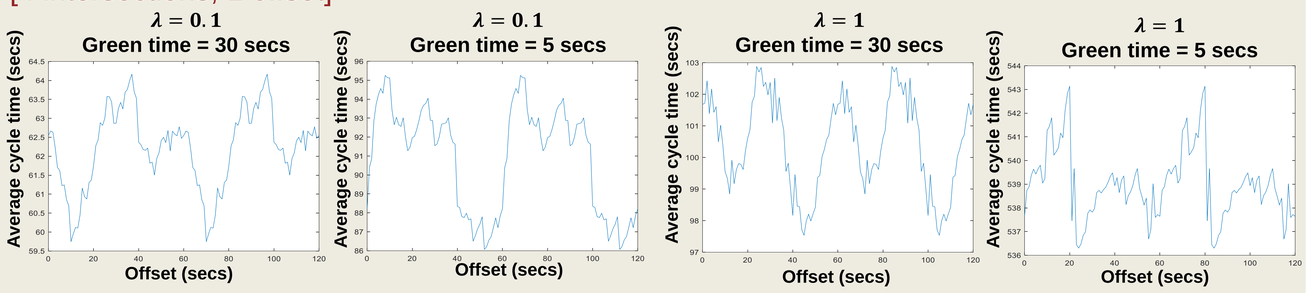
[2 intersections, 1 offsets]



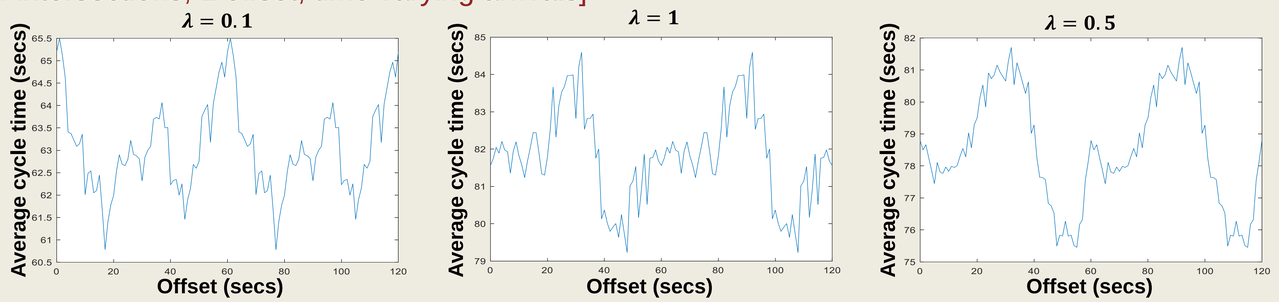
How we can make multiple different problems with the traffic signal control problem?

- Easily generate stochastic oracles of traffic lights with high dimensions by increasing the number of intersections.
- Span a variety of functional shapes and behaviors by varying the parameters that include the arrival, probabilities of choosing destinations, and the lengths of lights.

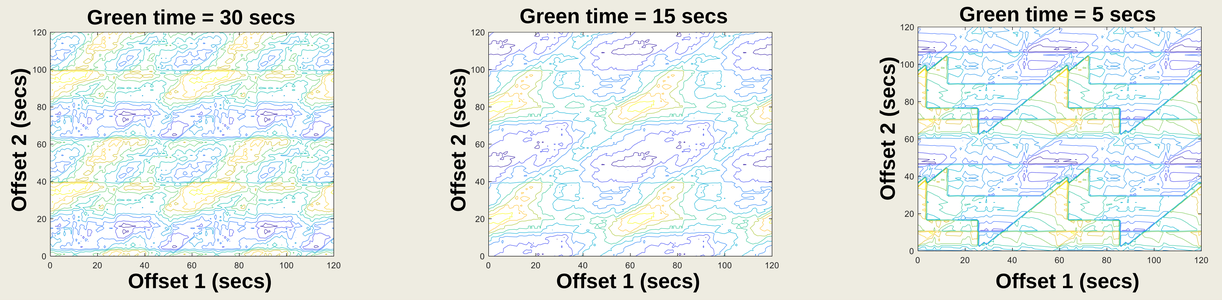
[4 intersections, 1 offset]



[4 intersections, 1 offset, time varying arrivals]

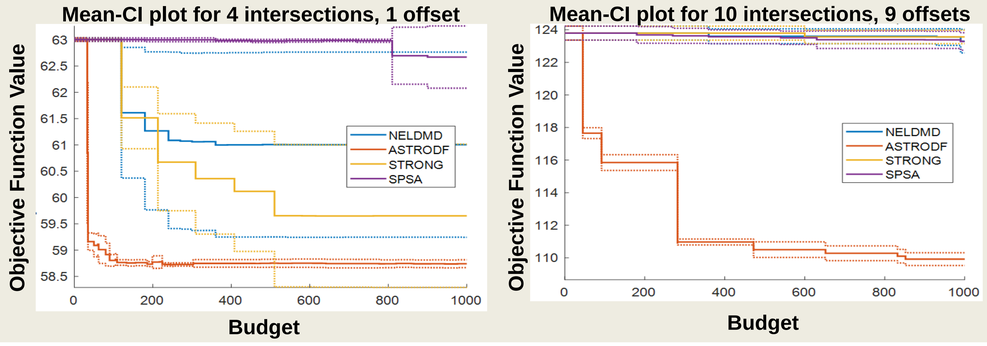


[4 intersections, 2 offsets]



Result

1. Model-based method
   - ASTRO-DF
   - STRONG
2. Direct-search method
   - NELDMD
3. Gradient-based method
   - SPSA



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