Maximizing Capacity of Urban Networks

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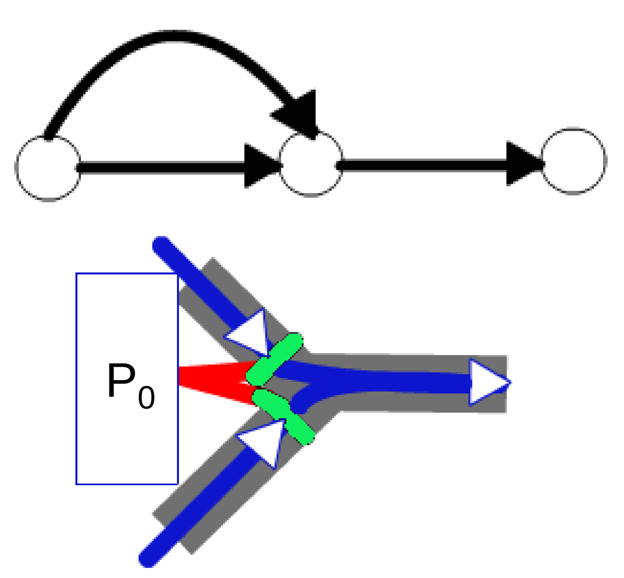
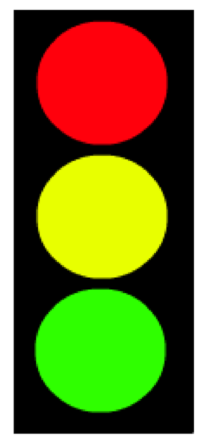
Abstract: A traffic network is assumed to have the same users each day. Given an origin-destination (OD) on any day, a driver is assumed to swap routes to a choice that is cheaper with respect to time. Given a set cycle time and swapping red times based on the pressure of each stage, the system maximized the capacity of a given network. The created scalable algorithm uses a 3 by 3 link node system, having one route as the arterial of the network. The model converges like the assumed behavior and the scaled network maximizes capacity.

Background

Wardrop Equilibria
- Dynamic System
- Route Swaps
- Assumed Behavior

P_0 Timing Plan
- How to Utilize Behavior?
- Swaps Green-Time
- Utilizes Wardrop
- Maximizes Capacity



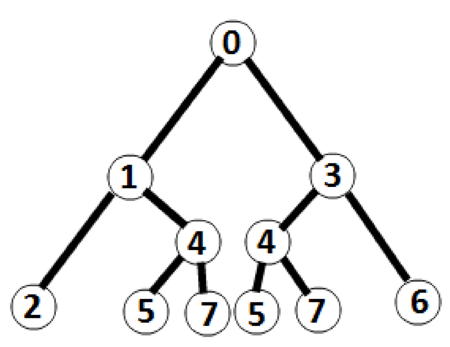


Methods

- Scalable Algorithm
- Implemented on python
- Origin Destination
- Route Swap
- Saturation Flow vs. Bottleneck Delay

Pressure Formula 1 [1]:
- Gradual Swap
- PressureStage1 > PressureStage2
- Green Swaps
- GreenTime2 ⟸ GreenTime1
- G1 + G2 = CycleTime

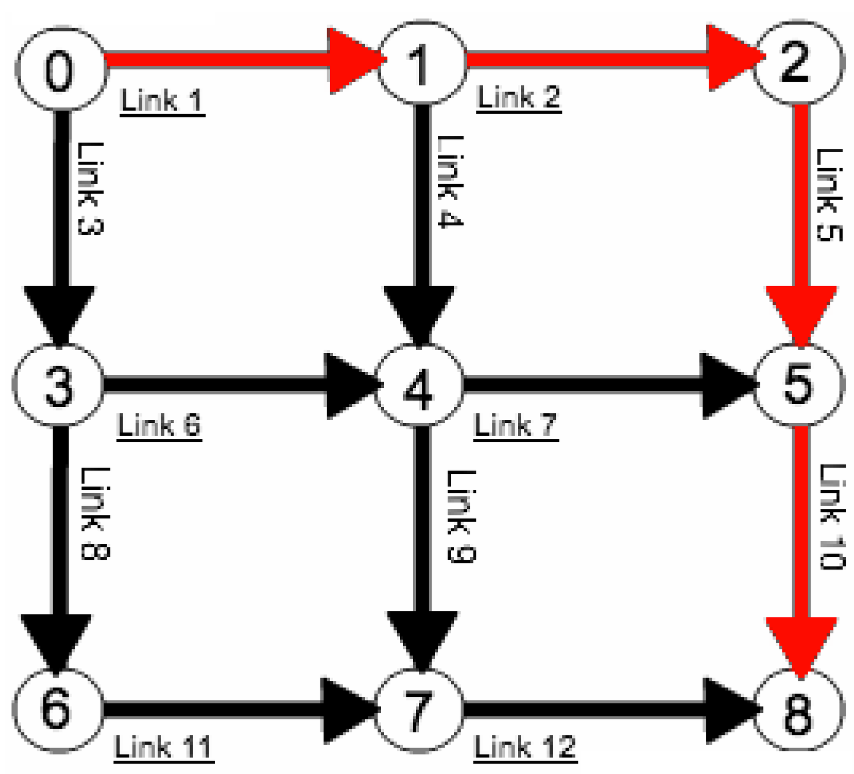
Pressure Formula 2 [3]:
- Exact proportion swapped each day
- $G_i = \frac{e^{\eta(s_1(Q_1 - Q_2))}}{\sum_{i \in j} e^{\eta s_i(Q_i - Q_K)}}$



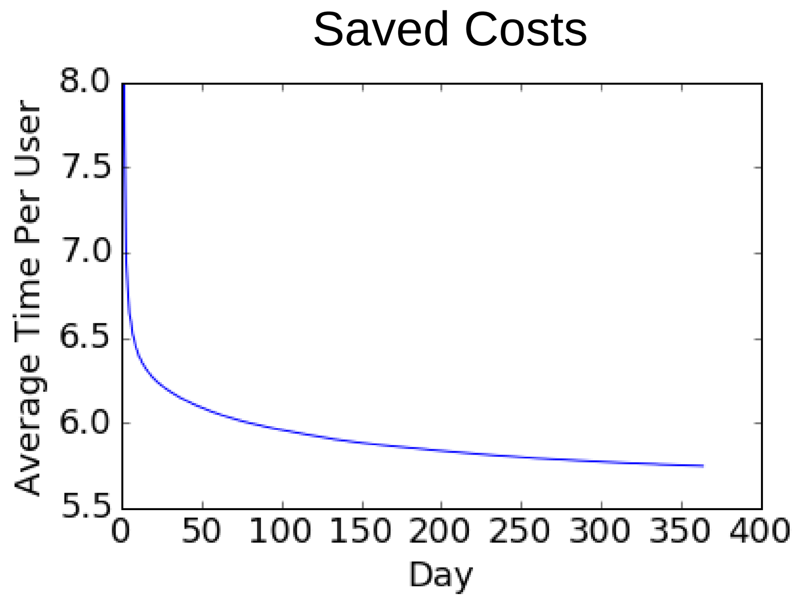
Time cost on link i:
$C_i = K_i + AX_i + b_i$

Route incidence matrix:

$$\begin{bmatrix} 0 \text{ or } 1 & \cdots & 0 \text{ or } 1 \\ \vdots & \ddots & \vdots \\ 0 \text{ or } 1 & \cdots & 0 \text{ or } 1 \end{bmatrix}$$



Data Analysis



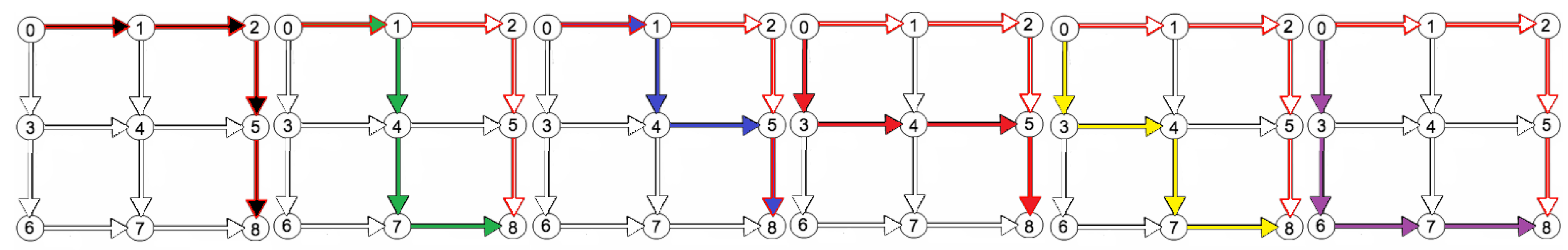
7.9 min – 5.7 min
2.2 minutes on average saved

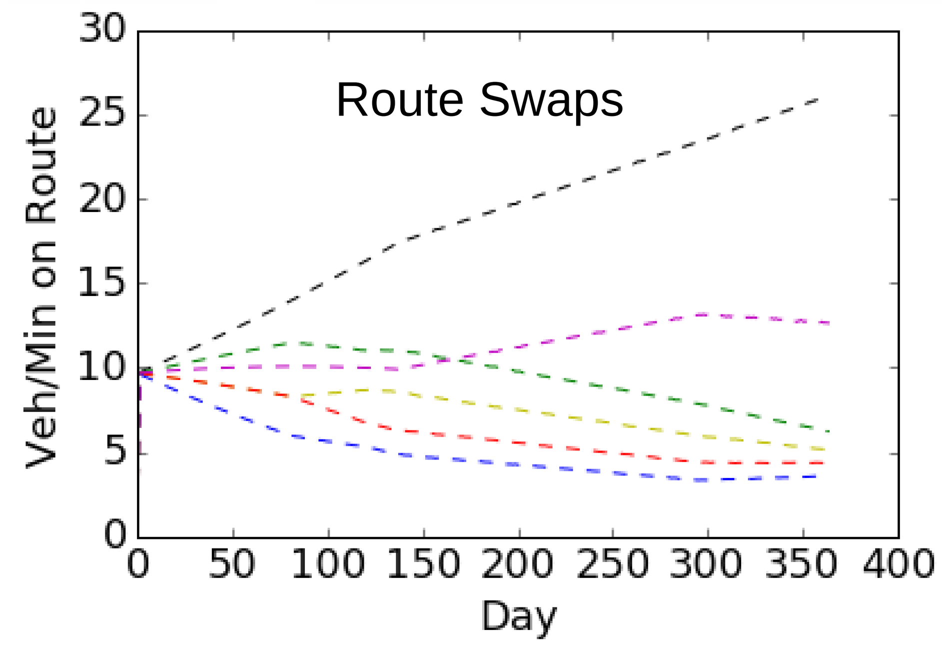
Demand
- 3 by 3 example
- Constant 60 users per minute
- 8 hours each day

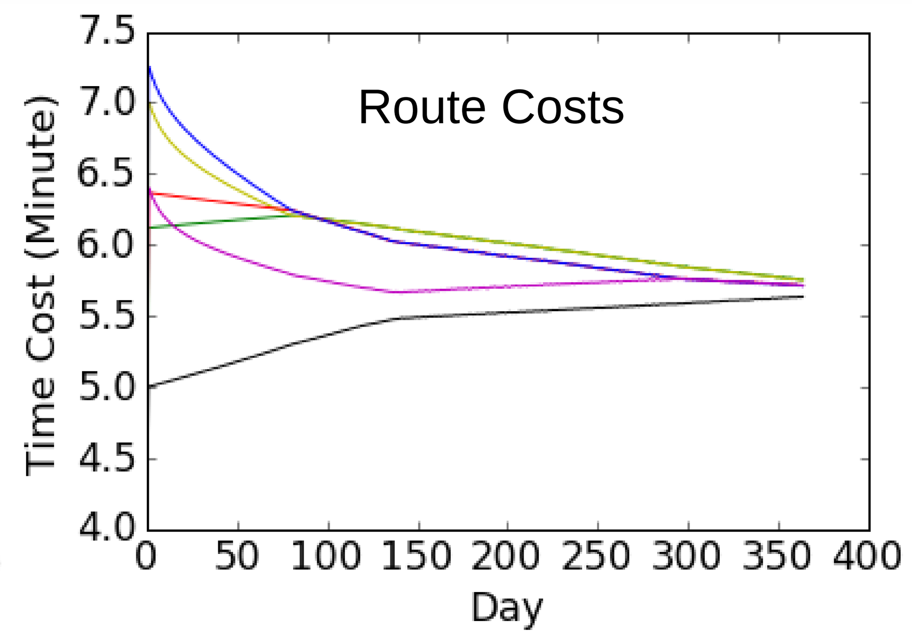
Tested:
- How the system swapped routes
- Which route swap method produced a higher capacity for a given network
- Saved time

Convergence

Routes



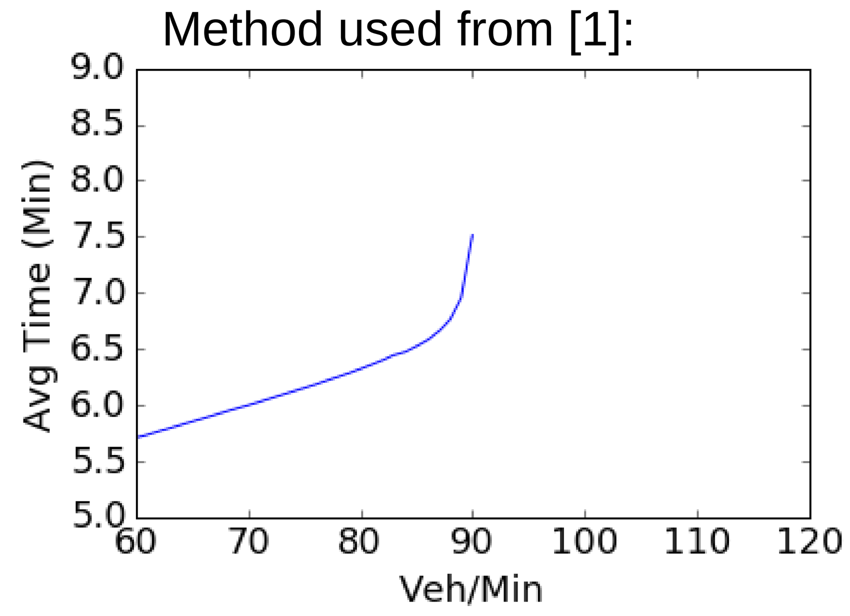


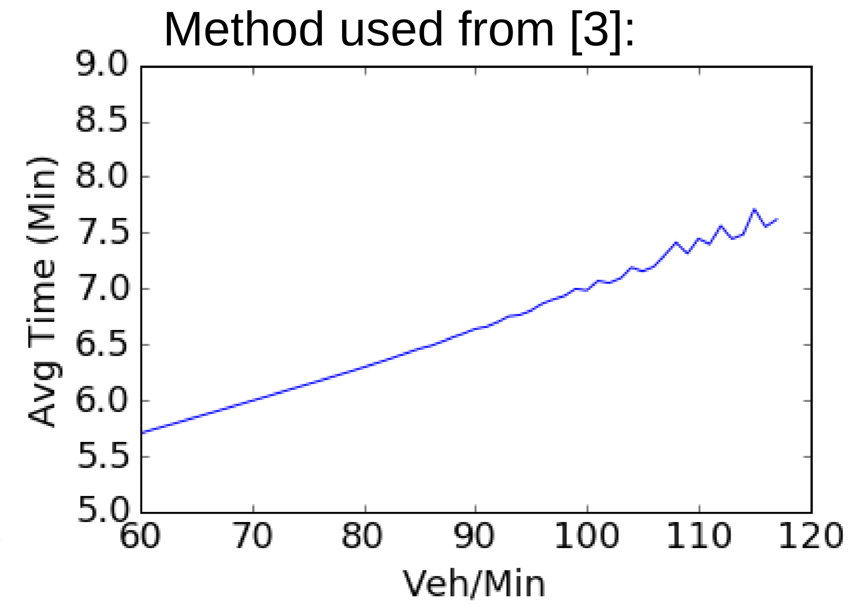


- Equilibrium
- Routes that shared more links had least flow

- Wardrop shown
- Diminishing Returns

Feasibility Test





Final Demand: 90 117

Discussion/Future Work:

- Roughly 44 years saved (once at equilibria)
- The arterial route was favored by almost half of the users
- Pressure method [3] obtained a 30% improvement compared to [1] pressure method
- The work done by [3] needs more integration into the model
- Advance the model to more dynamic routes, including multiple origin-destinations
- Obtain real data and potential test network for study, as well as creating dynamic method for fluctuating demand

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References:

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