Optimal Traffic Light Control With Pedestrians

By Joshua Koh, Supervised by Dr. Michael O'Sullivan and Dr. Cameron Walker

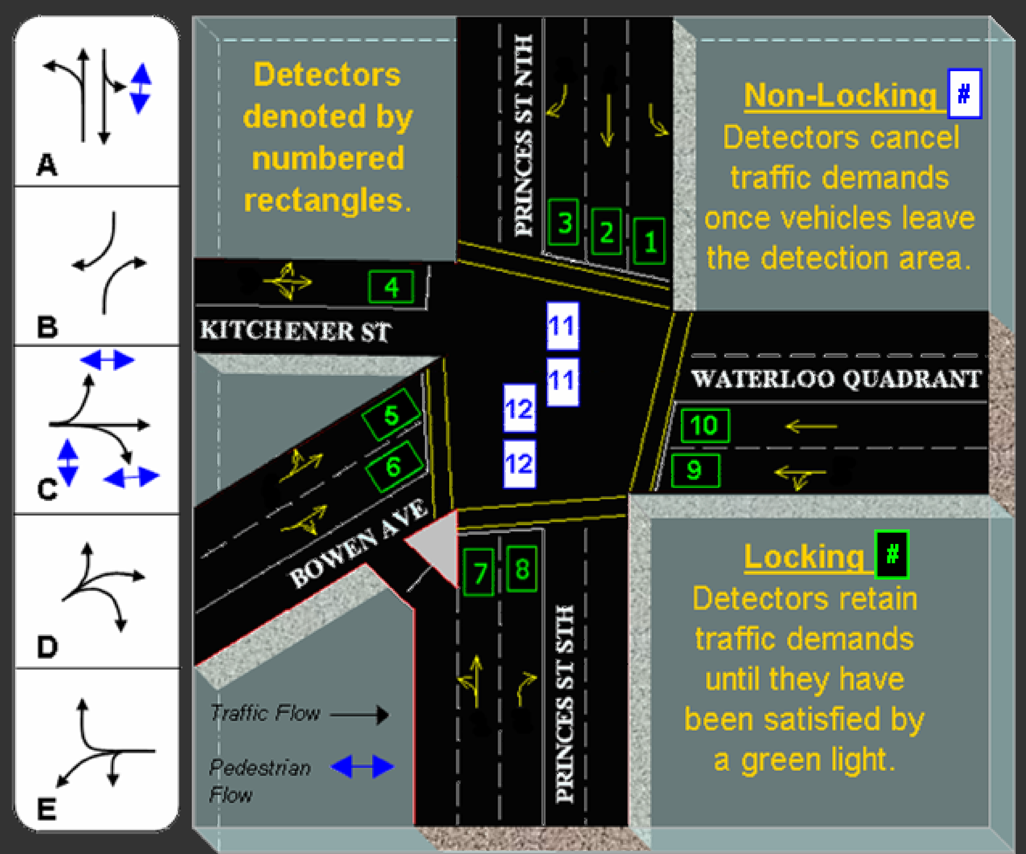
THE UNIVERSITY OF AUCKLAND
FACULTY OF ENGINEERING
TRANSIT NEW ZEALAND

Introduction

In this project, we utilised a simulation software package, Arena, to build a simulation model of the traffic control system at the Waterloo Quadrant – Princes Street intersection (Figure 1). Improvements, including pedestrian movements, were made to a previous traffic model developed by Jimin Hong.

GOAL: To create a realistic traffic model, then validate it using real system statistics, and finally, perform experiments to minimise the vehicle waiting time in system.

Figure 1. Intersection/Phasing Details



Pedestrian Interaction

The Waterloo Quadrant – Princes Street intersection signalised control is characterised by 5 distinct phases, A to E (Figure 1). Phases A and C allow pedestrian movement. These phases affect traffic in several ways:

- The green light for the phase has to run at least as long as the pedestrian cross signal (green and flashing red man)
- The pedestrian call-box registers a demand for a pedestrian right-of-way. The system controller then attempts to satisfy this demand as soon as possible.
- Pedestrians have right-of-way over turning traffic.

Methodology

Arrivals to System

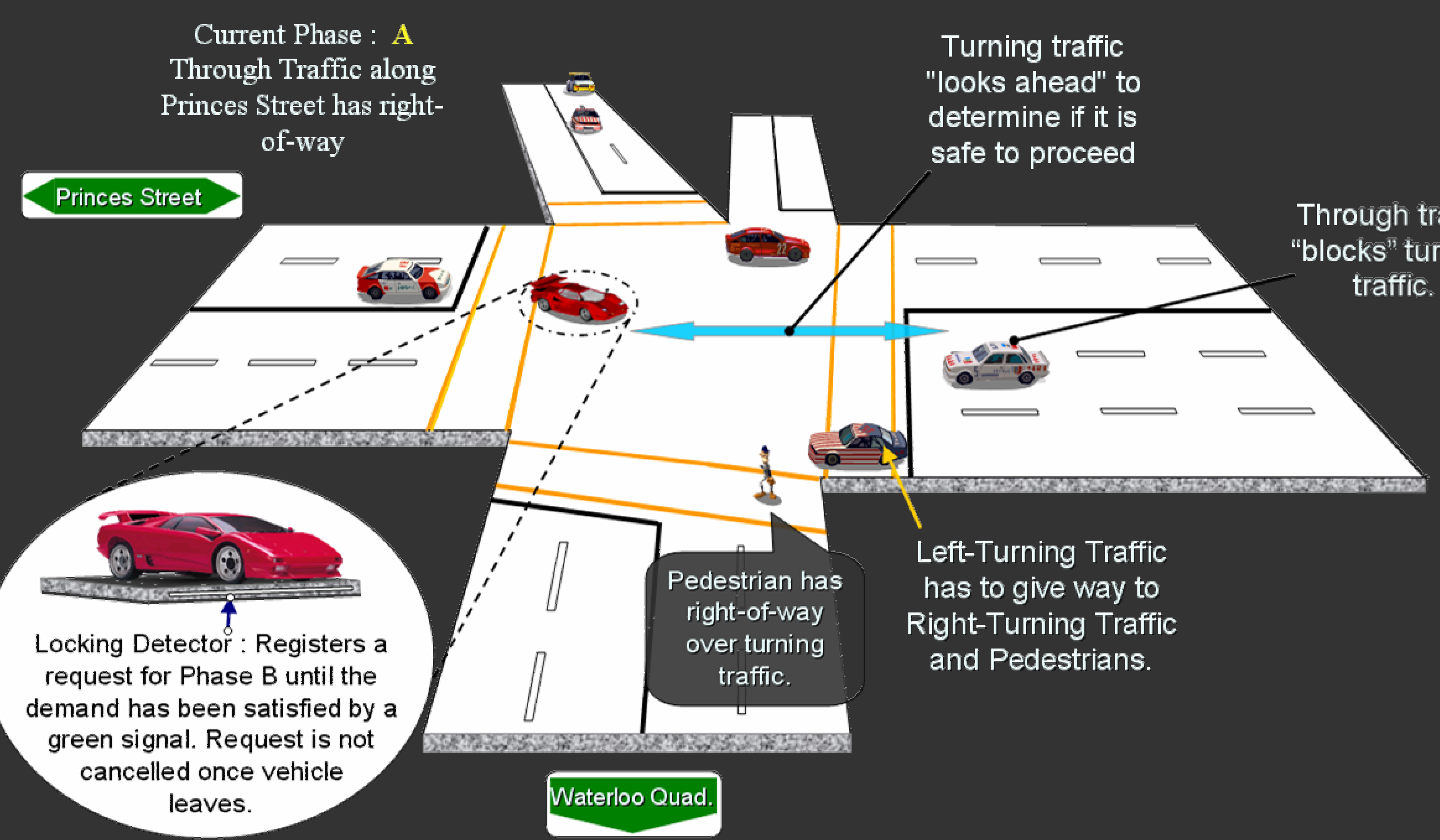
The key time periods we were interested in, were the AM peak (7-9am) and PM peak (4-6pm).

- Vehicle arrivals were generated using lane-by-lane arrival statistics over a 5-day working week.
- Pedestrian arrivals were generated using a piece-wise constant probability function.

Pedestrian Modeling

- Pedestrian phases governed by 2 settings, **Walk Time** (green man) and **Clear Time** (flashing red man).
- Pedestrians were assigned a normally distributed crossing time.
- In Phases A and C, competing traffic waits for pedestrians to complete crossing before proceeding.
- Crossing times were initially treated as unknowns and were initialised based on intuitive guesses.

Figure 2. Changes to the Traffic Model



Calibration

Used a built-in optimization software called Optquest.

- We specified the unknowns to be calibrated as control variables.
- We chose the phasing statistics (% of time and frequency per phase) as response variables.
- Optquest then adjusted the values of the control variables such that our model matches the real system.

Optimisation

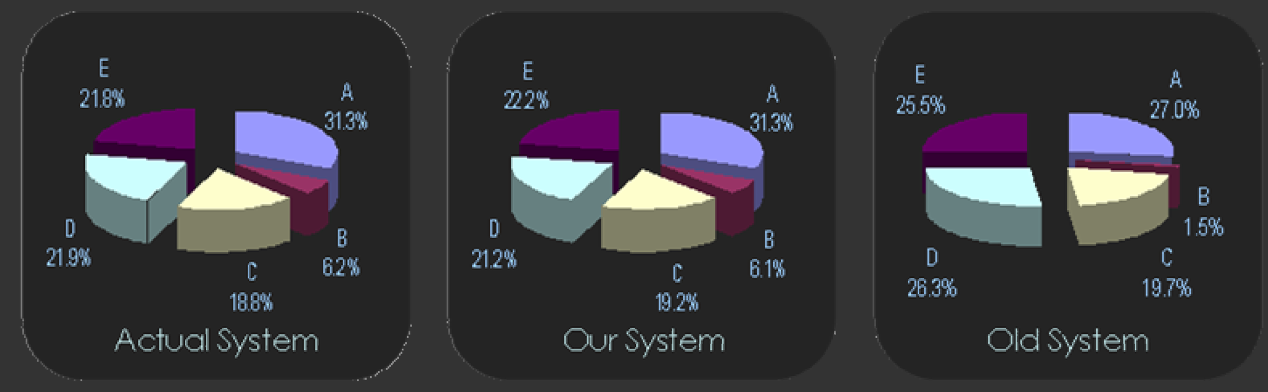
Used Optquest to minimise the **average waiting time** of vehicles in the system.

- We specified a minimise objective on the **average waiting time** (response variable).
- We specified all controller settings as control variables.

Results

The results of our calibrated model, compared to Hong's original model and the actual system are illustrated below.

Figure 3. Phasing Percentages (PM Peak)



System Fault

We uncovered an inconsistency with the actual and conceptual system configuration. Detectors 11 and 12 (Figure 1), were specified to be "**non-locking**", however, further investigation proved that the detectors were indeed **locking** and unnecessarily extending cycle time.

Through this, Transit New Zealand confirmed the presence of a software fault in the controller, which caused it to retain a Phase B call when it should have been cancelled due to non-occupancy mid-junction.

Table 1. Comparing Waiting Times (PM Peak)

	Average Waiting Time	Max. Waiting Time
Validated Model	52.52 seconds	125.9 seconds
Optimised Model	49.12 seconds	117.6 seconds
Optimised Model with non-locking Phase B	47.02 seconds	114.6 seconds

Conclusions

- Optimal values of the controller settings (by time period) from Optquest should be used to minimise the **average waiting time** of vehicles during peak periods.
- Detectors 11 and 12 should be set to "**non-locking**".
- Pedestrian detectors to allow for more efficient allocation of **Walk Time** and **Clear Time** in real-time.