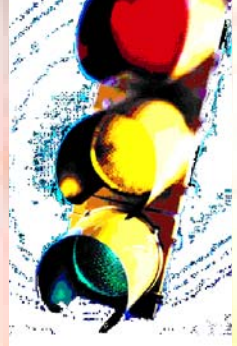
Simulation of a Traffic Light Control System

Jimin Hong Dr. Michael O'Sullivan Jr. & Dr. Cameron Walker
Department of Engineering Science



BACKGROUND

Intersections in Auckland

Delay at signalized intersections is a major source of frustration for drivers that we experience every day, especially in Auckland where the number of cars is growing even faster than its population.

We want efficient flow of traffic; minimal number of stops and minimal waiting time at the green light.

Current method - Vehicle-Actuated control

In New Zealand, traffic signals at intersections are controlled by Vehicle-actuated control with an additional Headway-Waste feature.
Using the vehicle detectors placed on the approaches, an actuated controller continuously "adjusts" phase length based on the "real-time" traffic demand.

Simulation of the Real-world intersection

Due to the randomness in traffic and the complexity in the control method as well as varying conditions for different intersections, we cannot study the signalized intersections using easy, analytical methods.
We need a "model" that virtually represents the real system so we can "experiment" with various options to evaluate the quality of performance and look for improvements. In this project we built and tested a simulation model of a real-world intersection (Waterloo Quadrant – Princes Street intersection).

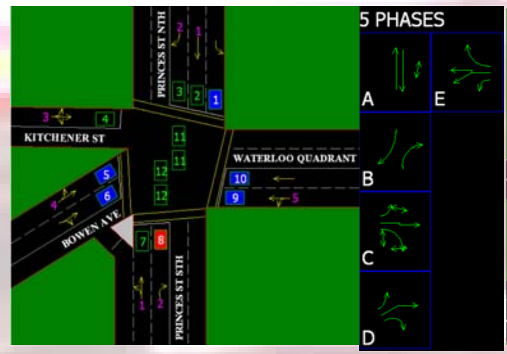


Figure 1: Physical layout of Waterloo Quadrant – Princes St. intersection and its 5 signal phases

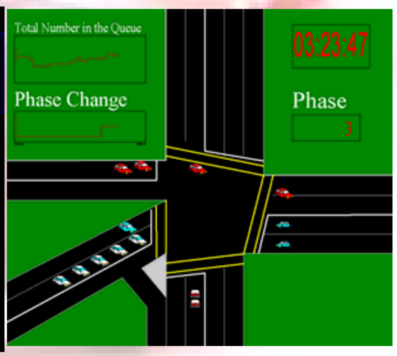


Figure 2: Screenshot of ARENA Simulation Model animation

OBJECTIVE

To build an accurate simulation of a traffic control system, and evaluate the effectiveness of three possible signal control methods - Pre-timed; Normal Vehicle-actuated control (with no Headway-Waste settings); Vehicle-actuated control with Headway-Waste settings (the current method).

METHODOLOGY

– EXTENSIVE SIMULATION MODELLING CYCLE

STEP1 - RESEARCH
Identify all the necessary features of the signal control mechanism; This includes dynamic interaction between system components with resulting logical complexity

STEP 2 - FORMULATION
Plan & Design the ways of "how" we translate the system into a model

STEP 3 – MODEL DEVELOPMENT
Utilise the ARENA simulation software package to build the computer representation of the system

STEP 4 - VERIFICATION
Test against the conceptual model

STEP 5 - VALIDATION
Compare against the real system

STEP 6 - EXPERIMENTATION
- Compare the current signal control method with two alternatives; pre-timed control; and vehicle-actuated control without the Headway-Waste feature. (Our measure of efficiency was the average vehicle waiting time)
- Sensitivity analysis: examining the effect of changes in the controller time settings on the vehicle's waiting time

STEP 7 - RESULT ANALYSIS

RESULTS

Figure 3: Comparison between Different methods - Average Waiting Time

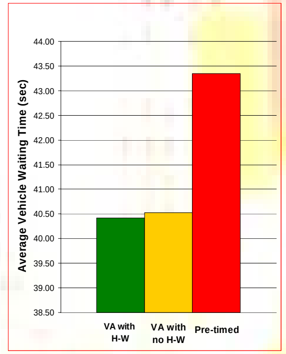
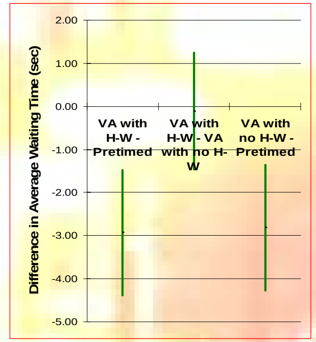


Figure 4: 95% Confidence Interval for Difference



Figures 3 and 4 show the results from the simulation for PM peak (4pm – 6pm). The VA with H-W resulted in the shortest average waiting time, followed by the VA with no H-W. There was no statistical difference between these methods (95% C.I contains 0.0 in Figure 4). The Pre-timed resulted in the longest average waiting time and this was proven statistically (95% C.I'.s do not contain 0.0).

CONCLUSIONS

- Our model replicates the complex logic of the vehicle-actuated control mechanism and gives a good insight into the real system.
(Note: the findings from this current model are limited to the signal control at intersections involving no pedestrian movement)
- This project was a good first step towards studying signalised intersections and provides a starting point for future traffic signal control optimization projects. In particular, the simulation can be a tool for evaluating proposed changes to the signal control method.
- Further study is encouraged to expand the model to take account of the pedestrians and the corresponding operations.