Actuated signal controller for Aurora RNM
- a preliminary note

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4 April 2008

0. Introduction

This note presents some preliminary ideas for implementing actuated signal controller into Aurora RNM.

1. Basics - Actuated signal controller (ASC)

This section provides some basics for actuated signal controller (ASC). Further details can be referred to Gomes and Skabardonis (2006).

Under actuated control each intersection operates locally, with no communication to adjacent intersections. The controller architecture has two levels: a *dual-ring controller* (Section 1.1) and a phase interval timing controller (Section 1.2).

1.1. The dual-ring controller

The objective of the dual-ring controller is to maintain safe conditions by allowing only compatible vehicle movements to enter the intersection at any time. Compatible movements or phases are those that:

1) belong to different rings;
2) are on the same side of the barriers (see Figure 1).

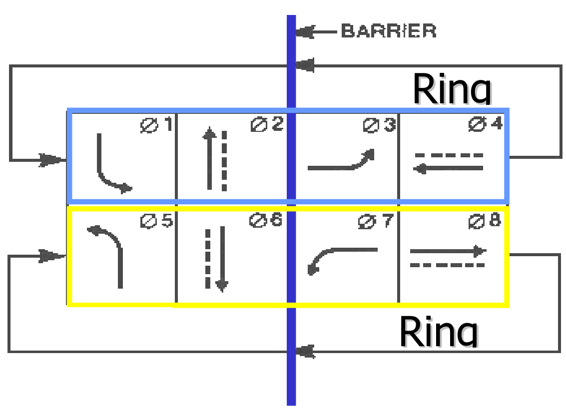

Figure 1 A dual-ring for a 8-phase intersection

Phases on opposite sides of a barrier are in conflict, and can therefore not be combined.

The controller advances by initiating phases and, upon termination, selecting the next one to execute. The upcoming phase is found by searching along the ring for the next protected phase which has either registered a vehicle presence or has been designated as a *recall* phase. Unprotected phases are always skipped. A recall phase cannot be skipped, even if no vehicle is registered by its stopline detectors. If no vehicle is registered on a non-recall phase, that phase may be skipped.

1.2. Interval timing controller

The timing of a phase is illustrated in Figure 2.

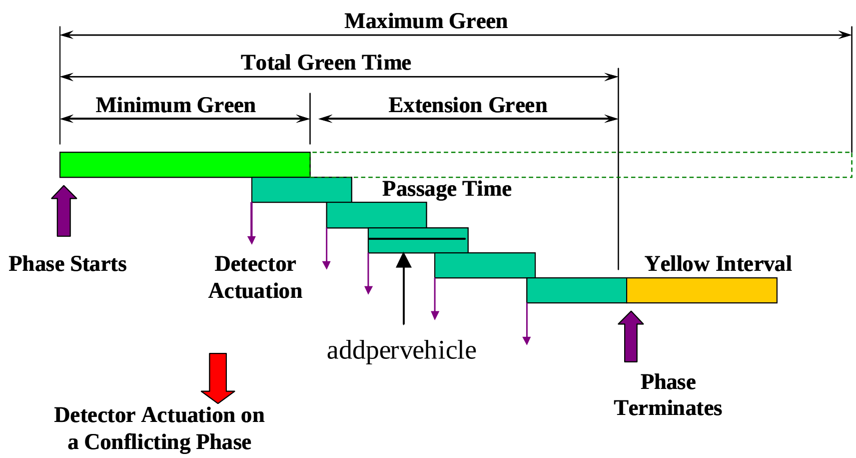

Figure 2 Interval timing

The dual-ring controller initiates the phase at “START". This point is synchronized with the transition from green to yellow of the previous phase (“END"). The initial wait period is equal in length to the yellow and red clearance intervals of the previous phase. Thus, the transition from wait to green is simultaneous with the transition from red clearance to idle of the outgoing phase. The green interval is divided into two portions: the initial green interval and the extension interval. The duration of the initial green interval is calculated based on the maximum number of vehicles registered by the approach loops during the preceding red interval. The result is limited by mingreen and maxinitial:

During the green interval, vehicles detected by an approach loop are given extension seconds of green time to move through the intersection, without exceeding the maximum green duration. The green interval ends when either:

i) the maximum green time is reached (max out);
ii) the time gap between consecutive vehicle actuations exceeds the ‘largest permitted gap’ (gap out).

The ‘largest permitted gap’ is a function of time, as plotted in Figure 3. It starts at ‘Maximum gap’ and begins to decrease after a vehicle is detected on a conflicting phase.

The size and frequency of the gap reduction is determined by reducegapby and reduceevery, and the minimum value is mingap.

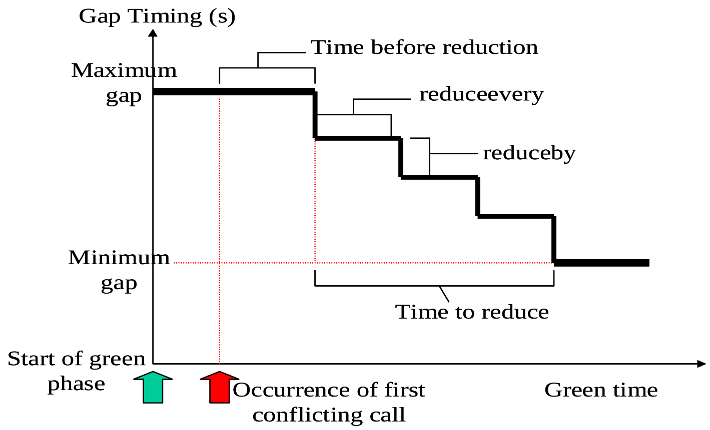

Figure 3 Permitted gap function

2. TOPL – Aurora RNM

The actuated signal controller is operated by individual (i.e. microscopic) vehicle detections.

Aurora RNM is a macroscopic model in which traffic is represented by flow, speed, and density. To implement ASC, we need to convert these macroscopic quantities to microscopic information (which is headway and/or spacing between vehicles).

Basic relationship between macroscopic and microscopic traffic quantities:

$$\bar{d} = \frac{5280}{\rho} \qquad (1)$$

$$\bar{h} = \frac{3600}{q} \qquad (2)$$

$$v = \frac{\bar{d}}{\bar{h}} \qquad (3)$$

where

$\bar{d}$ is the *average* spacing (ft) between two successive vehicles

$\bar{h}$ is the *average* headway (sec) between two successive vehicles

q, ρ, and v are flow (veh/hr), density (veh/mile), and mean speed (fps) respectively.

Note that $\bar{d}$ and $\bar{h}$ are microscopic data while q, ρ, and v are macroscopic.

At the moment, I can think of two approaches to determine the 'headways':

A. Deterministic approach: Given the flow, density, and speed (q, ρ, v), we assume that headways (and hence spacing) are fixed and determined by (q, ρ, v).

B. Stochastic approach: Given the flow, density, and speed (q, ρ, v), we assume that the headways are random variable following certain kind of distribution (e.g. exponential, by assuming that the arrival of vehicles is a Poisson process) with an expected value given by $\bar{h}$.

Having the headways (by either deterministic or stochastic approach), the profile of vehicle actuations should be able to be determined. Hence, an actuated control plan can be worked out.

Reference:

Gomes, G. and Skabardonis A. (2006) Paramics Plugin for Actuated Signal Control and First Generation UTCS. California PATH Working paper UCB-ITS-PWP-2006-08.