Traffic Signal Timing Optimization Analysis and Practice

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INTRODUCTION

The objective of traffic signal timing is to reduce traffic delays and possibility of accidents by minimizing the point of conflict and assigning right-of-way to different streams of traffic appropriately (Garber & Hoel, 2009). Traffic *signal timing optimization* adjusts signal timing to account for changes in traffic patterns due to new developments and traffic growth. It also reduces stops and delays, improves traffic flow through a group of signals, reduces emissions and fuel consumption and postpones the need for costly long-term road *capacity* improvement (Koone, 2008).

Outline

This paper studies the traffic signal optimization problem from a business analytics' aspect by comparing researchers' and practitioners' approaches. The research problem has been studied since the 1960s. For one-way streets with closely spaced traffic signals, the problem is formulated based on the *bandwidth maximization* principle, which has been used for a long time by off-line *signal timing optimization* programs like PASSER II and MAXBAND. The principle maximizes the length of the platoon of vehicle that can pass along an arterial without stopping at any signal. The bandwidth is defined as the time elapsed between the front and back of the longest platoon that can just pass through all signals without stopping. Figure 1 shows an illustration of the bandwidth concept.

The concept of bandwidth is particularly useful where the mainline traffic along an arterial is predominant. However, if there is a variation in the traffic flow at different times of the day the bandwidth may need to be adjusted to maintain an uninterrupted flow.

While successive research attempts have been made for optimizing signal timing, practitioners may have their own way of approaching the problem and adjusting the traffic signal. The practitioner's approach details the generation of signal timing settings and the use of Synchro, one of the signal timing programs to develop the timing plan and optimize *cycle length, splits* and offsets. This paper examines the varying perspectives of researchers and practitioners and offers some concluding remarks based on the business analytics' aspect.

BACKGROUND

The traffic *signal timing optimization* has received renewed interest in recent years due to growing congestions and delays along urban arterials. Delay and congestion accounts for billions of dollars in lost travel time which has a significant impact on the economy of a nation. The basic principle of optimizing signal timing is based on a *bandwidth maximization* approach which was

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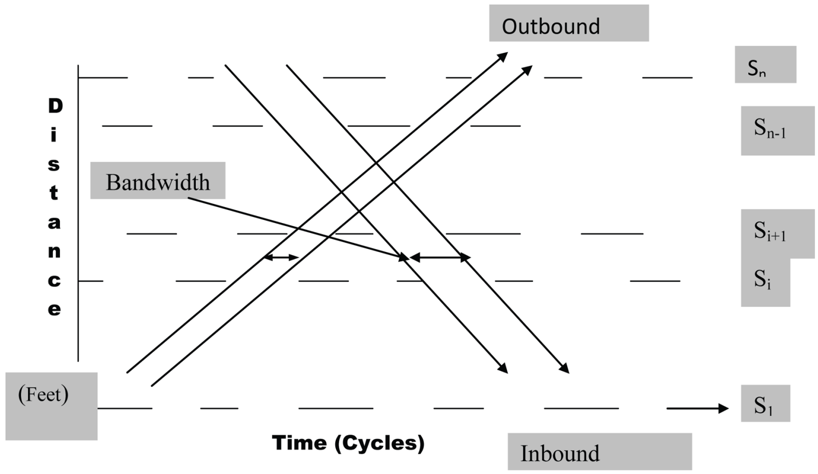
Figure 1. Space-time diagram: Bandwidth maximization concept



introduced in the 1960s. The original *bandwidth maximization* formulation provided by Morgan & Little, 1964 did not:

1. Account for Side Street delay
2. Address multicommodity flow delay
3. Address the effects of turn-in and turn-out traffic
4. Address change in traffic conditions
5. Address Traffic variability and band along intersections.
6. Expanded to *multiarterial networks*

In this paper we study the traffic *signal timing optimization* problem from a researcher's and practitioner's perspective. The researcher's perspective examines different formulations available in the literature and offers a new formulation based on a multi-commodity flow while accounting for side-street delay. Formulation for both single and *multiarterial networks* is provided. Side street delays experienced by multicommodity flows are also discussed. The practitioner's perspective discuses a state transportation agency's approach to solving traffic signal optimization problems using an example from the Maryland State Highway Administration (SHA).

Literature Review

A review of relevant literature is presented here to gain insight to the *bandwidth maximization* problem:

- Little et al. (1966): Provided maximization of a weighted combination of the bandwidths in the two directions of the arterial. The program was named MAXBAND. The program did not provide any significant improvement to the original formulation.
- Chang et al. (1988) developed MAXBAND-86 program by solving the *bandwidth maximization* problem for a closed grid network of arterial streets with the side street delay. The program however did not address variable traffic flow at intersections and delay experienced by multicommodity flow.
- Gartner et al. (1991); Gartner et al., (1990) introduced a traffic dependent criterion in the MAXBAND formulation (Little et al., 1981) to calculate individual bands between every pair of the intersection. The program was named MULTIBAND. This was a significant improvement from previous formulations. However, delay on side streets still needed to be addressed.

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