Quantifying Benefits of Signal Timing Maintenance and Optimization Using both Travel Time and Travel Time Reliability Measures

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ABSTRACT

Maintaining and optimizing signal timing directly contributes to an improved end-user driving experience. With recent developments in crowd-sourced vehicle probe data, travel time improvements associated with signal re-timings can be quantitatively assessed without costly infrastructure.

This study compares the performance of three signal re-timing scenarios – 1) pre-maintenance, 2) post-time-of-day and clock maintenance, and 3) post-progression optimization – for the weekday AM peak, mid-day, and PM peak time periods. The percentage of vehicles arriving on green and vehicle travel time distributions were evaluated for each of the tasks in each period. User benefits were then quantified using the travel time data with the mean-variance method to determine the dollar savings for the tasks performed. Signal time-of-day plan maintenance and clock synchronization accounted for some of the travel time benefits, but the savings were less reliable than progression optimization, which improved both travel times and reliability.

SIGNAL TIMING MAINTENANCE

Maintenance includes checking the proper operation of vehicle detection components, timing parameters (locally and relative to system), data logging, and communication at each intersection in the corridor. This insures detector actuation is functional, clocks are synchronized, and performance measures can be generated for evaluation and subsequent system optimization.

HIGH-RESOLUTION DATA

High-resolution signal event data are digital logs of controller events, including phase indications and detector activations, to one-tenth of a second time resolution. Logs are stored in binary format, which can then be retrieved and translated. The resulting data is in a human-readable format that is mapped to a set of events of a controller.

VEHICLE ARRIVALS ON GREEN

Using the high-resolution event data, the number of vehicles arriving during the green phase can be counted for each cycle or time-of-day period.

OFFSET OPTIMIZATION

The link-pivot combination heuristic was used to improve progression on the corridor by using historic arrival data to predict optimal offsets at each intersection. The objective is to maximize the total number of vehicles arriving on green. The below example shows a 17-second offset adjustment at intersection 1, visualized using the Purdue Coordination Diagram (PCD).
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AM PEAK PERIOD RESULTS

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<th>Approach</th>
<th>Pre-Maintenance</th>
<th>Post-Maintenance</th>
<th>Post-Optimization</th>
<th>Z-Score</th>
<th>P-Value</th>
<th>Improved?</th>
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<td>Post-Optimization</td>
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MID DAY PERIOD RESULTS

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STATISTICAL SIGNIFICANCE

CHANGES IN PERCENT VEHICLE ARRIVALS ON GREEN (α = 0.05)

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POST-MAINTENANCE

- Travel Time Savings
- Travel Time Reliability

POST-OPTIMIZATION

- Travel Time Savings
- Travel Time Reliability

CONCLUSION

1) Maintenance is a critical precursor for optimization.
2) Performing signal timing maintenance without immediately implementing a robust optimization scheme can itself provide a non-trivial amount of improvement to corridor performance.
3) The evaluation of costs-to-benefits can help agencies decide whether robust investments in traffic signal infrastructure are justified over simple maintenance.

Travel time savings from signal timing maintenance alone.

2 Minutes improvement to NB median travel time with link-pivot optimization.