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

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.

STUDY LOCATION

INDIANA STATE ROAD 37

CLOUD-BASED DATA

Crowd-sourced probe vehicle data has become widely available on the cloud via third-party traffic data service providers such as INRIX. These data consists of average speed information to determine arterial travel time in both urban and rural areas for most times of the day. Below is an example of how travel times are computed using this data.

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).

For more information:  http://doi.org/10.5703/1286284315333

Photo courtesy of Alex Hainen

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Howell Li, Steven M. Laurenz, Christopher M. Day, Amanda Stevens, Darcy M. Bullock
1. Purdue University; 2. Indiana Department of Transportation

AM PEAK PERIOD RESULTS

MID DAY PERIOD RESULTS

PM PEAK PERIOD RESULTS

USER BENEFITS OF RE-TIMING

COMBINED NORTHBOUND AND SOUTHBOUND, ALL PERIODS, ANNUALIZED

TRAVEL TIME SAVINGS

Morted user benefits by reducing mean corridor travel times. Average volumes of all intersection approaches are used to compute benefits.

TRAVEL TIME RELIABILITY

The reduction in the variability of travel times monetized as a user benefit using the mean-variance approach.

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.