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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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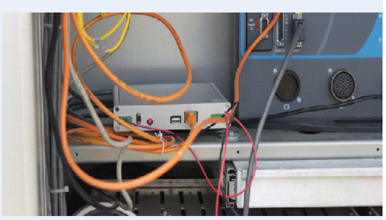
PROJECT COST:
$105,000



A data collection unit collects event-based traffic and signal data and sends it to a remote center for analysis.

Putting Research into Practice: SMART-SIGNAL Automatically Updates Traffic Signal Timing, Reduces Delay

A signal timing plan for TH 13 in Burnsville using data from the SMART-SIGNAL system reduced travel delays by 5 percent per vehicle. By automating data collection and timing plan generation, SMART-SIGNAL enables more frequent updating at lower cost, resulting in significant travel delay reductions.

What Was the Need?

Traffic delays typically increase by 3 to 5 percent each year solely due to outdated signal timing plans. Because of budget constraints, most traffic signals in the United States are retimed only every two to five years. More frequent signal retiming could reduce traffic delays significantly.

But retiming signals is time-consuming and costly—about $3,500 per intersection in Minnesota—because staff must collect data and then optimize the timings. Over the past several years, however, MnDOT research has developed the SMART-SIGNAL system, which automatically collects event-based data about traffic and signal phase changes on arterial roads. An implementation effort was needed to bridge the gap between collecting that data and using it to reduce traffic delays at signals.

What Was Our Goal?

This project sought to develop a framework to identify and diagnose operational problems that cause delays at traffic signals on arterial roads as well as an algorithm that could automatically generate an optimized signal timing plan to address these problems.

What Did We Implement?

This project continues the development of the SMART-SIGNAL system that began with Report 2009-01, Development of a Real-Time Arterial Performance Monitoring System Using Traffic Data Available from Existing Signal Systems. Development continued with projects 2013-06, Research Implementation of the SMART SIGNAL System on Trunk Highway (TH) 13, which refined the system and its user interface, and 2013-17, Improving Traffic Signal Operations for Integrated Corridor Management, which developed data-based strategies for relieving congestion by adjusting signal timings.

How Did We Do It?

Three critical parameters in a traffic signal timing plan are the overall length of a cycle, the green splits (the length of a single phase or movement type within a cycle) and the offsets (the time between green lights at adjacent intersections). Researchers first developed an algorithm to calculate optimal values for these parameters and diagnose corridor performance issues. For example, the algorithm can identify instances when a green split is programmed for 15 seconds, but only 12 seconds is needed for waiting cars to pass through.

Since adjustments to one property typically affect the others, researchers developed techniques to fine-tune green splits and offsets iteratively until no further fine-tuning is needed. For green splits, this adjustment is based on the utilized green time (the amount of time needed to clear waiting vehicles and any that arrive during the phase).

continued

"We implemented the SMART-SIGNAL's timing plan on Trunk Highway 13 and saw a real benefit. Other corridors with more serious traffic delays could have even greater impacts."

—Steve Misgen,
Traffic Engineer, MnDOT Metro District

"This was a great project. The traveling public benefits because if the signal timing is more efficient, motorists will spend less time on the road, and MnDOT now has a tool to see how signals in a corridor are working."

—Alan Rindels,
MnDOT Research Development Engineer

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MnDOT has installed SMART-SIGNAL at more than 100 intersections. After several MnDOT research projects, the system is ready to evolve into a commercial product available for wider use.

To facilitate offset fine-tuning, researchers created a procedure to construct a time-space diagram, which visualizes how vehicles progress through a signalized arterial corridor.

What Was the Impact?

Researchers implemented the traffic signal timings that SMART-SIGNAL proposed on Trunk Highway 13 in Burnsville, Minnesota, which led to a 5 percent reduction in delays per vehicle on the corridor. It is very possible that other corridors that currently experience more serious delays could see greater impacts, possibly in the double digits.

Traditionally, signal retimings are based on 12 hours of data per intersection that are collected manually. SMART-SIGNAL automatically collects this data, which will make it much easier to identify when a signal's timing plan is no longer optimal for an intersection's traffic patterns.

Traffic signals typically use several timing plans during a day to accommodate different traffic patterns. This project developed an algorithm to identify the optimal time to switch between patterns based on when there are significant changes in traffic volumes.

What's Next?

SMART-SIGNAL is ready to evolve into a commercial product, so this is likely the final MnDOT research project to focus on its development. MnDOT has installed SMART-SIGNAL at more than 100 intersections, and it will continue to explore applications for the system's data.

One potential application under investigation is determining whether SMART-SIGNAL data can improve safety at intersections with unusually high crash rates and predict what intersections are likely to have elevated crash rates in the future. MnDOT is also using the system's data to look at how traffic and vehicle routes are affected by construction lane closures and detours on signalized arterials. SMART-SIGNAL will also be used to develop traffic signal timing models for diverging diamond interchanges.

A real-time adaptive signal control, which would automatically adjust signal timings based on current conditions, is not currently feasible due to elevated maintenance costs to ensure constant data availability. This project does, however, automate the data collection and calculations necessary to ultimately develop such a system.

This Technical Summary pertains to Report 2014-38, "Automatic Generation of Traffic Signal Timing Plan," published September 2014. The full report can be accessed at http://www.lrrb.org/PDF/201438.pdf.