Putting Research into Practice: Reducing Corridor Congestion Using Real-Time Traffic Data

What Was the Need?
Transportation corridors often have unused capacity such as parallel routes and lanes in the nonpeak direction, even while certain roads within the corridor are congested. The Integrated Corridor Management approach seeks to alleviate congestion by using this unused capacity. ICM can be complex, but it shows promise as a congestion management tool.

Previous research developed the SMART-SIGNAL (Systematic Monitoring of Arterial Road Traffic and Signals) system, which makes it possible to quantitatively monitor traffic on signalized arterial streets in real time. However, research was needed to develop an ICM traffic control model as a step in using the system to reduce traffic congestion.

What Was Our Goal?
The goal of this project was to use the data collected by the SMART-SIGNAL system to develop a real-time signal control system that can diagnose congestion problems and suggest signal control strategies to address them. The system would also respond to traffic incidents on freeways by diverting traffic to arterials as appropriate.

What Did We Implement?
This research continues work that began with Report 2009-01, “Development of a Real-Time Arterial Performance Monitoring System Using Traffic Data Available from Existing Signal Systems,” which developed and tested the SMART-SIGNAL system. That project was followed by Report 2013-06, “Research Implementation of the SMART SIGNAL System on Trunk Highway (TH) 13,” which refined the system and its Web-based user interface to make it easier and less expensive to install and access.

How Did We Do It?
Investigators first developed a strategy to alleviate congestion on signalized arterials by adjusting signal timings. They tested this model in a VISSIM simulation of a five-intersection network on Fair Oaks Avenue in Pasadena, California.

Next, they developed integrated control strategies to reduce congestion caused by traffic incidents on adjacent freeways by diverting traffic from the freeway to arterials and adjusting arterial signal timings to minimize delays caused by the diverted traffic. They tested these strategies in a simulation model of the Interstate-394/Trunk Highway 55 (I-394/TH 55) corridor in Minneapolis.

Finally, they installed the SMART-SIGNAL in 10 intersections along TH 55. Real-time performance can be monitored on the SMART-SIGNAL website.
What Was the Impact?

Investigators developed a model for managing oversaturation on signalized arterials based on previously developed oversaturation severity indices. Under this model, several mitigation measures were developed for different types of congestion:

- When the green phase of a traffic signal is insufficient to fully discharge the queue, extend the green phase of the signal.
- If the queue from a downstream signal spills over to block an upstream intersection, relieve the blockage by extending the red phase at the current light to gate the flow of traffic to remove the downstream spillover.
- When both situations occur simultaneously, increase capacity downstream from the intersection by reducing the red phase there. Alternatively, combine the two prior methods by extending both the red and green phases of the light.

To optimize traffic flow, investigators developed a two-part procedure. First, red and green times are calculated to eliminate spillover and residual queue along the direction of traffic. Then, working against the direction of traffic, green time changes are made to gate traffic when the first set of calculations are not feasible due to other constraints.

The Pasadena simulation demonstrated that this Forward-Backward Procedure is optimal. Relative to actuated-coordinated control with an 80-second cycle, the FBP with an 80-second cycle reduced average delay by 21 percent. With a 120-second cycle, the FBP reduced average delay by 30 percent.

The model for diverting traffic between freeways and parallel arterials uses real-time calculations of travel times on both routes and a variable message sign on the freeway to advise drivers of when the arterial route would reduce travel time. The simulation of the I-394/TH 55 corridor showed that this diversion strategy reduced delays after a peak-hour traffic incident by 26.13 percent over the base scenario.

What’s Next?

MnDOT has installed SMART-SIGNAL devices at 85 intersections in Minnesota and is currently using the devices for data collection only. Another SMART-SIGNAL project, Automatic Generation of Traffic Signal Timing Plan, will develop algorithms that MnDOT can use to automate signal timing.

A second project, Develop Annual Arterial Congestion Report, will track signal performance measures to help prioritize signal retiming projects and produce an annual report similar to one already produced for the Twin Cities area freeways.

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