Project Summary

Texas Department of Transportation

0-5998: Evaluation of Best Practices for Controlling Signal Systems During Oversaturated Conditions

Background

Signalized intersections are often the source of urban traffic congestion, which may remain localized or quickly spread to adjacent signals or freeway off-ramps. The latter scenario occurs on a daily basis in many cities, resulting in increased delays, fuel consumption, vehicular emissions, driver frustration, and crashes. Unfortunately, no standardized procedures, tools, or guidelines are available to practitioners to provide for proper characterization and effective mitigation of specific congestion problems in their systems. The objective of this project was to develop guidelines for effectively combating congestion in traffic signal systems.

What the Researchers Did

The project had four key tasks. First, researchers conducted a thorough review of literature to identify all previous research dealing with congestion at traffic signals. This task included assessment of documented field studies. Topics studied during this process included characteristics of congestion at traffic signals, their root causes, and tools available to minimize the impacts of these causes. This information provided the basis to develop preliminary guidelines for mitigating congestion at traffic signals.

In the next task, researchers gathered related information from selected practitioners in Texas. These practitioners included personnel from Texas Department of Transportation (TxDOT) districts, other public agencies, and consultants. Researchers limited the focus of this inquiry to Texas. To collect information about practitioners' perceptions regarding congestion at traffic signals and practical approaches for its mitigation, researchers developed a questionnaire and sent it to 27 selected participants. Researchers received the completed questionnaire from 17 people and synthesized this information.

Next, researchers used a microscopic simulation program to study the capacity of an approach lane feeding traffic to a through plus a left-turn lane at a signalized intersection. The simulation enabled exploration of the impacts of bay-length, signal phasing sequence, cycle length, and traffic distribution on the capacity.

In the fourth and final task, researchers conducted limited field studies to refine and apply guidelines developed previously. For these field studies, they collected data for a small three-intersection system in College Station, Texas, and three intersections in Austin, Texas.

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Project Completed: 8-31-09

Data collection at the first site consisted of in-field manual data collection and extraction of data from video recordings at the site. For the Austin sites, data came from videos recorded by the City of Austin at sites selected by the researchers after field visits. Researchers used computer simulation and engineering judgment to derive and recommend improved timings for two of these sites.

What They Found

The literature review revealed a lack of tools and guidelines for congestion mitigation in signalized systems. Furthermore, there is a lack of published case studies to convey lessons learned. Even though a precise definition of congestion does not exist, there is agreement that congestion results in detrimental queuing. Therefore, a major thrust of research has been on the development of procedures for queue management. Most procedures assume knowledge of true demand and capacity, which is assumed to be fixed. In congested signal systems, these assumptions are not true.

Conceptually, accurate demand estimation should be possible by monitoring queue-change over time. However, field studies in this project revealed that this is not always possible. This challenge can be overcome by using a repetitive process of demand assessment and timing adjustments. Simulation experiments revealed that signal capacity is a function of geometry, traffic conditions, and control parameters, and may be significantly less than expected. Key findings include:

- When blocking occurs, increasing cycle length decreases capacity.
- Lagging phases with heavy demand improves throughput.
- A 500-foot single-lane left-turn bay is sufficient when cycle length is set properly.

The two cases studied in this project showed how to mitigate traffic congestion under certain conditions. At the College Station site, field observation and available tools demonstrated the benefit of using shorter phase times. The second study demonstrated how congestion could be mitigated using simple field observation and expert judgment.

What This Means

Mitigating traffic congestion in traffic signal systems is not an easy task because common assumptions about capacity are often violated and because demand is difficult to assess when queues have grown beyond certain bounds. Adverse impacts of congestion can often be reduced by proactive management. This strategy requires optimal controller settings, functioning traffic sensors, and properly trained and experienced staff.

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