Project Summary

Texas Department of Transportation

0-5422: Ramp Treatment and Dynamic Closure Strategies for Incident Traffic Management

Background

As traffic congestion levels throughout the nation continue to increase, huge amounts of research, political, and technical effort have been invested to alleviate the negative impacts of congestion. Most freeway congestion is a result of nonrecurring events such as incidents, a fact that has spurred significant innovation in incident management techniques and practices designed to minimize the impact of these unexpected events.

One recently proposed strategy for severe or extended freeway incidents involves the closure of selected onramps in the vicinity of the incident. This strategy makes sense, given that access to freeways is completely controlled by these ramps and that ramp treatment strategies have been successful in reducing recurring congestion.

A number of challenges exist in determining how ramp closure should be used in response to incidents. Closing a ramp results in system-wide impacts as drivers are forced to re-route, possibly exacerbating existing congestion on these alternate routes. Depending on the infrastructure and technology used to physically restrict access, the act of closing the ramp may require diverting resources and personnel away from the incident itself. For these reasons, previous research has been limited to typical "steady state" situations in which the impacts of a ramp closure can be addressed in detail. In this research project, we developed methods to analyze ramp closure within the time constraints imposed by real-time incident management.

What the Researchers Did

When an incident occurs, the two key questions regarding any ramp closure policy are **which** ramps should be closed (if any) and **how long** the closure(s) should remain in effect. A four-step procedure was developed to answer these questions:

1. Determine if closing a ramp is even feasible in the vicinity of the incident.
2. Determine if the incident is severe enough to consider further analysis.
3. Run a **Phase I** model to determine which ramps should be closed.
4. Run a **Phase II** model to determine the durations of closure.

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Several challenges arise in answering these questions in a practical manner: by its very nature, incident management is characterized by uncertain and incomplete information, and swift responses are necessary to minimize the impact on the freeway and surrounding facilities. Thus, throughout the project, the researchers attempted to find a compromise between model fidelity and complexity and the speed required for the results to be useful in practice.

What They Found

A suite of models was developed to address the four steps introduced in the previous section. Regarding the first step: it is not always possible to close a ramp in such a way that drivers cannot bypass the gate. Or, there may not be a gate installed on a ramp, and portable installation barriers cannot be brought to the onramp in a reasonable amount of time. Likewise, if there are no viable alternate routes available, ramp closure should not be attempted. A variety of engineering, technology, and political constraints, specific to the implementation location, need to be taken into account before any further analysis is warranted.

The second step acknowledges that ramp closure is likely to be useful for only the most severe incidents because of the operational difficulties and disruption to traffic flow involved in closing a ramp. Thus, it is useful to predict the severity of an incident while it is still in progress. A novel model based on naïve Bayesian classification is developed to predict the clearance time for incidents; this, in turn, can be used to estimate the total delay that will be caused by the incident, which is a suitable metric for overall severity.

If ramp closure is feasible in the location of the incident, and if the anticipated severity of the incident is great enough, a two-phase model is run to determine which ramps should be closed and for how long. For the third step, the Phase I model is designed to run as quickly as possible, and uses the results of a previously performed traffic assignment to predict: 1) how drivers will re-route in response to the ramp closures; and 2) the resulting impact on the macroscopic system. This model outputs the combination of ramps that should be closed—including the possibility that no ramps should be closed at all—to maximize overall system performance.

The fourth and final step involves a series of microsimulation analyses performed to predict the impact of different closure durations. Although the Phase II model requires more computation time than the previous one, speed is less critical in this step than in the previous three steps. Knowing which ramps to close needs to be done as quickly as possible; knowing when to re-open them can be delayed because the incident will not clear for some time.

What This Means

This research presents the first rigorous approach for determining how ramp closure should be applied to best minimize the impact of incidents on network performance. The four-step modeling framework describes a logical progression for developing such a policy on an incident-specific basis. Further, all of the data required for these models is already present; many traffic management centers routinely log incidents as they occur and automatically record traffic volumes from loop detectors; these can be combined to estimate incident severity (Step 2). Traffic assignment (Step 3) is routinely performed by planning agencies, and many microsimulation packages can extract a simulation subnetwork for determining the duration of a ramp closure (Step 4).

Although no set of algorithms can replace human judgment and the experience of trained engineers, the procedures developed in this research nevertheless provide an important tool for incident management. With the proper models to serve as a guide, ramp closure shows promise for lessening the impact of the most severe incidents, leading ultimately to improved freeway performance and travel reliability.

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