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Proposed Data-Driven Performance Measures for Comparing and Ranking Traffic Bottlenecks

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Abstract

To justify investments towards improved traffic operations, engineers and policy-makers need scientific and accurate methods of congestion measurement. However, status-quo methods are limited and/or outdated. Peak-hour analyses are becoming outdated as a sole source of traffic assessment, because they fail to account for changing conditions throughout the year. There has been a movement towards "reliability" modeling, which attempts to capture these annual effects. But due to significant input data and calibration requirements, the reliability models suffer from practicality issues. Next, there have been recent improvements in data-driven ITS technologies, which identify congestion in real time. However, there is room for improvement in the robustness of performance measures derived from these technologies. Finally, some engineers have compared and ranked congested locations (i.e., bottlenecks) on the basis of experience and judgment. Despite their cost-effectiveness, judgment-based qualitative assessments will lack credibility unless backed by quantitative results. In a recent Federal Highway Administration study, congestion measurement was a primary area of emphasis. This paper discusses project-specific software development, which produced new and innovative performance measures for congestion measurement. It will present concepts and evidence to imply superiority of the proposed new measures. This paper is intended to serve as a preview of a future full journal paper; which will rank ten or more real-world bottlenecks according to new and old performance measures, to demonstrate impacts of the new measures. It is hoped that the new performance measures will be adopted by states and/or commercial products, for a new level of robustness in congestion measurement.

Keywords: performance measures, traffic bottlenecks, INRIX, reliability

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1 Introduction

Precise congestion measurement is one of the best ways that traffic engineers can demonstrate a solid return on investment, in a time of tight budgets. It can also be an important first step towards identifying and ranking congested locations (i.e., bottlenecks) (Elhenawy, Chen, & Rakha, 2015). However improved methods of congestion measurement are needed, because the status-quo methods are either limited or outdated. Congestion measurement should be more cost-effective, precise, and scientific. When considering the status-quo methods, it is possible to associate each one of them with one or more fundamental disadvantages. Back in the 1990s, most traffic engineers were modeling the peak 15-minute period, and using the peak hour factor. However this paradigm did not take into account the significant factors that come into play throughout the year; such as seasonal demand volume fluctuation, weather, and incidents. These days, improved procedures are available for analyzing the entire year; but they are extremely data-intensive, which makes them difficult to use. Improved measurement technologies deployed by companies such as INRIX are now available. However performance measures derived from these new data sources have not adequately accounted for variability, reliability, or throughput. This paper will describe some recent improvements in congestion identification, which leverage the latest advances in both research and ITS technology. Some drawbacks of the status-quo methods are briefly summarized below.

In the 1990s, peak 15-minute modeling was the norm, and was recommended by the Highway Capacity Manual (Transportation Research Board, 2010). The peak hour factor, used to convert hourly flows into peak 15-minute flows, was a required concept for transportation engineers and software products. In micro-simulation analysis, peak 60-minute analyses were also popular. However regardless of the time period duration being used, peak period modeling did not take into account significant factors that come into play throughout the year; such as seasonal demand volume fluctuation, weather, and incidents. Instead, it was necessary to analyze and design for the peak 15-minute period, and hope that design would work well throughout the year. Without the data-driven technologies available today, it was difficult for the 1990s engineer to independently verify how well their design was working throughout the year.

Modeling frameworks are now available for analyzing the entire year, and reflecting some of the elements that were not recognized by peak period modeling. The drawbacks of today's reliability models include a relatively extensive input data requirement, which increases their risk for engineers who would use them. The time, money, and expertise needed to fulfill the input data requirement essentially increase the probability of late deliverables, funding shortages, and human errors. Moreover, when micro-simulation is used to analyze scenarios occurring throughout the year, excessive computer run times become a problem, further reducing the practicality of reliability modeling. Finally, popular reliability model performance measures (e.g., Travel Time Index) assume inflexible comparisons to the free-flow speed, and do not directly account for traffic volume levels.

In contrast to the 1990s, it is now common for traffic measurement data sources (e.g. INRIX, HERE, PeMS, TomTom) to be constantly collecting data in the field. Some organizations have used these rich sources of data to develop bottleneck rankings based on traffic measurements, as opposed to traffic models. However, this paper will attempt to show that some bottleneck rankings in the industry are relatively insensitive to traffic volume levels, congestion variability, and travel time reliability. Through extensive personal observation, traffic engineers can develop a sense for specific areas containing the worst traffic problems. However without precise annual measurements, it is more difficult to communicate the duration and extent of traffic problems to decision-makers. When operational improvements are made, it is more difficult to verify the beneficial impact of these improvements.

This paper will propose and describe new, data-driven performance measures, designed to overcome limitations of the status-quo methods described above.