DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

HOT Lane Calibration and Simulation Algorithms

This research will study the High Occupancy Toll (HOT) lane on I-680 and create a model of how the driver behave in the HOT lane.

Transportation Safety and Mobility

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Project Title:
UTC - HOT Lane Calibration and Simulation Algorithms, (UCTC)

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WHAT WAS THE NEED?

Express lanes are specially designated highway lanes that offer toll-free travel for carpools, vanpools, motorcycles, buses and eligible clean-air vehicles. Solo drivers also have the choice to pay to use the lanes to avoid congestion. Bay Area transportation agencies are developing a 550-mile network of Bay Area Express Lanes that will be completed in 2035. Metropolitan Transportation Commission (MTC) will convert 150 miles of existing High Occupancy Vehicle (HOV) lanes to express lanes and add 120 miles of new lanes to close network gaps. The expected benefits of the express lane deployment include: (1) making the best use of HOV lane capacity; (2) providing travelers with the choice of more reliable travel option; (3) better lane management to increase traffic throughput; and (4) creating seamless network of HOV lanes to encourage carpools, vanpools and transit use.

Simulation tools presently capable of proper express lane modeling are commercial micro-simulators, whose main shortcoming is the difficulty of building and maintaining models of particular traffic networks. To avoid dealing with micro-simulation, Caltrans District 4 adopted and successfully used macroscopic simulation software FREQ. Unfortunately FREQ cannot directly model express lane behavior and performance; and, moreover, it is no longer supported. Thus, there is a need for FREQ replacement.

WHAT WAS OUR GOAL?

The goal was to create the methodology and a suite of algorithms for express lane modeling, which could be used for planning future express lane projects, conducting before- and after-studies and even performing real-time decision support during the operation of future express lane projects in California.

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WHAT DID WE DO?

This research developed a systematic approach to express lane studies using macroscopic models. This was accomplished by first creating calibration methodologies and traffic macroscopic modeling algorithms that were suited for simulation of freeway networks with express lanes in different configurations (buffer separated with ingress/egress gates and all access), and subsequently tested these calibration methodologies and modeling algorithms on actual freeway data.

The researchers used the HOT lane on I-680 South as a reference site for testing the model. Operational since September 2010, I-680 express lane is located on a 14-mile stretch of southbound Interstate 680 from Highway 84 to Highway 237; 11 miles of the project is in Alameda County, with 3 miles in Santa Clara County. It is a buffer separated HOT facility with 3 ingress and 3 egress gates.

The research developed a model that can simulate HOT lane operations: from 5 am to 8 pm, allow HOVs and Single Occupancy Vehicles (SOVs) that pay a toll; adjust the toll dynamically based on the traffic condition; if speed in the HOV lane drops below 45 mph, switch to HOV-only mode; before 5 am and after 8 pm operate as a general purpose (GP) lane. The model simulated how toll pricing affects the HOT lane utilization.

WHAT WAS THE OUTCOME?

In the course of this project a simulation framework for freeways with managed lanes was developed around the Berkeley Advanced Traffic Simulator (BeATS). It was tested with freeway segments of I-680 North (full access HOV lane), I-210 East (limited access HOV lane) and I-10 West (limited access HOT lane). As test examples show, the simulation can adequately reproduce traffic behavior in the presence of multiple vehicle classes and managed lane facilities. Model calibration guidelines are provided.

This project is an important step in the development of the open source software package for operations planning in multimodal transportation networks. The implemented framework enables the following analyses:

- Estimate impact of different freeway traffic modes on system performance;
- Given a traffic pattern, estimate HOT revenue projections;
- Optimize dynamic toll strategy;
- Optimize ramp metering plans;
- Determine the cause of congestion — excessive demand or poor operational strategy.

The developed simulation framework has some limitations that require further research to be overcome. Some of these limitations are just the absence of certain nice-to-have features, such as:

- Connection to the 4-step travel demand model, which would allow seamless development of future year projections;
- Inclusion of arterial signals adjacent to freeway on- and off-ramps.

More important is the ability to assess impact of violators on HOV/T facility's operational and fiscal performance. The implemented HOT controller has no knowledge about cheaters, SOVs that declare themselves HOVs to avoid the toll, and uses data collected from FasTrak transponders as is. The other type of violations, specific to limited access facilities, is the crossing between GP and HOV/T lanes through the barrier (solid white line). Empirical data suggest that such violations are common, and it is important to quantify their impact. It is possible to extend the existing simulation model to include violator vehicle class with its behavior model.

The most significant limitation of the current simulation framework is that currently it is built in MATLAB. An incremental step is required to make it usable for Caltrans engineers. There are two possible approaches:

1. Build a downloadable, self-installable distribution that can automatically check for updates, similar offline version of MS Office;
2. Establish online interface, by means of which spreadsheets with simulation input and data can be exchanged between the user and the server running the computational tasks.

In both cases, the software will remain open source and free. We recommend the second approach as more efficient of the two. Moreover, it will allow to connect simulation data with online maps, such as Google Maps or Bing.

WHAT IS THE BENEFIT?

This project produced a toolbox for:

- Macroscopic simulation of freeway corridors with HOV/HOT lanes, where a HOV/HOT lane may be all-access, buffer-separated or a combination of the two;
- Methodology for fast calibration of such models with high definition traffic data.