RESEARCH NOTES

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Caltrans

Real-time Adaptive System-wide Ramp Metering and Signal Control
(ATMS TESTBED PHASE III FINAL REPORT)

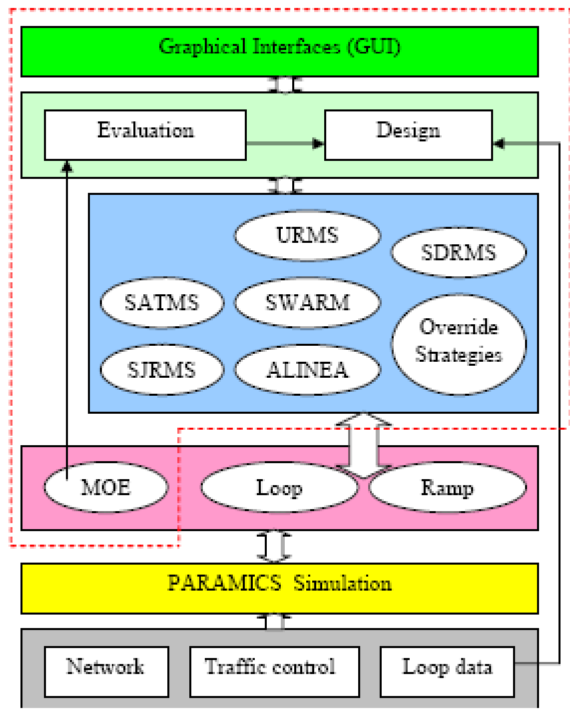
Why was this Research Undertaken?

Ramp metering has been recognized as an effective freeway management strategy to avoid or ameliorate freeway traffic congestion by controlling access to the freeway. However, studies show that significant benefits can be obtained from ramp metering only when implemented correctly and operated effectively.

In order to ensure the success of the implementation, it is important to first investigate during a pre-implementation phase questions related to whether or not ramp metering is warranted, which kind of ramp metering algorithm is suitable to the peculiarities of the target network, how to implement a specific metering algorithm, and how to setup the parameters of the algorithm. With the advancement of technology, more complicated metering algorithms, such as System Wide Adaptive Ramp Metering (SWARM), have been (and will be widely) implemented in the real world. These algorithms have more parameters and depend on accurate detector data. Their correct implementation and performance optimization depend on greater expertise from operators and more research on the part of researchers.

What was done?

In support of Caltrans' ramp metering deployment efforts, an evaluation platform based on PARAMICS simulation is being developed jointly by the Testbed and PATH. The ramp metering design tool handles how to implement a metering algorithm within a target freeway corridor. The ramp metering evaluation tool employs the testing and evaluation of a metering algorithm and its design based on performance measures obtained from simulation. A library of metering algorithms either currently or potentially applied in California is included in this platform. These algorithms include District 3, 6, 8, and 11's SDRMS, and District 7 and 12's SATMS, as well as some adaptive metering strategies (e.g., ALINEA, and SWARM) that potentially can be applied. The platform has intuitive graphical interfaces in order to facilitate Caltrans practitioners. The overall framework of the platform is shown in the figure. The input data of PARAMICS simulation are network geometries, traffic control data, and traffic demand data estimated from real-world loop data. The platform has four main modules, and each module is made up of several components.



Evaluation Framework

The components within the red dotted box represent the newly developed modules. The light green module is the core module, including two functional tools, design and evaluation. The bright green module is the graphical interface module through which users can access these tools. The blue module is metering algorithm module that consists of a library of Caltrans' metering algorithms (implemented as PARAMICS plug-ins). The pink module is the supporting module, which includes several PARAMICS API plug-ins used to support various metering algorithms and measurement data collected from the simulation world.

The latest web-based programming technologies have been used to implement the platform; the web pages containing the GUI have been developed using HTML and JavaScript; the core module of the platform is implemented in

Java language, which has strong capabilities of the development of graphical interfaces; XML (eXtensible Markup Language) is used for data exchange between the core module and two PARAMICS plug-ins modules, including metering algorithm module and supporting modules.

A series of performance measures for evaluating various aspects of ramp metering can be extracted, including the following time-dependent measures:

1. Average mainline travel speed/travel time and its standard deviation.
2. Total delay at an on-ramp.
3. On-ramp queue length.
4. Time percentage of queue spillback to the local streets at an on-ramp.
5. Travel time from an on-ramp to downstream end of freeway and its standard deviation.

The evaluation tool of the ramp-metering platform employs the evaluation of the metering design of a metering algorithm, and various traffic operational aspects of the ramp metering control. It links a specific ramp metering study, such as a study of freeway mainline efficiency, with required performance measures. Examples of these ramp-metering studies include freeway mainline efficiency, on-ramp delay, and equity analysis of a metered freeway corridor. As a result, the applications of the evaluation tool are:

1. Investigate whether metering has been operated correctly and efficiently.
2. Analyze, evaluate and improve the current metering operations.
3. Test new algorithm and fine-tune parameters.

These studies can be done based on trial-and-error method and selected performance measures. Through the GUI, users can dynamically observe the performances of various aspects of metering control.

What can be concluded from the Research?

Compared to field tests, the platform should provide a quick and cost-effective way to conduct ramp-metering studies in the microscopic simulation environment. The platform can be used to analyze and improve current metering operations, to test a new algorithm, to fine-tune parameters of an algorithm, to evaluate various aspects of performance of a metering strategy, and to conduct a series of deeper level analysis of the performance of the algorithm.

What do the Researchers recommend?

The platform can serve as a training environment for Caltrans personnel to gain experience with various metering algorithms, especially those coordinated metering algorithms that are characterized by many parameters and complicated control logic. This platform should be used to guide Caltrans personnel on how to successfully manipulate the various aspects of the ramp-metering systems, including initializing parameters, fine tuning of parameters, performance analyses, and hypothetical "what if" simulated testing.

Implementation Strategies

Ramp metering control involves balancing the interests of local (arterial) and through (freeway) traffic, and thus its applicability, onsite deployment and operation continue to face political challenges that call for the cooperation of related parties. Because of the complexity of these coordinated ramp metering systems, their successful implementation depends both on such hardware (or ITS infrastructure) as communication system and loop detectors installed at specific locations and on software. Studies show that significant benefits can be obtained from ramp metering only when implemented correctly and operated effectively (Pearce 2000). Therefore, questions related to which kind of ramp metering algorithm is suitable and how to calibrate and optimize the operational parameters, ought to be investigated during a pre-implementation phase in order to ensure the success of the implementation.

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