Comparative Analysis of Dynamic Pricing Strategies for Managed Lanes

Hyun Woong Cho, Jorge A. Laval

Georgia Tech College of Engineering, School of Civil & Environmental Engineering

STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

GDOT Georgia Department of Transportation

Overview

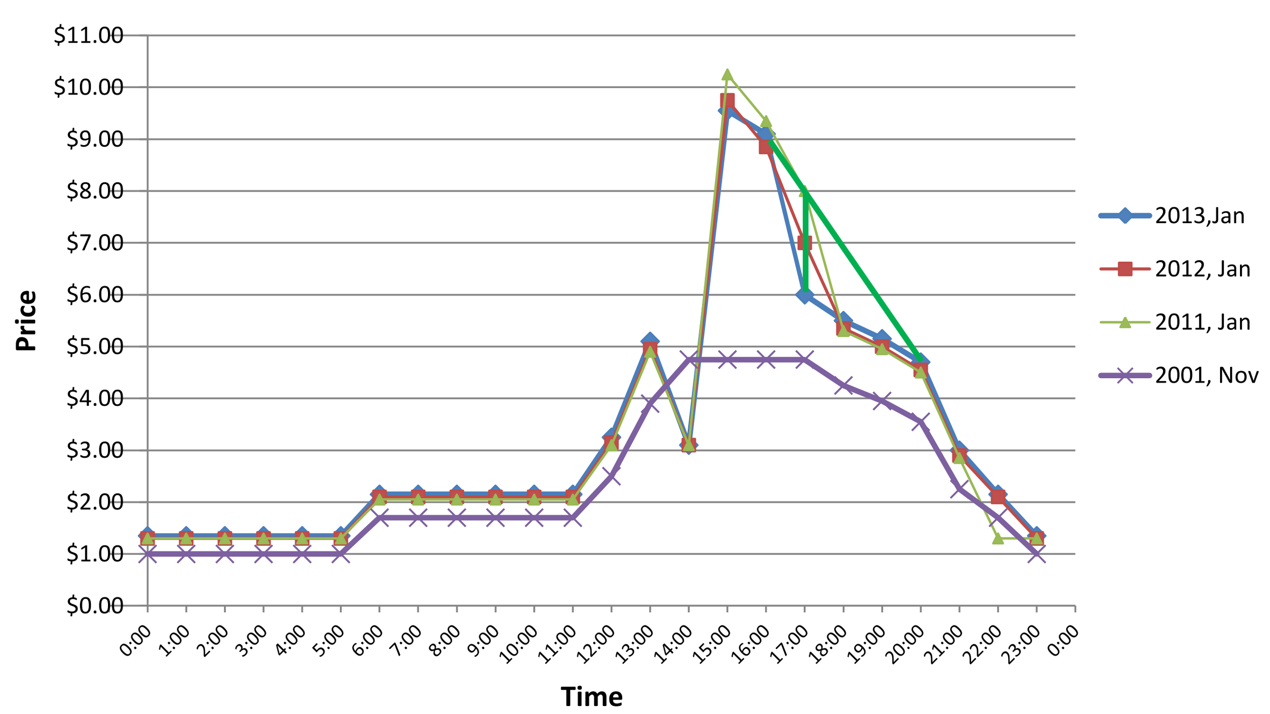
There are currently more than twelve Managed Lanes facilities in operation today in the United States, and this number is increasing rapidly. The pricing strategies in these facilities are inspired by the congestion pricing concept borrowed from the economics literature. This concept has been thoroughly adapted to the case of traffic flow for the case of static network conditions. Little has been done, however, in the dynamic case, where travel time delays due to congestion may change rapidly in time.

We investigate the performances of different dynamic pricing strategies for Managed Lane facilities in analytical, graphical approach. The strategies are 1) Time-do-day pricing based on historical traffic data, 2)Real-time pricing based on traffic conditions on the Managed Lanes and/or General Purpose Lanes, 3) Real-time pricing with options based on predicted uncertainties,

The focus is on the traffic dynamics resulting from each pricing strategy and the benefits and costs. The problem is analyzed from three different perspectives: the users, the tolling authority(i.e. DOT), and the society, which leads to three different performance measures.

Time-of-Day Pricing

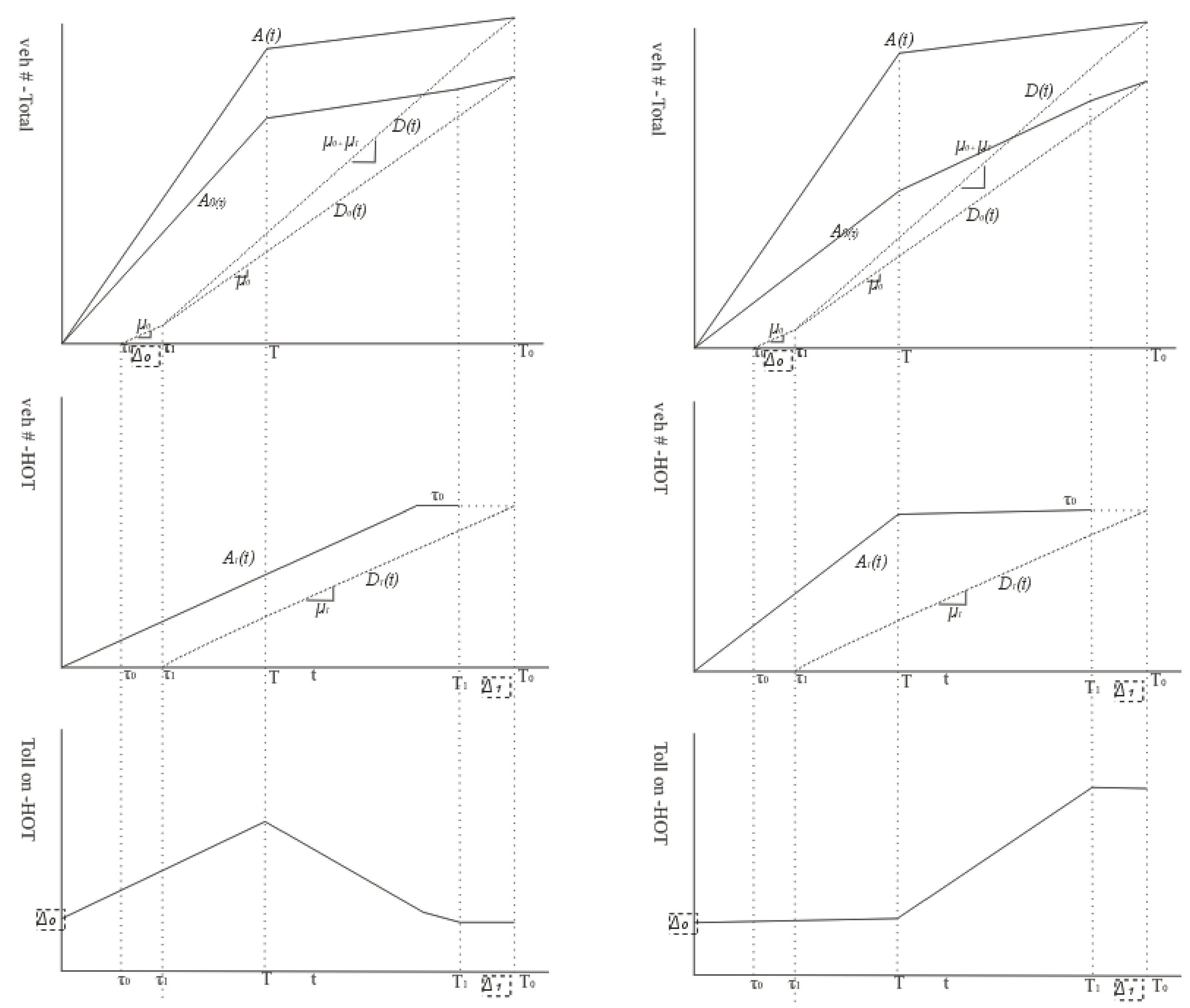
Tolls on SR-91 for Friday sharply increase at the beginning of super peak and gradually decreased by the end of the peak. This phenomenon can be explained by the externality and the marginal cost concept. The externality of vehicle is that a given vehicle experiencing the queue imposes on the rest of the users. Hence, the earlier vehicle that arrive the queue the larger externality the vehicle has. The feature of convex instead of linear is presumed to be delay experienced by the traveler in MLs.



Hourly toll on SR-91 for Friday for different years.

Real-time Pricing based on ML/GP Lanes

In this strategy, the toll rate is adaptive to real-time traffic conditions. The first objective is to maintain high vehicle speeds in the MLs. Queues are not allowed in this case. The second objective is maximize the revenue of the toll authority.



$$\pi(t) = \frac{N}{\mu_0} - m\left(\frac{1}{\mu_0} + \frac{1}{\mu_1}\right) + \frac{w(t)\frac{\mu_0}{}}{\mu_0 + \mu_1}$$

$\pi(t)$: *toll equation*

N : total number of vehicles

m : total number of vehicles using HOT Lane

$R(\pi) = \int_0^{T_0} \sigma_1(t)\pi(t)dt$, σ_1 : arrival rate of HOT lane

Real-time Pricing based on predicted uncertainties

While priced MLs provide an alternative travel choice for road users, travelers in general may have a negative attitude towards pricing. One plausible reason is that travelers may not receive the benefits they expected when choosing to pay to use the MLs due to traffic uncertainties. This strategy is specifically proposed to address this issue. The idea is to offer a "price guarantee option" to a traveler when driver is choosing to pay for MLs. The toll paid by the traveler will be refunded if the MLs travel time saving does not reach the minimal amount guaranteed.

I-85 Toll lanes in Georgia is implementing this strategy. Even though this strategy reduces revenue of the toll authority in short period, it enhances travelers' acceptance and reliability on MLs.

Traffic of Rush hour on I-85 toll lanes in Georgia

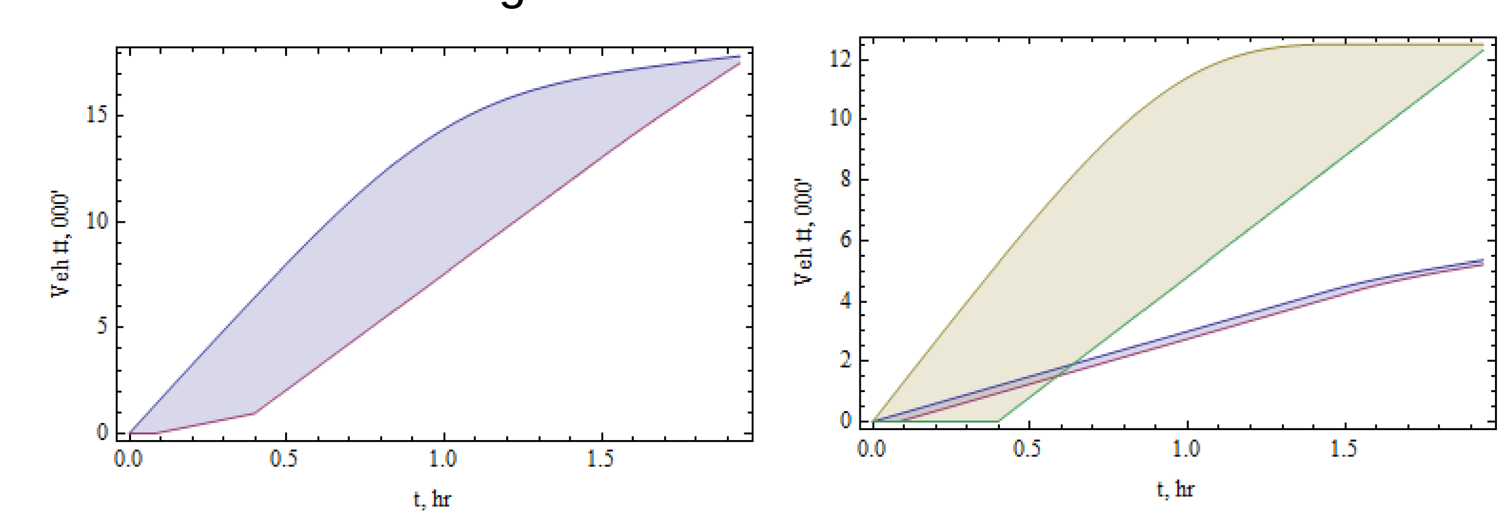
Comparative Analysis

Assuming that we know the arrival patterns of the vehicles in given time, we can measure the benefits of each strategies.

Benefits	Users	Authority	Society
TOD	+	+	+
No queue MLs	+	+	=
Max. Revenue	-	++	=
Refund	=	=	=

Develop numerical simulation model

Strategy analyzed in the project is implemented numerically in order to obtain solutions for larger networks.



Outputs from Mathematica Simulation modeling

Planned Activities

- Develop analytical Real-time differentiated pricing with respect to travel characteristics(O/D)
- Implement Meso-scopic traffic simulation modeling analysis
- Refine numerical simulation model