Markets for Transport

Eliminating Congestion through Scheduling, Routing, and Real-time Pricing

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• Global congestion costs $1 trillion/year
• Los Angeles congestion costs $23 billion/year
CLOGGED STREETS, UNHAPPY TOURISTS

By Beth Teitell
GLOBE STAFF

Boston traffic has been driving locals berserk for years. But now it's become so toxic that it's taking aim at our guests — and threatening Boston and Cambridge's $13 billion tourism industry.

Every major sightseeing firm contacted by the Globe has made or is mulling changes to deal with paralyzing congestion that never seems to end, and frustration is so intense that even PR types aren't trying to sugarcoat the situation.

"It just stinks to tour Boston right now," said Steven Grasso, president of North American Traveler, a North Reading-based travel-planning firm. One of his groups recently spent 35 minutes in a coach traveling from Faneuil Hall to the Boston Opera House — a 0.9-mile trip, according to Google Maps. "You can't move," he said.

As Bostonians know, no app in the world is capable of outsmarting local traffic. That leaves sightseeing companies to do what little is under their control.

They're cutting major destinations from itineraries — who needs to see Harvard, Charlestown, the Seaport, or...
Transport market

• Open access
• Scheduled/routed transport
• Efficient congestion pricing

No congestion
The time is right

• Advances in mobile communications enable
  – Precise (to 1 cubic meter) location of vehicles
  – Easy communication of preferences, prices, schedules

• Advances in computers and markets enable efficient
  scheduling/routing and pricing of transport

And case for innovation gets stronger each year
Autonomous vehicles are here
Trade-offs in transport
Vehicle: MD 012 ABC

via I-495 W
Fastest route, the usual traffic
Leave around 8:30 AM

28 min
22.4 miles
$3.42↑
Tip: Prices typically increase in late afternoon.

via I-66 W
27.8 miles
$3.78↑

4:21 AM—6:32 AM
2 h 11 min
Today’s transport is mostly free, but comes at the cost of uncertain congestion delays.

Our market puts a price on transport, but avoids delays (and improves throughput).

Both regimes cause some drivers to leave early, late, or not at all, or to switch roads ...
“The number of vehicles that get through per hour can drop by as much as 50 percent when severe congestion sets in. At high-traffic levels, the freeway is kept in this condition of ‘collapse’ for several hours after the rush of commuters has stopped.”
Behavioral research questions

Do *individuals* pick departure time and roads rationally?

- Simple competitive markets are known to work well (e.g., Smith 1962), but few lab studies look at behavior along different dimensions in competitive markets, such as time and space.

- Economic traffic experiments focus on simple, repeated coordination games without prices (Selten et al. 2007, Chmura/Pitz 2004a,b, Schneider/Weimann 2004, Rapoport et al. 2004), or include a simple toll (Gabuthy et al. 2006, Hartman 2009); almost all experiments induce identical driver preferences, inelastic demand and deterministic supply (but see Lopez 2017).

Are *markets* more efficient and acceptable than the status quo? Which market design effectively promotes participation & acceptance?
Privacy
Equity

VS
Market objectives

• Efficiency
• Transparency
• Simplicity
• Fairness

*Draw on best practice from existing time and locational markets*
Key market principle: open access

• Transport network is open to all
• Nondiscriminatory terms
• Network capacity cannot be withheld
  ⇒ Efficient congestion pricing

• Basis for restructured electricity markets in US, Europe, ...
- **52 inches** of rainfall in southeast Texas
- Harvey made landfall **multiple times**
  - **Category 4** near Port Aransas, Texas
  - **Tropical storm** in Cameron, Louisiana
- More than **42,000** lightning strikes
- Record number of tornado warnings in southeast Texas

Transmission Damage
Players

• Independent System Operator (ISO)
  – Runs market
• ISO or service providers
  – Develop user app for expression of demand
  – Aggregate user demand
  – Guide user (scheduling/routing)
  – Establish user plans and settle payment
• Users
  – Provide fundamental demand for road use
Product design

• Slot on congested road segment at particular time (e.g. 10 minute time interval)
Important features of setting

• Limited number of congested road segments
  – Bridges, tunnels, and other bottlenecks
• Congested segments are highly predictable
• Demand *does* respond to price even close to real time
  – Time shifters: shift transport to less congested time
  – Route shifters: shift route to less congested route
  – Mode shifters: take train, bus, bike or work-at-home
How today’s apps would change
Your location:
Work

32 min
1 hr 44
3 hr 57
32 min
1 hr

Uber
Lyft

$22
$30
$87

POOL
uberX
UberBLACK

5 min wait

CONTINUE

Confirm pickup point:
6419 Dahlonega Rd

Drag the map to change pickup location.

American Express
03

$26–$35
uberX
8 min away

BOOK

The transaction will be processed by Uber.
Sequence of auctions

- Multiple opportunities to trade
  - Reduces risk of service provider
  - Facilitates planning of service provider
  - Provides price transparency
  - Mitigates market power
Sample demand for bidder

Manhattan (peak) monthly

<table>
<thead>
<tr>
<th>Price</th>
<th>Quantity</th>
<th>Change in Quantity</th>
<th>Commitment (180 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$9.00/GB</td>
<td>-1,000,000 GB/h</td>
<td>-3,000,000 GB/h</td>
<td>-$4,860,000</td>
</tr>
<tr>
<td>$7.00/GB</td>
<td>-200,000 GB/h</td>
<td>-2,200,000 GB/h</td>
<td>-$2,772,000</td>
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<tr>
<td>$6.00/GB</td>
<td>500,000 GB/h</td>
<td>-1,500,000 GB/h</td>
<td>-$1,620,000</td>
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<tr>
<td>$5.00/GB</td>
<td>2,000,000 GB/h</td>
<td>0.000 GB/h</td>
<td>$0</td>
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</table>

Current Round

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<tr>
<th>Price</th>
<th>Quantity</th>
<th>Commitment</th>
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<tbody>
<tr>
<td>$4.00/GB</td>
<td>2,083,333 GB/h</td>
<td>$60,000</td>
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<tr>
<td>$3.80/GB</td>
<td>2,100,000 GB/h</td>
<td>$68,400</td>
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<tr>
<td>$3.50/GB</td>
<td>2,300,000 GB/h</td>
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Past Rounds

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<thead>
<tr>
<th>Price</th>
<th>Quantity</th>
<th>Commitment</th>
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<tbody>
<tr>
<td>$3.00/GB</td>
<td>2,400,000 GB/h</td>
<td>$216,000</td>
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<tr>
<td>$2.50/GB</td>
<td>2,500,000 GB/h</td>
<td>$225,000</td>
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<tr>
<td>$2.00/GB</td>
<td>2,666,667 GB/h</td>
<td>$240,000</td>
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</table>

Price Floor

<table>
<thead>
<tr>
<th>Price</th>
<th>Quantity</th>
<th>Commitment</th>
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</thead>
<tbody>
<tr>
<td>$1.00/GB</td>
<td>3,000,000 GB/h</td>
<td>$180,000</td>
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<tr>
<td>Type</td>
<td>Mon</td>
<td>Tue</td>
</tr>
<tr>
<td>--------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Daily trip</td>
<td>●</td>
<td>●</td>
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<table>
<thead>
<tr>
<th>Round trip</th>
<th>One way</th>
<th>Multi-stop</th>
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</thead>
<tbody>
<tr>
<td>Home</td>
<td>Work</td>
<td>MD 0123</td>
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</table>

<table>
<thead>
<tr>
<th>Begin</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wed, 1 Nov 2017</td>
<td>Thu, 30 Nov 2017</td>
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</table>

<table>
<thead>
<tr>
<th>Depart</th>
<th>Arrive</th>
<th>Home to Work</th>
<th>Work to Home</th>
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<tbody>
<tr>
<td>8:00am</td>
<td>8:28am</td>
<td>5:00pm</td>
<td>5:28pm</td>
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<table>
<thead>
<tr>
<th>Alternatives and Price Change</th>
<th>Later</th>
<th>Earlier</th>
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<tbody>
<tr>
<td>+10 min</td>
<td>$ 0.45</td>
<td>-10 min</td>
</tr>
<tr>
<td>+20 min</td>
<td>$ (0.20)</td>
<td>-20 min</td>
</tr>
<tr>
<td>+30 min</td>
<td>$ (0.46)</td>
<td>-30 min</td>
</tr>
<tr>
<td>+40 min</td>
<td>$ (1.11)</td>
<td>-40 min</td>
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<td>+50 min</td>
<td>$ (1.21)</td>
<td>-50 min</td>
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<tr>
<td>+60 min</td>
<td>$ (1.40)</td>
<td>-60 min</td>
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<td>+70 min</td>
<td>$ (1.56)</td>
<td>-70 min</td>
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<td>+80 min</td>
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<tr>
<td>+90 min</td>
<td>$ (2.01)</td>
<td>-90 min</td>
</tr>
</tbody>
</table>

Cost per trip: $ 3.76

Add to Cart
Investment

• Transparent pricing provides detailed information for network investment
• Revenues provide essential funds for investment
Conclusion

• Assures transport network is used efficiently
• Eliminates congestion through scheduling/routing and congestion pricing
• Transparent pricing motivates network investment and provides much needed funds