BU Initiative on Cities: Beyond Congestion

Matthew Raifman
Senior Manager, Ford Smart Mobility
Why do we care about congestion?

- Time (travel time, predictability)
- Greenhouse Gas Emissions (CO, CO2, NOx)
- Health (stress, exposure to PM)
- Vehicle costs
What is Congestion?
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Excess of vehicles on a portion of roadway at a particular time resulting in a reduction below the total possible throughput.
What is Congestion? What can we do about it?

Excess of vehicles on a portion of roadway at a particular time resulting in a reduction below the total possible throughput.

- Fewer vehicles
- More roads
- Spread demand over time
- Improve the overall efficiency of the roadway
What is Congestion? What can we do about it?

Excess of vehicles on a portion of roadway at a particular time resulting in a reduction below the total possible throughput.
How might we access more roadway?

• Build more roads
• Repurpose greenspace, bikelanes, and sidewalks
“If you build it, they will come” induced demand on Boston Artery
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What’s the right mix of green lanes, roads, sidewalks, parking, and dedicated bus lanes to optimize throughput?
What is Congestion? What can we do about it?

Excess of vehicles on a portion of roadway at a particular time resulting in a reduction below the total possible throughput.
How might we reduce the number of vehicles on the road?

• Shift commuters from private vehicles to more efficient modes

NACTO, Designing to Move People Guide
How might we reduce the number of vehicles on the road?

• Pool people and goods

<table>
<thead>
<tr>
<th>Number of Vehicles Needed to Carry 45 People</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
</tr>
<tr>
<td>Vanpool</td>
</tr>
<tr>
<td>3-Person Carpool</td>
</tr>
<tr>
<td>2-Person Carpool</td>
</tr>
<tr>
<td>Single Occupant Automobile</td>
</tr>
</tbody>
</table>

*Curbed; Shutterstock*
How might we reduce the number of vehicles on the road?

• Shift from cars to more efficient modes
• Pool people and goods
• Don’t drive in the first place
What is Congestion? What can we do about it?

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Spread demand over time
Spread demand over time?

• Workplace policies (staggered arrival times)
• Off hour goods delivery
• Technology-enabled routing across time
What is Congestion? What can we do about it?

Excess of vehicles on a portion of roadway at a particular time resulting in a reduction below the total possible throughput.

Improve the overall efficiency of the roadway
How might we improve the overall efficiency of the system?

- Avoid unnecessary stopping (e.g. tolls, parking)
- Optimize speed to maintain throughput
- Dynamically reroute based on traffic conditions
Summary

• Behavior change away from single occupancy vehicles

• Technology can potentially enable behavior change... but policy, regulation, and pricing play a key role

• Technology can improve overall efficiency of system on the margins, but it is not a silver bullet
From Data to Models and Proposed Solutions

Yannis Paschalidis
yannis@bu.edu, http://sites.bu.edu/paschalidis/

Department of Electrical and Computer Engineering,
Division of Systems Engineering,
Department of Biomedical Engineering,
and Center for Information and Systems Engineering
Boston University

March 26, 2019
Forum at IOC
Traffic congestion responsible for **20% of fuel consumption** and **90% of CO** in large urban areas.

Cost of traffic congestion will reach **$2.8T** in the US by 2030 (≈ annual tax revenue).

On a per-driver basis, cost of traffic congestion is **$1740** annually in US/Europe.

Boston recently made news being declared **#1** in hours lost in rush-hour traffic per driver in 2018.
Congestion Maps for the Boston Area: 2012→2015


(Salo Wollenstein)
Transportation Network Models

- **Transportation** network modeled as a graph.

- **Dynamics**: Drivers have a congestion function function of flow for each arc and pick the cheapest arcs to traverse. Collective decisions lead to a Nash (Wardrop) equilibrium.

- To control/design we need to build accurate predictive models.
- Data: Traffic flows.
- Can we learn (the congestion function) from data?
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Price of Anarchy\textsuperscript{1}

- Having the congestion function allows us to answer many “what-if-questions”.
- We can also formulate a problem to obtain a socially optimal equilibrium.
- Price-of-Anarchy:

\[
\text{PoA} = \frac{\text{Congestion under Selfish Behavior}}{\text{Congestion under Socially Optimal Behavior}}
\]

- Useful to assess how good/bad things are, but also to design interventions.

\textsuperscript{1}Zhang, Pourazarm, Cassandras, Paschalidis, CDC 2016, IFAC 2017, Proceedings IEEE 2018.
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Boston Area Data\(^2\)

Eastern Massachusetts (EMA) Network

- Spatial average speeds for 13,000 road segments for each minute of 2012 (50 GB) and 2015 (130 GB).
- Capacity data in different times-of-day: lanes, peak vehicles counts, etc.

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Price-of-Anarchy (2012)
Road Congestion: Socially Optimal vs. User Optimal

“Spreading the traffic” results in:

![Graph showing traffic congestion metrics for User-centric and System-centric models for different link indices.](image-url)
Control and Interventions

1. **Sensitivities:** Where to intervene?

2. **Socially optimal route recommendations:** Can be shown that we can achieve the Socially Optimal solution through User Optimal actions if users use a properly modified congestion function!
   - Easier to incorporate in apps, even enforce with autonomous vehicles.
   - Take the driver “out of the picture.”

3. **Change demand!** Congestion pricing and incentives!
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Final remarks

- We have developed a new general framework for modeling driver behavior using data.
- Policy space: How to address traffic allocation issues and prevent NIMBY reactions?
New Skills for New Mobility

Boston University Initiative on Cities
March 2019

Jascha Franklin-Hodge / @jfh
What’s new?
New mobility is digital
New mobility is market driven.
New mobility is dynamic.
New mobility is dynamic.
New skill: Real-time data for planning
New skill: Data sharing with private sector
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1. Require licensees to provide to the locality anonymized fleet and ride activity data for all trips starting or ending within the jurisdiction of the locality on any vehicle provided by the licensee or any company controlled by, controlling, or under common control with the licensee, provided that (i) such data is provided via an application programming interface complying with the format requirements of the Mobility Data Specification and subject to the licensee's license agreement for such interface; (ii) any such data provided shall be treated as trade secret and proprietary business information, shall not be shared with third parties without the licensee's consent, and shall not be treated as owned by the local authority; and (iii) disaggregated ride history data containing GPS location traces of rides taken by users shall be considered personally identifiable information and shall under no circumstances be

"Bicycle lane" means that portion of a roadway designated by signs and/or pavement markings for the preferential use of bicycles, electric power-assisted bicycles, motorized skateboards or foot-scooters, and mopeds.

"Business district" means the territory contiguous to a highway where 75 percent or more of the property contiguous to a highway, on either side of the highway, for a distance of 300 feet or more along the highway, is occupied by land and buildings actually in use for business purposes.

"Cancel" or "cancellation" means that the document or privilege cancelled has been annulled or terminated because of some error, defect, or ineligibility, but the cancellation is without prejudice and

"Contract" means the agreement made by a person evidenced by a writing, in which the person is to perform or be liable for the performance of any act, and it includes a durable power of attorney and a will executed under the laws of this Commonwealth.

" Crime" means the act committed or attempted in violation of a law of this Commonwealth, or a law of the United States or of another state, that is punishable by a fine or by imprisonment or both.

"Durable Power of Attorney" means an instrument appointing a person to act as a duly authorized agent for another for the purpose of managing the property or affairs of the principal.

"Driver" means a person who is operating a motor vehicle.

"Employee" means an individual who is employed by a person or entity under a contract or agreement or employment relationship.

"Estate" means the total of all interest of a deceased person in property and rights in property, whether real or personal, including any interest that, at the time of the person's death, is held as a tenant by the entirety.

"Forfeiture" means the loss of property rights to persons whose unlawful conduct has occurred or whose unlawful state of mind existed during the pendency of proceedings to forfeit that property.

"Furnishing" means a provision of a goods or services for another, or any act done with the intent of furnishing a goods or services.

"Gift" means a transfer of property made without consideration.

"Governmental Entity" means any state or local government, public authority, or public instrumentality of this Commonwealth, including any board, commission, or agency.

"Homestead" means the property comprising the residence of the owner, together with any land and buildings thereon used in connection with the residence, and includes the property comprising a museum, library, or other public or educational institution, or any public hospital or sanitarium, or any public library, if the owner is incorporated under the laws of this Commonwealth.

"Improvement" means a structure or improvement of a public utility property within the meaning of the Uniform Statutory Exclusions of Real Property from Ad valorem Taxation Act.
New skill: Adaptive regulations

3.3.1 Dynamic Cap Adjustment Process

Operators interested in increasing their device cap must submit a request to the City with recent and relevant supporting data that demonstrates fleet utilization levels that meet or exceed the MUR. Data from the first 30 days of the pilot program should not be used in a request for adjustment. Utilization is calculated by dividing the sum of total daily rides within the jurisdiction over a one week period by the number of total devices available daily during the same timeframe. The highest and lowest outliers may be removed from the calculation.
New skill: Dynamic pricing
New skill: Incentives for outcomes

Your Uber and Lyft ride at Logan Airport may soon change

By Adam Vaccaro | GLOBE STAFF  MARCH 21, 2019

Those Lyft and Uber rides to and from Logan may be getting more expensive — and they probably won’t be dropping you off in front of the terminal anymore.

The Massachusetts Port Authority, which operates Logan Airport, on Thursday unveiled details of its plan to rein in the thousands of Uber and Lyft rides clogging its terminals and narrow roads, and a fee increase that would make its ride-hailing charge among the highest of any airport in the country.

“We have to do something,” said Edward Freni, the agency’s director of aviation, expressing exasperation about the daily traffic jams at the terminals and in East Boston.
New skill: Consumer protection

Why Uber and Lyft want to create walled gardens—and why it’s bad for urban mobility

As ride-hailing apps begin to control scooters and bike shares, they’re making it harder for people to make the best decisions about how to move around their cities.

[Photo: Mary Altaffer/AP/Shutterstock]

BY DAVID ZIPPER  6 MINUTE READ

If you’re not a techie, you may not have come across the term “walled garden” before. But it’s a critical concept these days.
The future of the DOT is roads...and code.