Incentive Mechanisms for Societal Networks

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Depts of EE and CS, Stanford
Background

My Research

Until 2008: Computer Networks—Internet Algos, Cloud Computing
2008—2015: Societal Networks—Transportation, Wellness, Recycling

Dec 2007
I visited Bangalore...
2008—2011: Stanford Research

Developed large-scale “nudge engines” for:

- Infosys (Bangalore)
- Singapore Public Transit
- Stanford (U.S. DoT)
- Bay Area Rapid Transit (BART)
- Accenture, USA → Wellness
12—now: **Urban Engines**

- Co-founded with some students and ex-Googlers
- Developed a big data system for large-scale mobility networks
  - Transportation systems: road, bus, train (metro) systems
  - Logistics and delivery chains

Urban Engines acquired by Google (Google Maps) in Sep 2016
Smart City Programs:
A Personal Perspective

Engineering at the beginning of the 20th century
Civil Engineering, Mechanical Engineering, Power Engineering
→ Call it the Edison-Ford type of engineering
→ Highly resource-constrained, “built to last”
Smart City Programs: A Personal Perspective

Engineering in the middle of the 20th century

Electrical Engineering (VLSI, Comm) and Computer Science
→ Call it the Bell-Watson type of engineering
→ Moore’s law, short product cycles, disruption
Smart Cities = Bell-Watson-ites working with Edison-Ford-ites
Urban Immobility
Chinese drivers stuck in the longest traffic jam

Authorities in China are racing to unscramble the world's longest traffic jam, a 60-mile tailing in the capital Beijing to the northern province of Inner Mongolia.
Not just commuter frustration and indignity...
The Cost of Congestion

Time and fuel wasted (TTI)
- $115 billion in 2007
- $121 billion in 2011

Emissions due to traffic
- 27% of all U.S. emissions (EIA)
- 25% for U.K. (DoE&CC, UK)

Safety, ...
The Visible Problem

Demand >> Supply
The Real Problem

Dated Transportation Architecture
Transportation Architecture of the 20th Century

Agencies / Operators
- Departments of Transportation
- Public transit operators
- Taxi companies

Networks

Commuters

No flow of information
Demand doesn’t talk to supply!
Transportation Systems of the 21st Century

Agencies / Operators
- Departments of Transportation
- Public transit operators
- Taxi companies

Operate

Networks

Use

Commuters
Transportation Systems of the 21st Century

Agencies / Operators

Operate

Networks

Real-time usage data

Cloud, Big Data, IoT

Real-time analytics

Incentives

User behavior

Commuters
Transportation Systems of the 21st Century

Agencies / Operators
- BART
- TAXI

Networks
- RAIL
- BUS
- CAR
- TAXI

Commuters

Key Enablers
- Cheap, ubiquitous sensors
- Abundant bandwidth
- Technological advances
  - Internet of Things
  - Cloud computing
  - Big data

Enablers:
- GPS
- RFID/NFC
- Bluetooth
- Cellular
- WiFi
Commerce and Retail in the 20th Century

The Producers
Designers/Manufacturers

PRADA  
D&G  
JIMMY CHOO  
Whirlpool  
BOSCH  
SONY  
BANG & OLUFSEN  
Kellogg's  
P&G  
Dasani  
PEPSI

Stores

macys  
bloomingdales  
Crate & Barrel  
IKEA  
Walmart  
SAFEWAY  
WHOLE FOODS

The Consumers
Customers

Shop  
Stock
Commerce and Retail in the 21st Century

The Producers/Manufacturers
- Prada
- Nike
- Jimmy Choo
- Dolce & Gabbana
- B&G
- BOSCH
- Grohe
- Bang & Olufsen
- Kellogg's
- P&G
- Pepsi
- Milk Company

Online + Delivery
- Macy's
- Bloomingdale's
- Crate & Barrel
- IKEA
- Safeway
- Walmart
- Whole Foods

eCommerce + Delivery
- Amazon
- Jet
- Alibaba
- Flipkart

Pickup + Delivery
- UPS
- FedEx
- Penske

The Consumers
Buy Online
Home Delivery
Basic Problem

Demand $>>$ Supply
Our Work

Demand $>>$ Supply

Reduce demand using incentives, not penalties

Increase supply using big data, matching markets
Incentives: Singapore MRT

• The INSINC project
  – Primary goal: Incentivize offpeak travel

• Launch and current status
  – Stanford + NUS, Jan—Jun 2012
  – Urban Engines, July 2012
  – Currently: Travel Smart Rewards
    • 380,000+ registered participants & 75+ corporate members
  – Shift in peak load: ~ 10%
INSINC Demo

Commuting History

kms to credits
3x for off-peak

The Insinc portal

Credit History

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15th June 2010</td>
<td>09:00:19</td>
<td>20</td>
</tr>
<tr>
<td>16th June 2010</td>
<td>08:10:45</td>
<td>10</td>
</tr>
<tr>
<td>16th June 2010</td>
<td>16:20:17</td>
<td>22</td>
</tr>
<tr>
<td>18th June 2010</td>
<td>06:15:20</td>
<td>20</td>
</tr>
</tbody>
</table>
INSINC: Jan 2012—June 2012

registered/admitted and activated
22,867/20,319

random/deterministic redeemers
87.6%/12.4%

number of recommend-a-friend emails sent
98,834 (excluding reminders)

people with friends
12,163 (59.9%)

total rewards (including referral and joining bonuses)
$137,639
FRACTION OF COMMUTERS IN 5-MINUTE SLOTS

TRIP START TIME

Before
After

-7.49%
-10.1%
-10.65%
-11.27%
<table>
<thead>
<tr>
<th>Type of participants</th>
<th>All in the group</th>
<th>Mild peakers</th>
<th>Medium peakers</th>
<th>Heavy peakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>participants</td>
<td>-7.49</td>
<td>-10.10</td>
<td>-10.65</td>
<td>-11.22</td>
</tr>
<tr>
<td>Those with Insinc friends</td>
<td>-9.70</td>
<td>-10.61</td>
<td>-11.14</td>
<td>-11.44</td>
</tr>
<tr>
<td>Those without Insinc friends</td>
<td>-3.70</td>
<td>-9.00</td>
<td>-9.69</td>
<td>-10.78</td>
</tr>
<tr>
<td>Game players</td>
<td>-8.40</td>
<td>-10.79</td>
<td>-10.92</td>
<td>-11.35</td>
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<tr>
<td>Fixed exchange</td>
<td>-5.07</td>
<td>-10.24</td>
<td>-10.96</td>
<td>-12.35</td>
</tr>
<tr>
<td>Short distance commuters</td>
<td>-4.96</td>
<td>-10.49</td>
<td>-10.83</td>
<td>-11.85</td>
</tr>
<tr>
<td>Long distance commuters</td>
<td>-9.13</td>
<td>-9.77</td>
<td>-10.51</td>
<td>-10.88</td>
</tr>
</tbody>
</table>
Our Work

Increase supply using big data, matching markets

Demand  >>  Supply

Reduce demand using incentives, not penalties
Things that move in a city

<table>
<thead>
<tr>
<th>GPS</th>
<th>Smart travel card</th>
<th>Smart phone</th>
<th>Barcode / RFID</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="GPS" /></td>
<td><img src="image" alt="Smart travel card" /></td>
<td><img src="image" alt="Smart phone" /></td>
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- GPS
- Smart travel card
- Smart phone
- Barcode / RFID
Lots of data, but it is...

Piecemeal: tap-in/tap-out, train loads, ...
Error-prone and noisy: needs healing and curing
Siloed: different orgs, database technologies and formats

What’s needed: A system and algorithms for solving a massive jigsaw puzzle