It pays to do the right thing: Incentive mechanisms for Societal Networks

Balaji Prabhakar
Departments of EE and CS
Stanford University

Joint work with
Adrian Albert, Naini Gomes, Deepak Merugu, Gearoid O’Brien and Tom Yue
Introduction

Societal networks: Networks concerned with societal processes

Transportation

Healthcare

Energy

Recycling

Societal Networks = Resources + Technological mechanisms + Human actions

Better technology

Incentivize people to do the right things
Issues with current Societal Networks

• Lack of scalability: Demand invariably exceeds supply

• Highly permeable nature of inefficiency: Too many holes to plug
  – Example, annual congestion costs in the U.S. [TTI reports]
  – Measured as wasted time and fuel = $87.2 billion in 2007
  – Measured at the individual level, this is less than $1.50 a day

• Lack of fine-grained sensing and measurement

• Social networks and Societal Networks
  – Social networks: network of friends
  – Societal networks: network of strangers
Smarter societal networks

Societal networks: Networks concerned with societal processes

Architectural principles
Spread information
Deploy economic incentives
Problems and Opportunities
Transportation

• **Road congestion**
  – More than 250 Million registered passenger vehicles in the US
  – In 2007 total cost of congestion in wasted fuel and time was about $87.2 Billion (source: TTI)
  – **Auto bailout**: $25 Billion

• **Emissions**
  – 27% of all U.S. emissions (source: EIA)
  – 25% for U.K. (source: DoE&CC, UK)

• Traffic accidents, parking ...
Chinese drivers stuck in the longest traffic jam

Authorities in China are racing to unscramble the world’s longest traffic jam, a 60-mile tailback from Beijing to the northern province of Inner Mongolia.
Carbon Footprint

- 746 trees to offset! (2300 kg)
- 44 trees to offset (132 kg)

*Car/Van data from USEPA, Public Transportation from SMRT. Calculated for an average commute of 9000 km/year
Public Transit

• Lack of adoption
  – Public transportation comprises less than 2% of all passenger miles in the US, Singapore has over 48% of journeys in public transportation
  
  – 98% of U.S. commuters prefer public transport for others. – *The Onion*
Or, Overcrowding

Japan

London

Seoul

Shanghai
Current Solutions
Charging and Rationing

• Congestion Charging
  – Singapore: ‘Electronic road pricing’
  – Congestion charge: London, Toronto, Bergen, Stockholm, Milan
  – Viewed as “yet another tax”, undemocratic, expensive

• Road Rationing
  – Sao Paulo, Santiago, Athens, China, ...
  – Places burden on enforcement
More bus services at peaks
By Maria Almendoar

Bus operators here will add more bus services on heavily-utilised stretches during peak hours. -- ST PHOTO: STEPHANIE YEOW
Our approach: Incentives

- Congestion market: charge congestors, pay decongestors
- Observation: To decongest, just remove 10% of the load
Micro-raffles

• In games with low stakes, players are more risk seeking

• Two envelope game:
  – Envelope 1: $100
  – Envelope 2: $11,000 with 1% chance, $0 else (Ave = $110)
  – Q: Which will you choose?

• Version 2:
  – Envelope 1: $1
  – Envelope 2: $110 with 1% chance, $0 else

• Theorem: If you choose Envelope 2 in Version 1, you will also choose it in Version 2 (else, you are irrational)
More precisely,

- If $U(.)$ is a concave utility function with $U(0)=0$, and assume one of the following two conditions holds:
  1. $-xU''(x)/U'(x) \geq 1$ (This is the well known Relative Risk Aversion function)
  2. $xU'(x)/U(x)$ is a monotonic decreasing function.

- If $X \geq 0$ is a random variable representing payoff, then for $0 < \delta < 1$,
  $E[U(X)] - U(\delta E(X)) \geq 0$ for sufficiently small $E(X)$. 
• **Airline travel award: Mileage ticket to Europe**
  – 50,000 miles
  – Option 2: 500 miles with 1% chance
  – Option 3: 25,000 miles with 50% chance

• **Faculty salary increases**
  – 2% per annum
  – Option 2: 200% with 1/100 chance!
Recycling Experiment

• Part of Freshman Seminar Course in Spring 2010

• Bring a can or a plastic bottle recyclable, choose a reward option
  – $0.05
  – $1 with probability 1/20
  – $5 with probability 1/100
  – $20 with probability 1/400
  – $50 with probability 1/1000
  – $100 with probability 1/2000

• Expected value of each option: $0.05
Pilots and Deployments
The INSTANT (Infosys-Stanford Traffic) project was a pilot study of using an incentive mechanism to decongest road traffic.
Morning GPS trace:
Jayanagar to Infy
Morning GPS trace: Jayanagar to Infy

Commute time: 29 mins. 20% of all commuters

Commute time: 82 mins. 80% of all commuters
The incentive mechanism

At a Glance

Commuter's working day begins

Arrival (swipe-in) time

- Arrival before 8.00 AM
  - Earn 1.5 credits
  - Incentive mechanism
  - Rewards given weekly
- Arrival between 8.00 – 8.30 AM
  - Earn 1 credit
- Arrival after 8.30 AM
  - No credit

Rewards given weekly
The reward pyramid

- Total sum of money = 96,000
- Total number of rewards = 66

No. of rewards $\times$ Amount of reward (credits needed)

- $2 \times 12,000$ (20)
- $4 \times 6,000$ (12)
- $12 \times 2,000$ (7)
- $48 \times 500$ (3)
The algorithm

- $2 \times 12,000 \ (20)$
- $4 \times 6,000 \ (12)$
- $14 \times 2,000 \ (7)$
- $52 \times 500 \ (3)$
Summary of INSTANT

• Pilot: Launched by N.R. Narayanamurthy, Co-Founder and Chief Mentor, October 6, 2008, concluded on Apr 10, 2009

• 14,000 commuters in total
  • Number of off-peak hour commuters increased from 4,500 to 9,200
  • Average commute time down by 40 mins

• Estimated savings in fuel cost: Rs. 15,000 per day

• Reduction in bus fleet size: 8 buses

• Popular interest, media coverage
  – The Times of India
  – Daily News and Analysis
  – The Deccan Herald
Traffles: Singapore Public Transit System

• Goals:
  − Mode shifting: Move people from private to public transportation
  − Incentivize offpeak travel

  “Transport is another area where people worry about congestion, especially on the trains” – Prime Minister Lee Hsien Loong, National Day Rally Speech
The Traffles portal

Credit History

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Commuting History

kms to credits

Electronic Ticket

Commuter

Jurong East

Outram Park

traffles

Micro-Raffles
Steptacular

Accenture Employee

Pedometer

Walking History

Steps to points

Steptacular portal

Points History

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Micro-Raffles
Wellness incentives

• Facts
  − More than 60% of Americans are physically inactive?
  − More than 65% of Americans are obese or overweight?
    New York State Department of Health
  − Medical costs associated with inactive lifestyles are estimated at almost $80 billion.
    Healthcare bill: $940 Billion over 10 years.

“What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?”
Stanford Congestion

- Agreement with Santa Clara County in 2001
  - Morning peak-hour limit = 3,319 vehicles, + 1% tolerance
  - Evening peak-hour limit = 3,446 vehicles, + 1% tolerance

- Decongestion project funded by U.S. Department of Transportation
  - RFID tagged parking stickers, gather commuting time history
  - Incentivize off-peak hour commuting
Our approach

Off-peak hour → Earn credits

RFID scanning system

Entry to Stanford
### Our approach

- **RFID scans**

**Database & Web portal**

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**Reward mechanism**
Bangalore bus pass