



designing the transit marketplace

Sid Banerjee

CNTS Workshop, July 2019

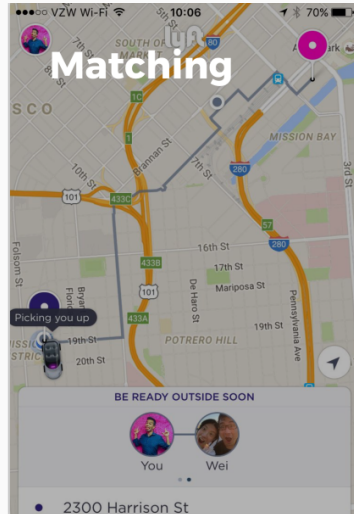
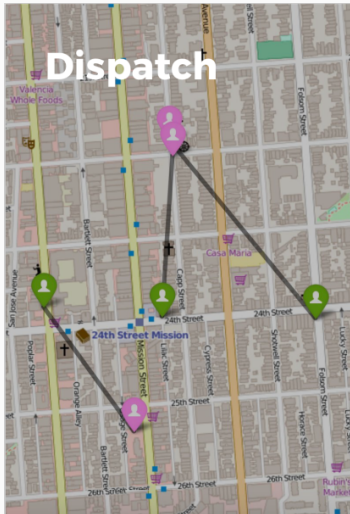
Operations Research, Cornell

ridesharing platforms



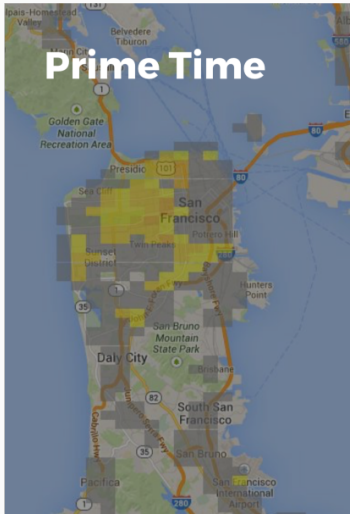
- critical components of modern urban transit
- **crucible for real-time decision making/OR/EconCS**

research in ridesharing: logistics



credit: lyft research science

research in ridesharing: market design



Supply Levers

9:54 AM
pages.lyftmail.com

31%

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The Power Driver Bonus Upgrade.

You know the Power Driver Bonus as a reliable way to earn almost all of your commission back each week - and now it's even better. With this upgrade, you can earn even more with greater flexibility. The new PDB features five extra bonuses and three additional tiers, starting with a new 30-ride benchmark.

	DRIVE	GET
NEW	30 Total Rides 10 PEAK HOUR RIDES	\$50 Bonus
NEW	50 Total Rides 20 PEAK HOUR RIDES	\$100 Bonus
	80 Total Rides 30 PEAK HOUR RIDES	10% Back + \$150 Bonus
	100 Total Rides 40 PEAK HOUR RIDES	20% Back + \$150 Bonus
NEW	120 Total Rides 45 PEAK HOUR RIDES	20% Back + \$200 Bonus

Plus, we added 19 more eligible peak hours that count toward your bonus.

credit: lyft research science

shout-out to all my co-passengers



Daniel Freund



Raga G



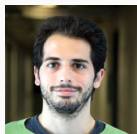
Chamsi
Hssaine



Ramesh Johari



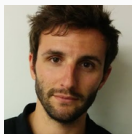
Yash Kanoria



Thodoris
Lykouris



Pengyu Qian



Carlos
Riquelme



Samitha
Samaranayake

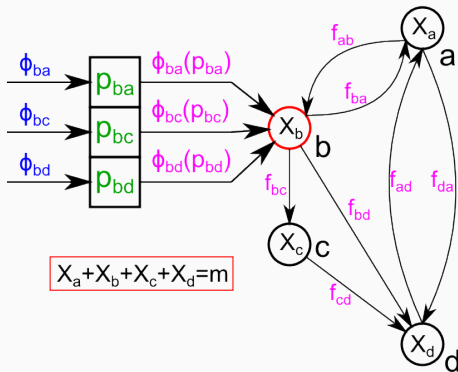


Thibault
Séjourné

special shout out to

- the amazing folks in the **lyft research science** team
- **ARO** (W911NF-17-1-0094) & **NSF** (ECCS1847393, DMS1839346) support

what we have worked on



stochastic control models for ridesharing

Markov chain (queueing network) of cars in network

- available cars + occupied cars + empty-car rebalancing
- Poisson passenger arrivals, loss system
- state-dependent pricing/dispatch/rebalancing

what we can do

theorem [Banerjee, Freund & Lykouris 2017]

flow relaxation gives **state-independent** dispatch policy which is

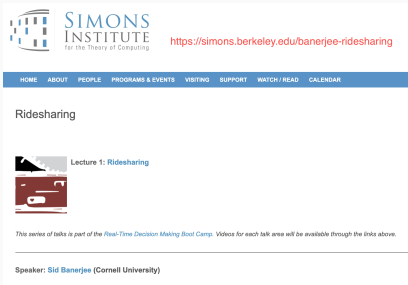
- $1 + \frac{n-1}{K}$ approximate (with instantaneous trips)
- $1 + O\left(\frac{1}{\sqrt{K}}\right)$ approximate (with travel-times, heavy-traffic)

theorem [Banerjee, Kanoria & Qian 2018]

family of **state-dependent** dispatch policies which are

- $1 + e^{-\Theta(K)}$ approximate (for large K , instantaneous trips)
- convex program gives **optimal exponent**

for more on this



The screenshot shows the Simons Institute website. The header includes the Simons Institute logo (for the Theory of Computing) and the URL <https://simons.berkeley.edu/banerjee-ridesharing>. A navigation bar contains links: HOME, ABOUT, PEOPLE, PROGRAMS & EVENTS, VISITING, SUPPORT, WATCH / READ, and CALENDAR. The main content area is titled "Ridesharing" and features a thumbnail for "Lecture 1: Ridesharing" with a small image of a car. Below the thumbnail, a note states: "This series of talks is part of the Real-Time Decision Making Boot Camp. Videos for each talk area will be available through the links above." At the bottom, it identifies the speaker as "Speaker: Sid Banerjee (Cornell University)".



survey chapter

Ride Sharing, Banerjee & Johari
in Sharing Economy, Springer Series in Supply Chain Management

so did ridesharing 'solve' transit?

How Park-and-Ride Encourages Car Use

ERIC JAFFE MAR 20, 2013

A new study finds that people who used to make the whole trip by bike or transit now drive to the station.



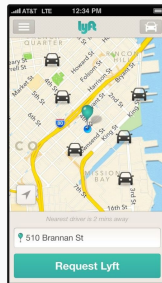
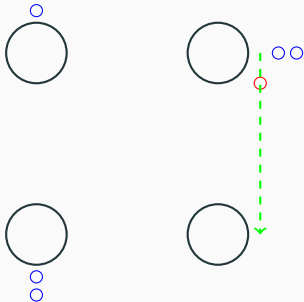
(my view of) the next big challenge

two research vignettes

- impact of platform competition
... and data vs. modeling
- designing transit marketplaces
... and the role of regulation

the price of demand fragmentation

price of fragmentation in ridesharing ecosystems

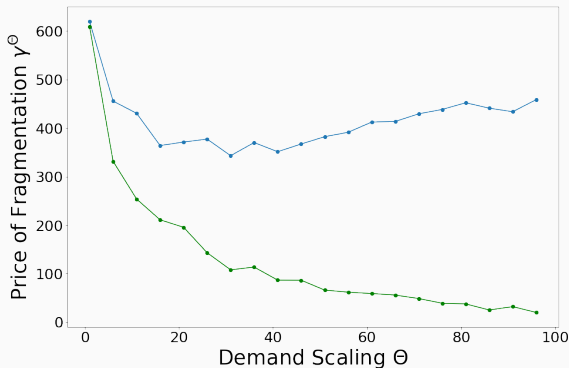


- ‘societal cost’ of decentralized optimization?
 - multiple platforms with **exogenously partitioned demands**
 - individual platforms do optimal **rebalancing**

price of fragmentation

under exogenous demand split, increase in rebalancing costs of **multiple platforms** vs. **single platform** (under large-market scaling)

counterfactual simulation: NYC taxi data



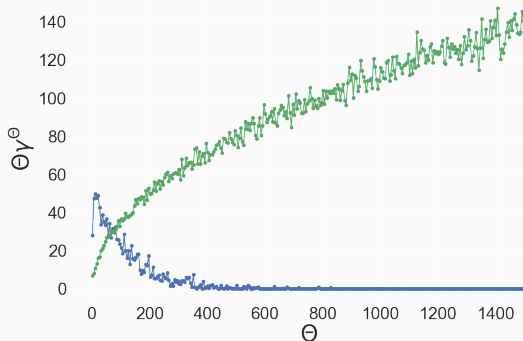
γ^θ vs. θ ; NYC TLC data clustered into 40 stations

price of fragmentation in ridesharing markets

theorem [Séjourné, Samaranayake & Banerjee 2018]

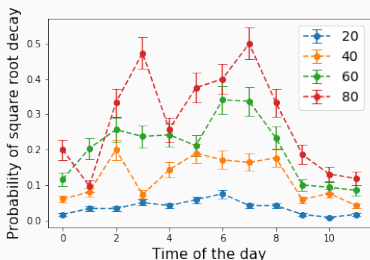
price of fragmentation undergoes a **phase transition** based on structure of underlying demand

– both regimes observed in NYC data ($\approx 10\%$ fragmentation-affected)

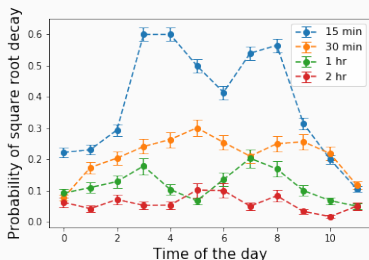


warning: affects numerical simulations in unpredictable ways

fraction of affected regimes depends on data-aggregation granularity
(number of stations/time interval)



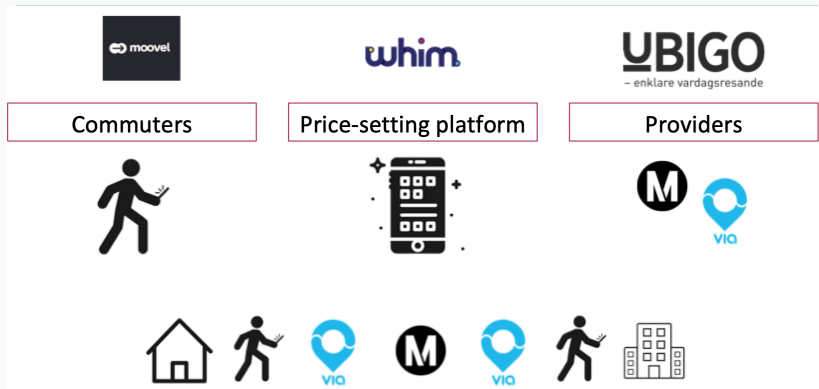
effect of spatial granularity



effect of temporal granularity

designing a transit marketplace

the transit marketplace



not yet, but. . .



FRIENDS WITH TRANSIT

Exploring the intersection of Lyft and public transportation.

Coming soon to the Uber app: bikes, rental cars, and public transportation

Uber CEO Dara Khosrowshahi is in Washington, DC today to extend the hand of friendship to cities and make some product news

By Andrew J. Hawkins | @randyljehawk | Apr 11, 2018, 10:30am EDT

AARJIAN.MARSHALL TRANSPORTATION 10.24.17 07:00 AM

LA LOOKS TO RIDESHARE TO BUILD THE FUTURE OF PUBLIC TRANSIT



DART, Lyft creating new transit choices

A new collaboration between Dallas Area Rapid Transit (DART) and the ridesharing app Lyft means North Texas travelers have a great new way to begin, continue, or end their trip.

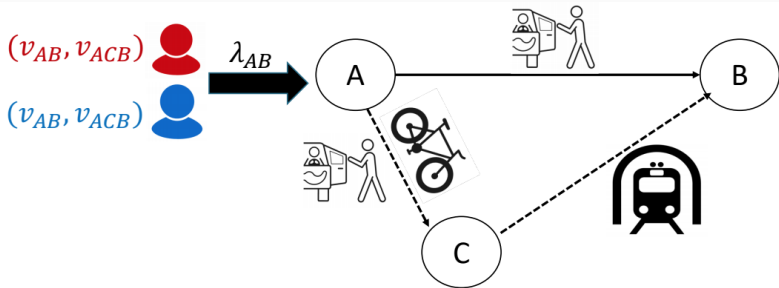


DART covers 700 square miles with a system of buses and trains connecting residents to major work, play, healthcare, and educational destinations. However, customers sometimes need a convenient way to start or end their trip. That's where ride sharing services like Lyft come in.

transit marketplace

model

- each commuter has a public **type**
 - type = vector of valuations, one for each multi-modal option
 - we normalize transit value to 0
- market presents **price-mode menu**: price for each multi-modal option



transit marketplace: objectives

operational objective

reduce frictions, improve reliability for multi-modal trips

economic objective

set prices to maximize overall social welfare

is this all we care about?

pareto improvement as a desiderata for markets

Buy-in from *all* parties (providers and commuters) necessary for success

The Boston Globe

**COMPUTERS CAN SOLVE YOUR
PROBLEM. YOU MAY NOT LIKE
THE ANSWER.**

What happened when Boston Public Schools tried for equity with an algorithm

The New York Times

***'Airbnb Tax' in N.J. Opens New Front
in Battle Over Internet Economy***

transit marketplace: objectives

operational objective

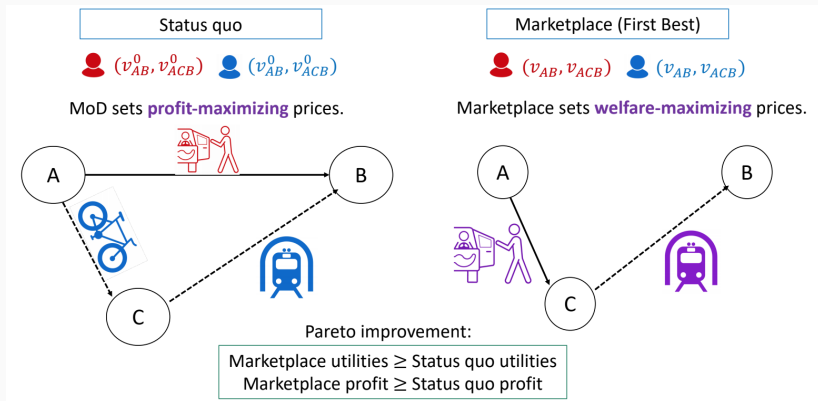
reduce frictions, improve reliability for multi-modal trips

economic objective

set prices to maximize overall social welfare AND

ensure pareto improvement for all participants (commuters/firms)

transit marketplace: incorporating PI constraints



problem: these may be incompatible! (Myerson-Satterthwaite)

transit marketplace: preliminary results

1. Find welfare-maximizing prices (via LP).
2. Raises prices until one of three things happens:
 - i. Efficient allocation is changed
 - ii. Commuter-PI is violated
 - iii. Enough money is raised
3. Final prices:

$$p_m = p_m^* + \Delta_{st}$$

System of linear inequalities
Linear in size of input

"Marketplace surcharge"

Informal Theorem. If there exist surcharges such that, for all commuters allocated a mode in the efficient allocation:

Worst-case welfare generated by commuter in marketplace

$$\max_m \left\{ v_{\theta m} - \sum_{(i,j) \in E_m} (c_{ij} + c_{ji}) \right\} \geq \text{Status quo utility} + \text{Surcharge}$$

Valuation of commuter for mode m

Cost of m + local rebalancing

Welfare generated by commuter in status quo

and the surcharges make up the status quo profit, then First Best is Pareto-improving.

my view of the transportation landscape

where we stand

- transportation network control is real!
 - Lyft/Uber operate giant network control systems
- unified models for ridesharing
 - guide for designing good online controls (pricing/rebalancing)
 - sandbox for studying more complex problems

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the big challenge

- challenges of designing transit marketplaces
 - impact of competing network platforms
 - the role of regulation
 - re-optimizing the network: transit routes, number of cars, etc.

Thanks!

