Modelling Mobility Service Provision

iCity-CATTS Symposium:
TRANSFORMATIVE TRANSPORTATION 2020
June 3, 2020

Francisco Calderón, PhD Candidate
Eric J. Miller, PhD
Department of Civil & Mineral Engineering
University of Toronto

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute

UTTRI

The Advent of Mobility Services

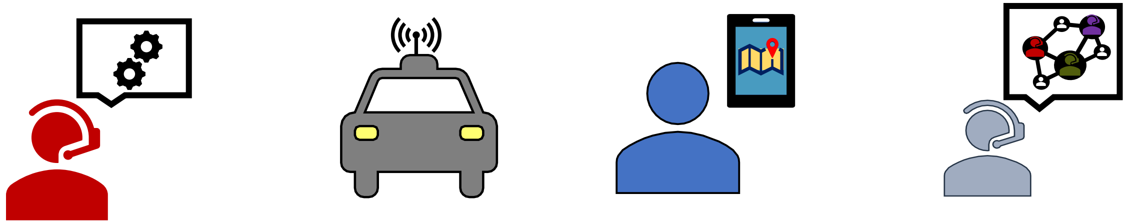
- Rapidly growing
- Broad range of service offerings

UBER
lyft
chariot
mass transit reinvented
lime
drOpbike
dropbike.ca
BIKE SHARE TORONTO

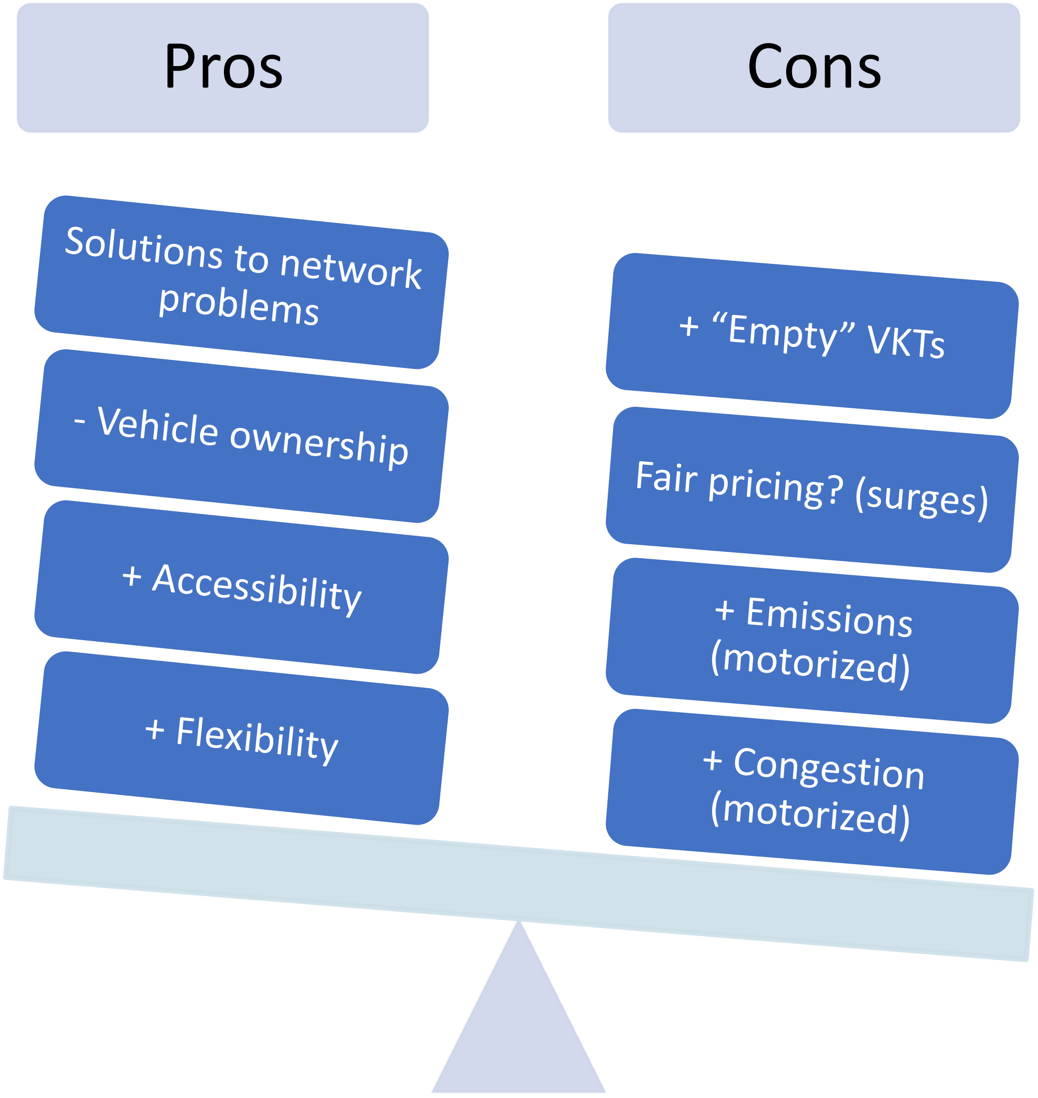
Pros	Cons
Solutions to network problems?	+ "Empty" VKTs
- Vehicle ownership	Fair pricing? (surges)
+ Accessibility	+ Emissions (motorized)
+ Flexibility	+ Congestion (motorized)

Modelling challenges

- How much does each “factor” really weigh?
- Speculative timelines, narrowed-down modelling scenarios
- Ever-changing service features/offerings
- What about large urban regions and multimodal transportation model systems?
- ***Agent-based microsimulation* offers a policy-sensitive planning tool to ask “what if” questions and test scenarios**



Service Providers Vehicles Users Mobility Providers



The first building block

Articles

A literature review of mobility services: definitions, modelling state-of-the-art, and key considerations for a conceptual modelling framework

Francisco Calderón & Eric J. Miller

Received 25 Feb 2019, Accepted 11 Nov 2019, Published online: 19 Dec 2019

Download citation https://doi.org/10.1080/01441647.2019.1704916 Check for updates

Key propositions:

- Over-attention to AVs can be counter-productive, modelling **driver activity** is essential
- Mobility as a Service paradigm: important to keep doors open for mobility services operating in isolation
- Complexity of emerging mobility services requires modelling of service provision
- **Operational activities are fairly generic among mobility service providers**
  - Matching (users & vehicles), Fleet Rebalancing, Dynamic Pricing

Modelling foundation: Conceptual Framework

TOWARDS HUMAN SCALE CITIES - OPEN AND HAPPY
15th biennial NECTAR conference

UNIVERSITY OF HELSINKI
FACULTY OF SCIENCE

TUULI TOIVONEN, KARST GEURS & ELIAS WILLBERG (eds.)

ABSTRACTS

24

Modelling Mobility Services: Towards a Supply-Centered Conceptual Framework

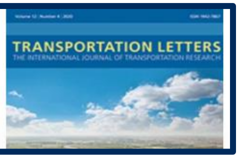
[1]Calderón, F.F. & [1]*Miller, E.J.

* lead presenter, miller@ecf.utoronto.ca
[1] University of Toronto, Canada

- Fully-developed framework under review in:

Transportation Letters

The International Journal of Transportation Research



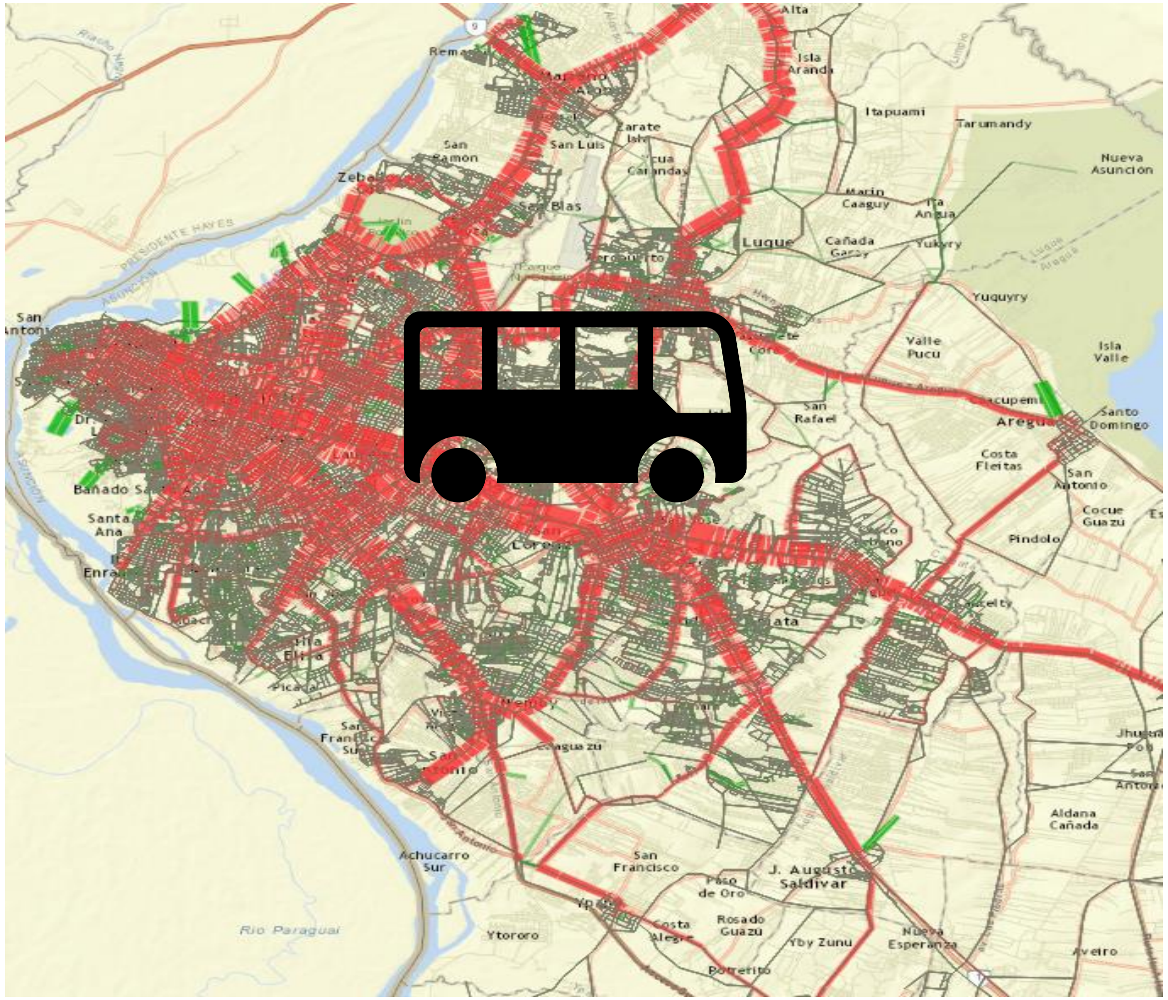
- Conventional models cannot fully accommodate service provision:
  - How to account for dynamics? (pricing, tracking/managing vehicle fleet)
  - Where within our models would operational tasks “fit in”? (matching, rebalancing, etc.)
  - How to model driver activity?
- High flexibility and generality is required to address “volatility”

Some fundamental principles

Separate Services from Networks

- Conventional models embed PT service concept within networks
  - Fixed schedules and alignments
- Practical, but no longer feasible

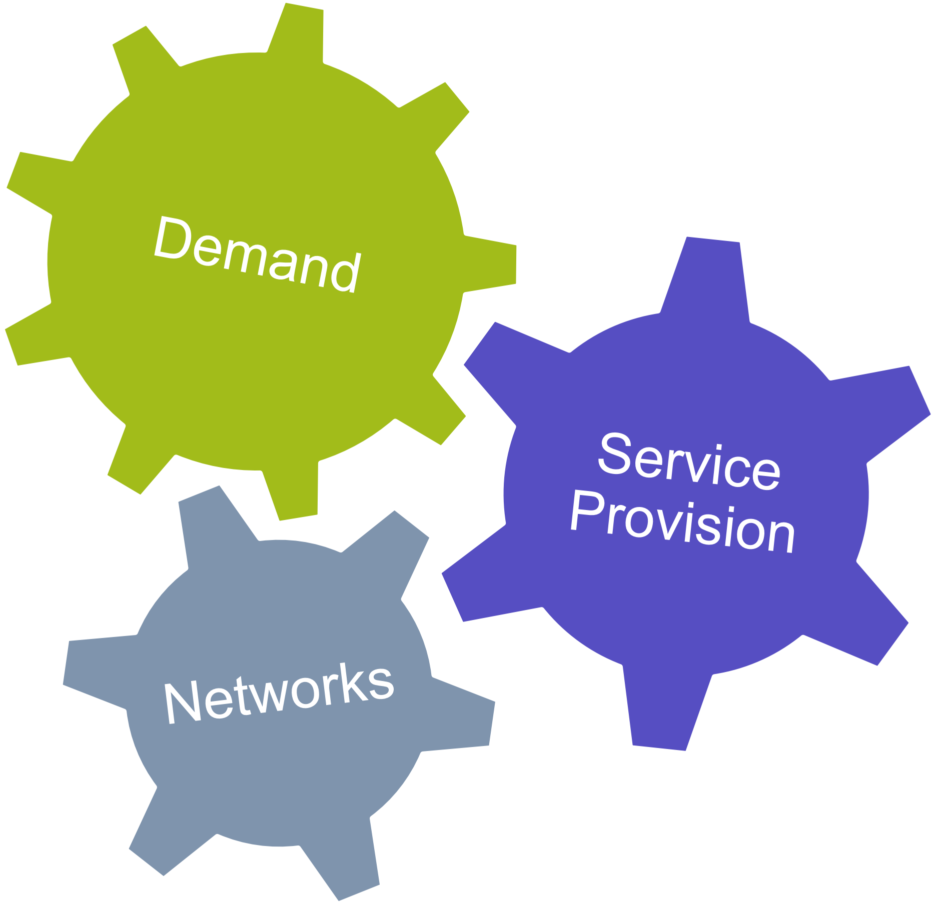
SERVICE PROVISION



Some fundamental principles

Encapsulation & Clear Interfaces

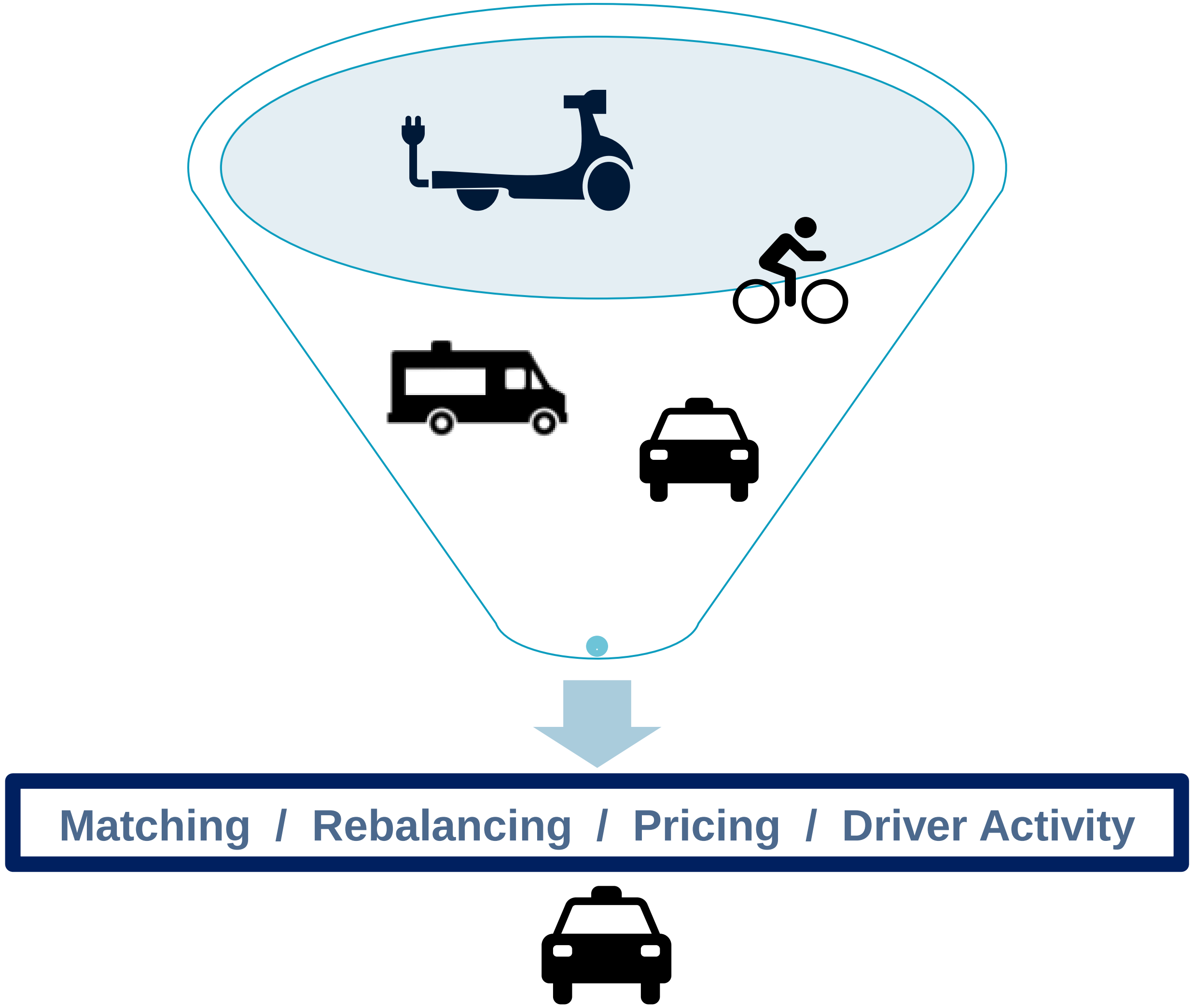
- Isolate components
- **Clearly defined interfaces** to interconnect components are critical to achieve model integration
  - Trips still are the basic unit of analysis (I/O for all components)



Some fundamental principles

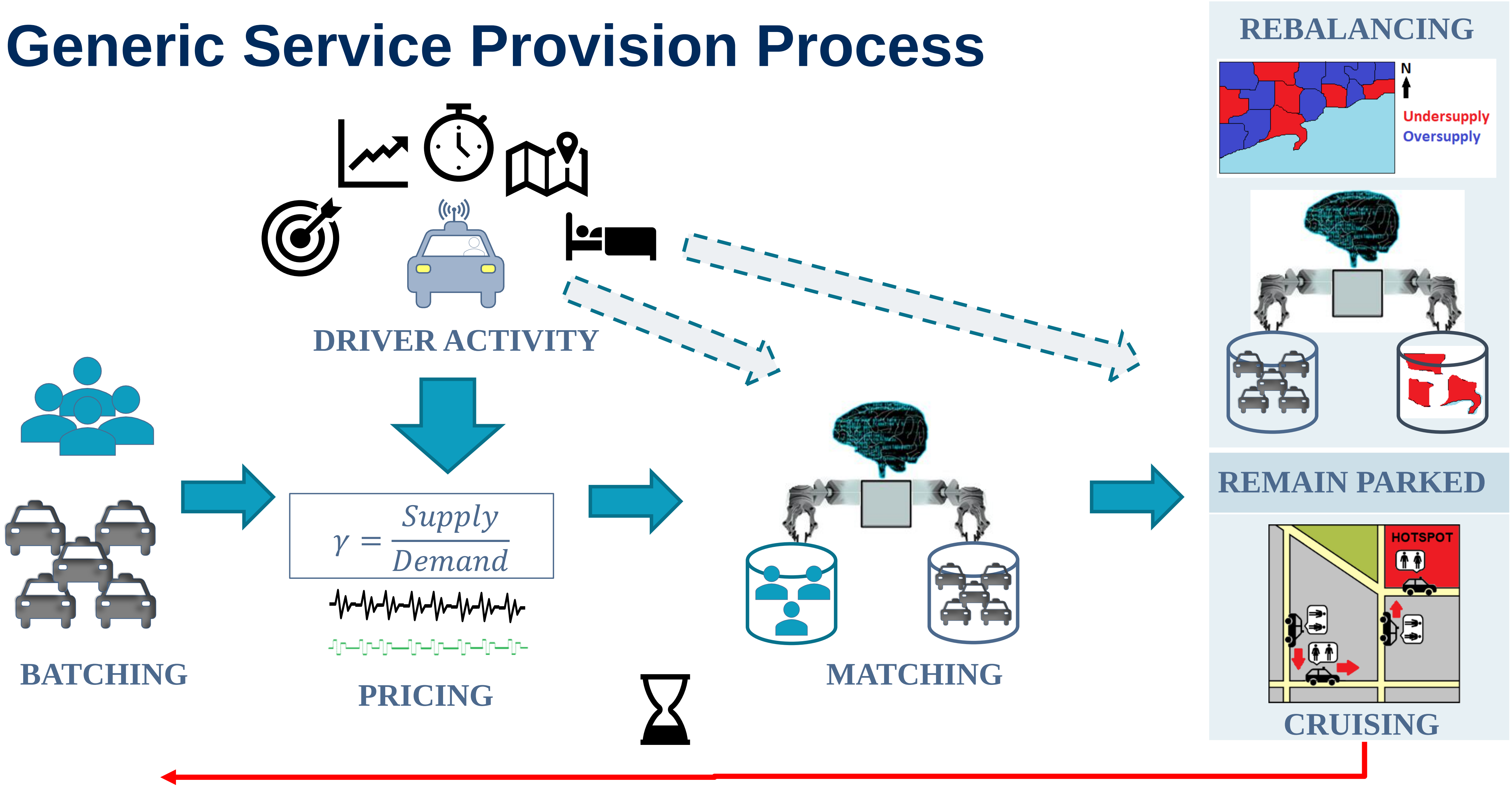
Bottom-up approach

- Outline generic service provision process with ridehailing (most representative case in terms of operational activities)
- Several other services can be represented by one or more activities
  - At most, minor modifications to the service provision process thanks to generic tasks



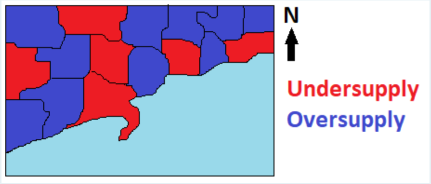
Microtransit icon retrieved from:
https://medium.com/@namyoonkim/what-is-a-microtransit-service-part-1-decc757b6a45

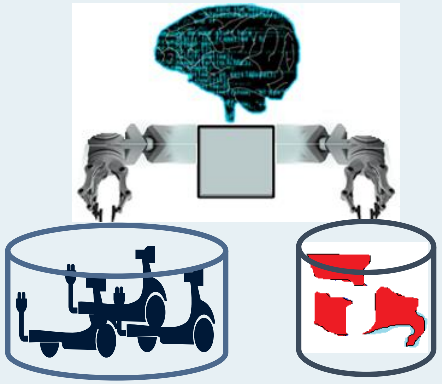
Generic Service Provision Process

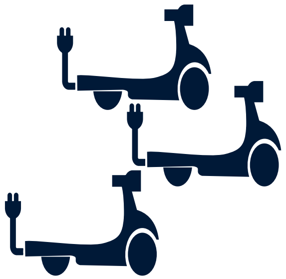


Generic Service Provision Process

REBALANCING

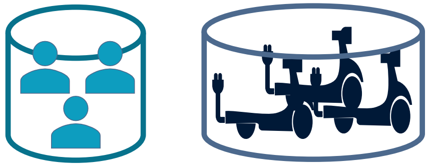






BATCHING

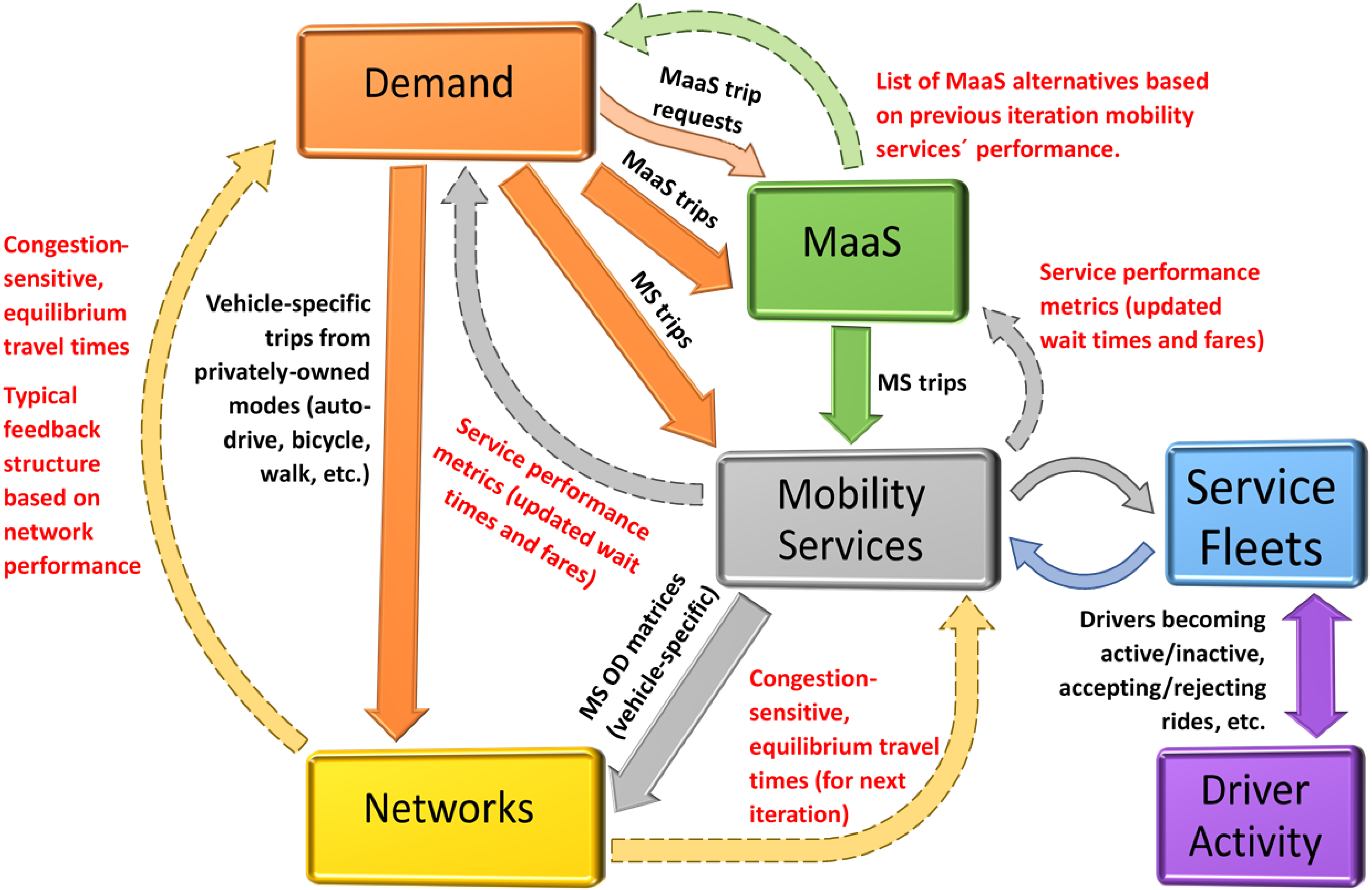
In-advance booking/
First-Come-First-Serve



MATCHING

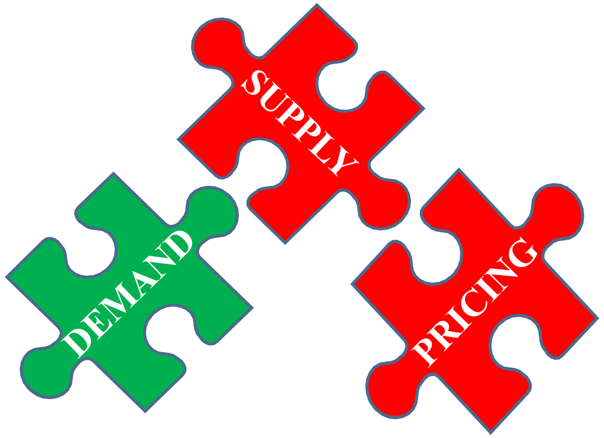
REMAIN PARKED

Putting all the pieces together

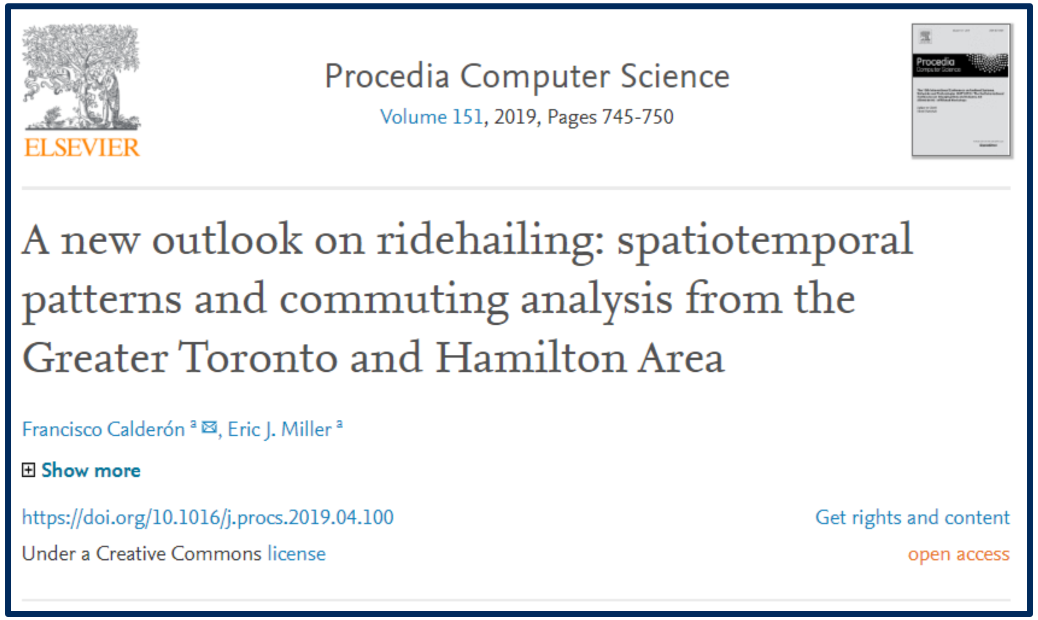


The Ridehailing use case

Limited data and operational knowledge!



- TTS 2016 included ridehailing for the first time
  - Sample size not enough for modelling service provision
- Vehicle For Hire Bylaw Review Project with the City of Toronto
  - Big data, but still only demand (realized trip records)


ELSEVIER

Procedia Computer Science
Volume 151, 2019, Pages 745-750

A new outlook on ridehailing: spatiotemporal patterns and commuting analysis from the Greater Toronto and Hamilton Area

Francisco Calderón [a], Eric J. Miller [a]

Show more

https://doi.org/10.1016/j.procs.2019.04.100 Get rights and content

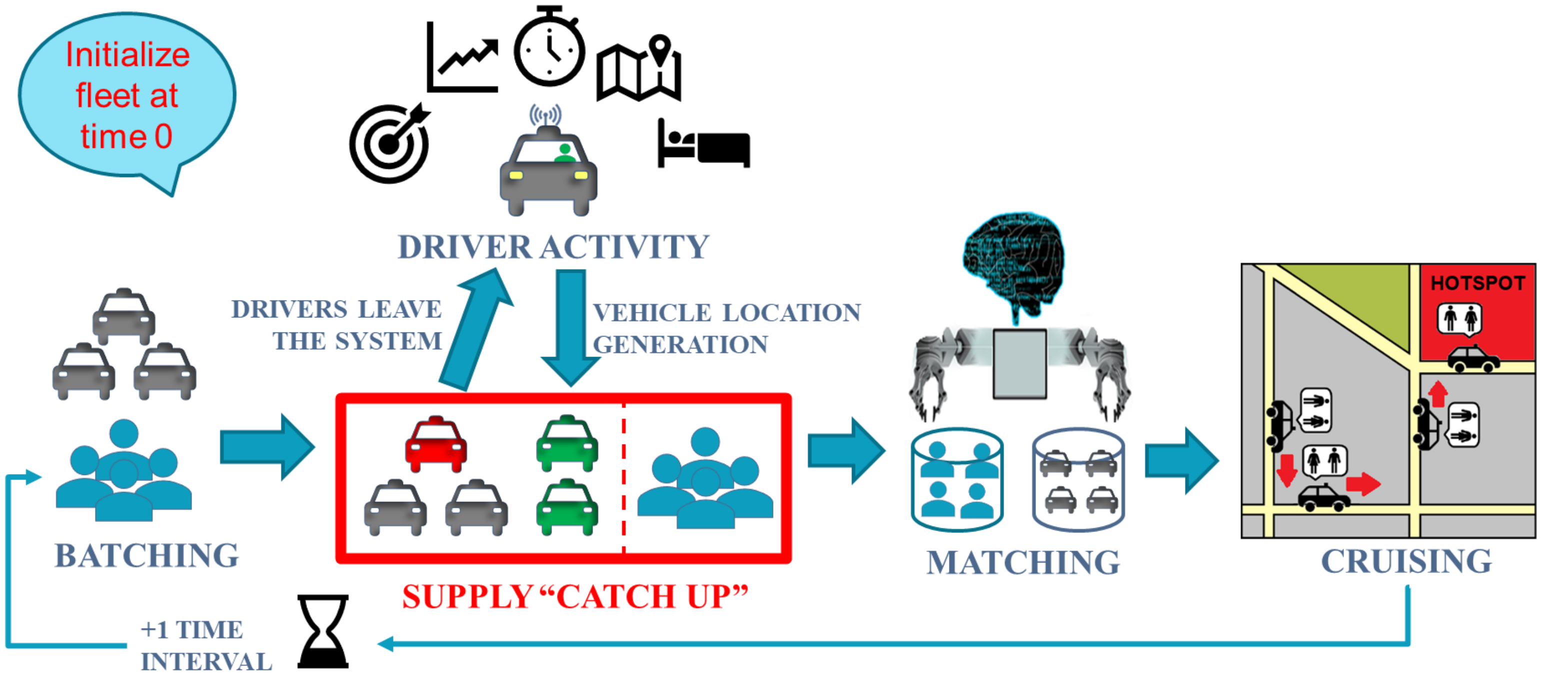
Under a Creative Commons license open access

First-Order Models of Ridehailing Service Provision

- “*A Prototype Model of Ridehailing Service Provision*” presented at:

- “*Modelling Within-Day Ridehailing Service Provision with Limited Data*” Forthcoming in:

Transportmetrica B
TRANSPORT DYNAMICS

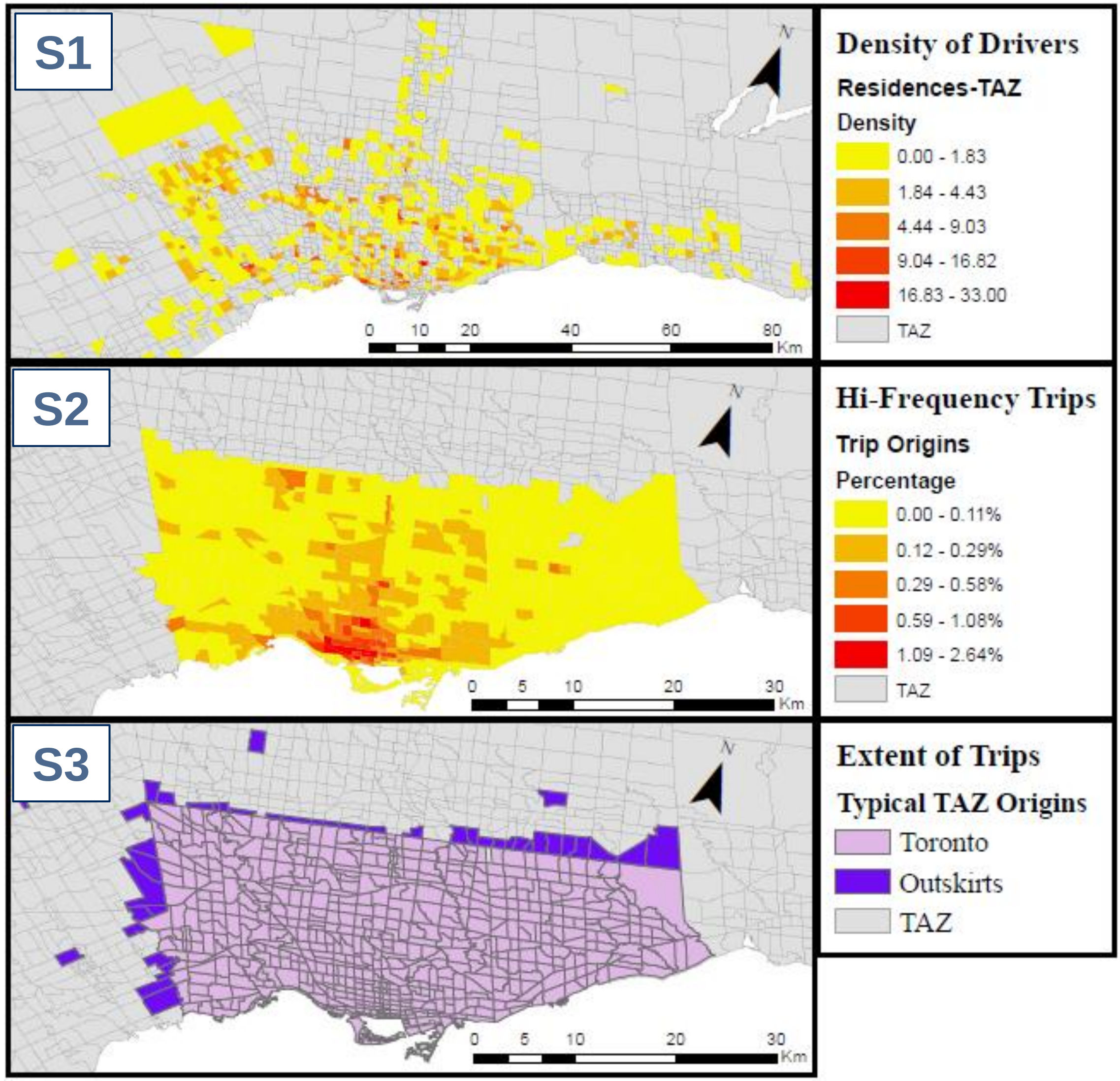


First-Order Models of Ridehailing Service Provision

Driver Activity:

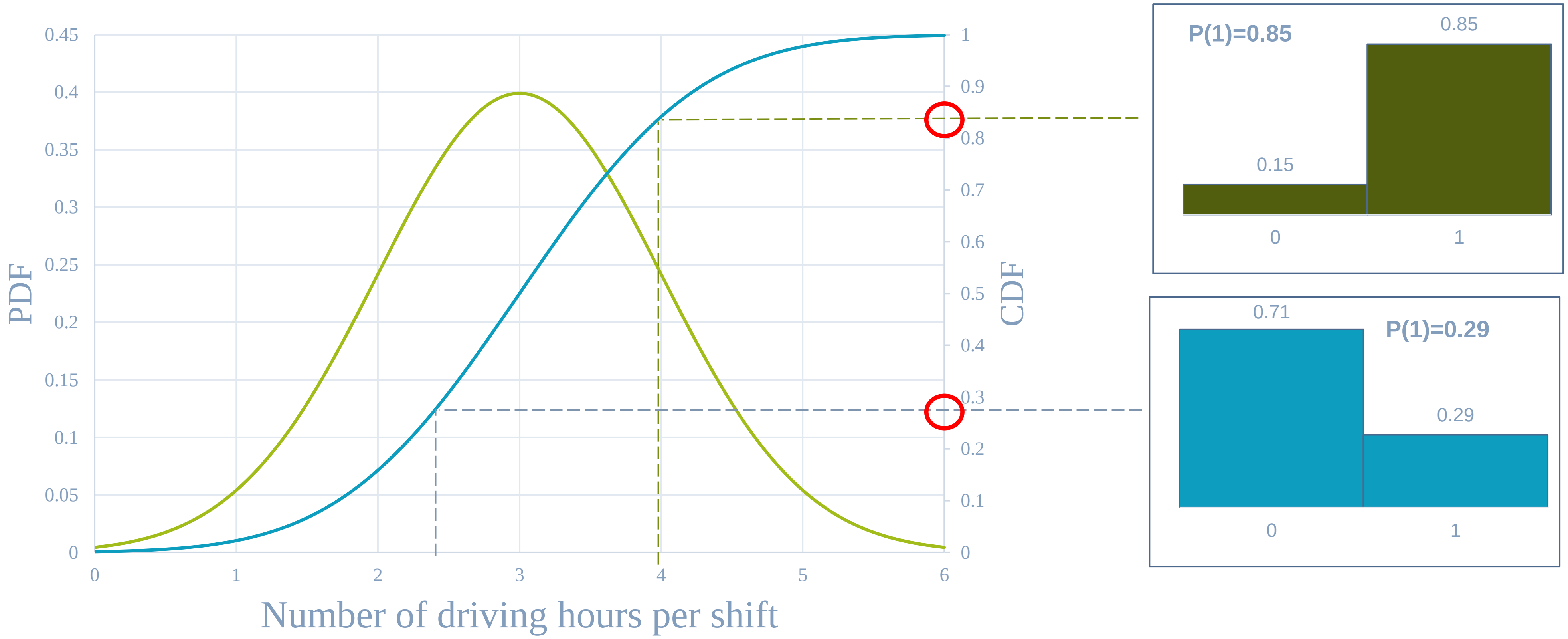
Vehicle location generation

Time Period	Special Demand Patterns?	1st SHIFT	>1 SHIFTS
AM (6-9)	Commute Outskirts	Strategy 1	Strategy 1
MD (9-15)	CBD and business	Strategy 2	Strategy 3
PM (15-19)	Normal	Strategy 3	Strategy 2
EV (19-24)	Entertainment	Strategy 1	Strategy 2
ON (24-6)	Return home	Strategy 2	Strategy 2



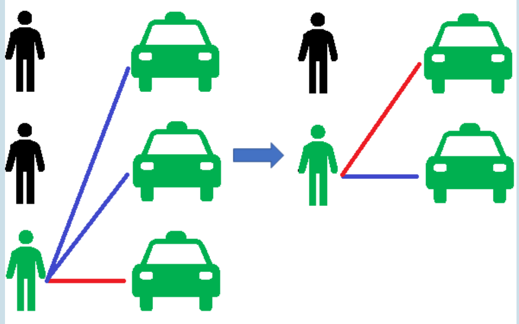
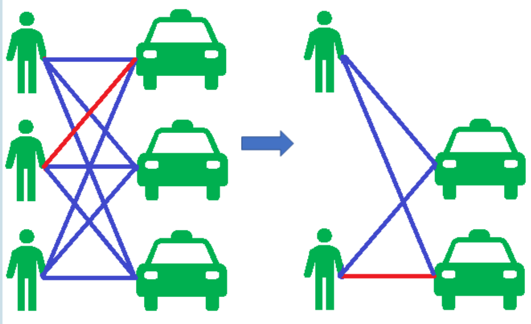
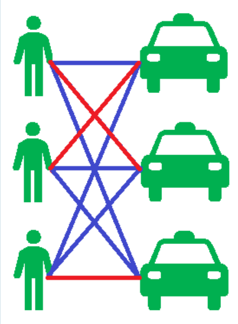
First-Order Models of Ridehailing Service Provision

Driver Activity: vehicles leaving the system



First-Order Models of Ridehailing Service Provision

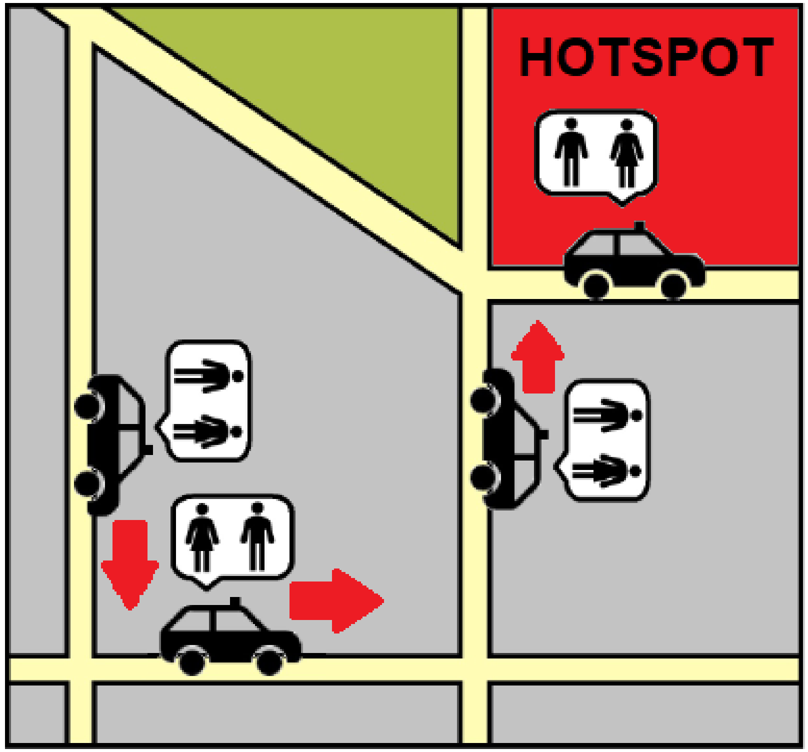
Matching algorithms

Greedy	Centralized Greedy	Hungarian
		
Closest distance from one random user to all available vehicles. Sequential, one match at a time. Random order of matches yields non-optimal outcomes	Closest distance from any user to any vehicle, but still sequential, one match at a time. Order is now deterministic, yet still yields non-optimal outcomes	Every possible match **and matching order** assessed **simultaneously**. This is an optimal assignment.

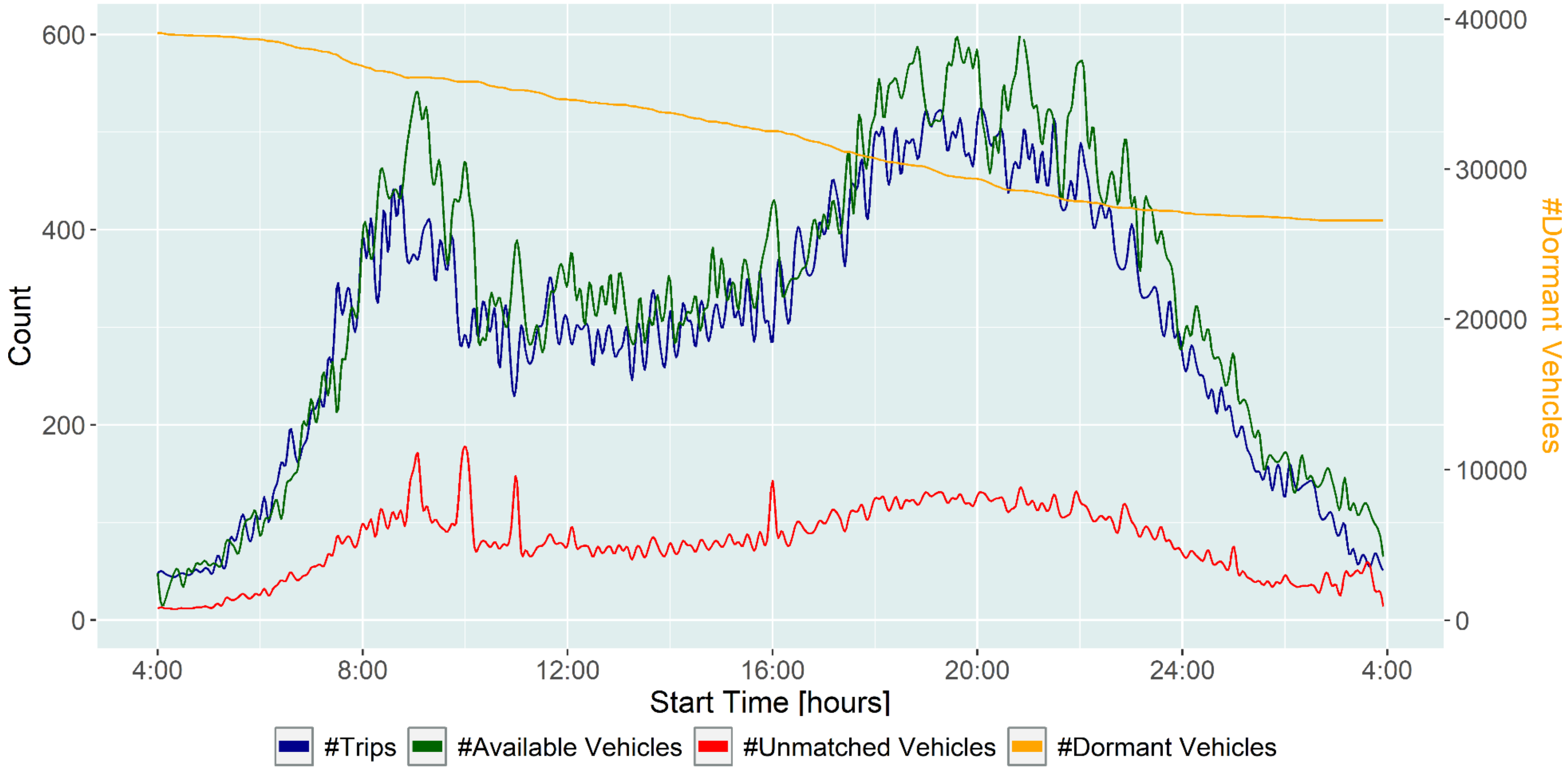
First-Order Models of Ridehailing Service Provision

Cruising

- High uncertainty due to lack of data and evidence
  - Research suggests that ridehailing drivers are expected to park to a larger extent than taxis (Xu, Yin, and Zha 2017).
- **Assumed**: every time interval, 70% of *idle* drivers relocate to their nearest high-demand zone (top-30% ranked from historical demand)

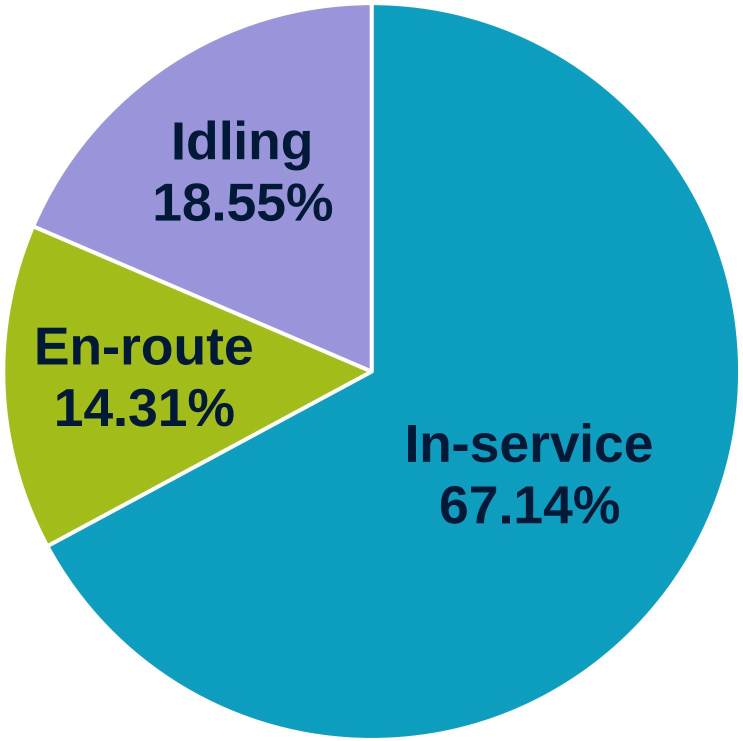


Model Outputs: Overall System Metrics

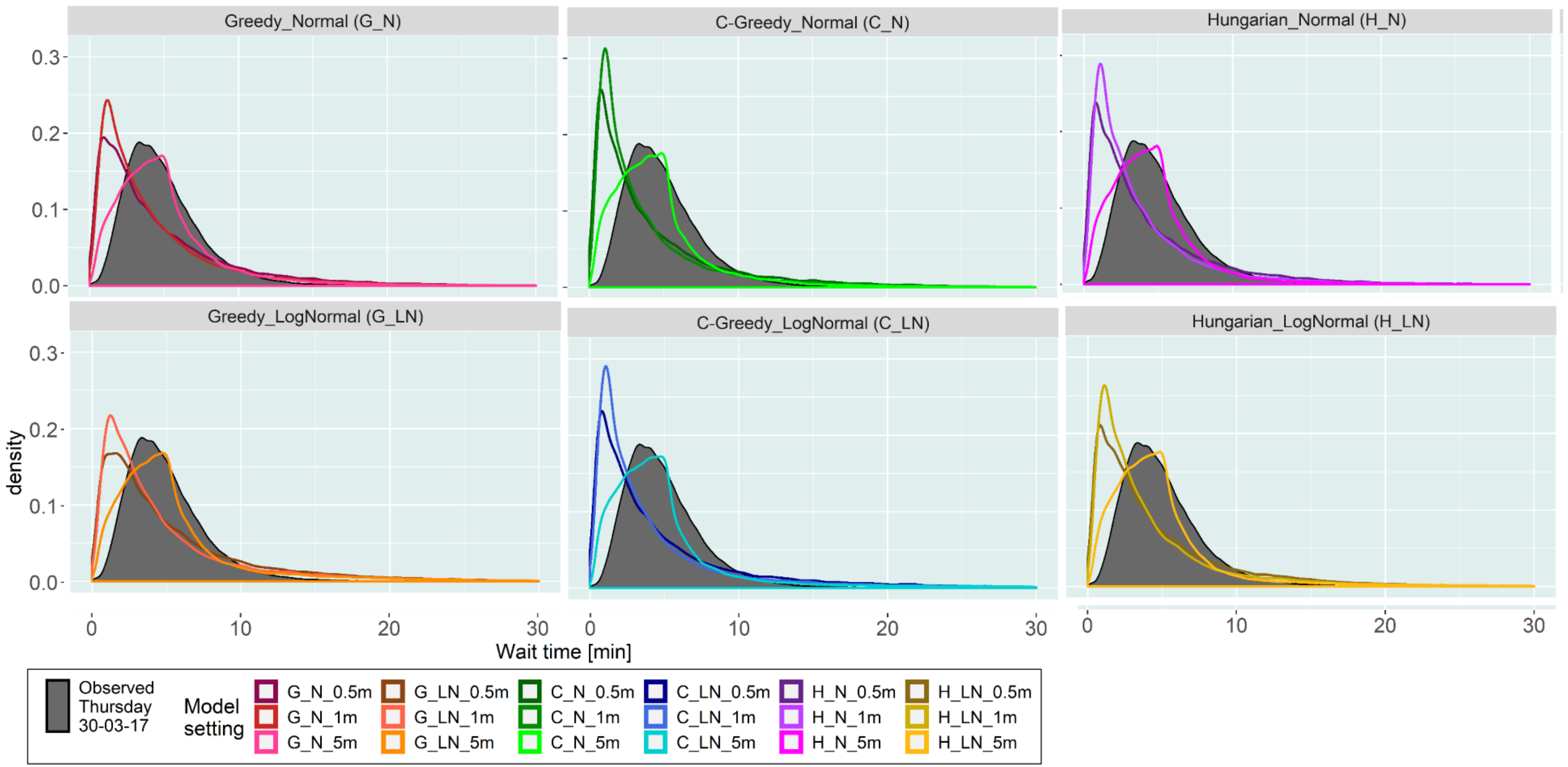


Model Outputs: VKT Breakdown

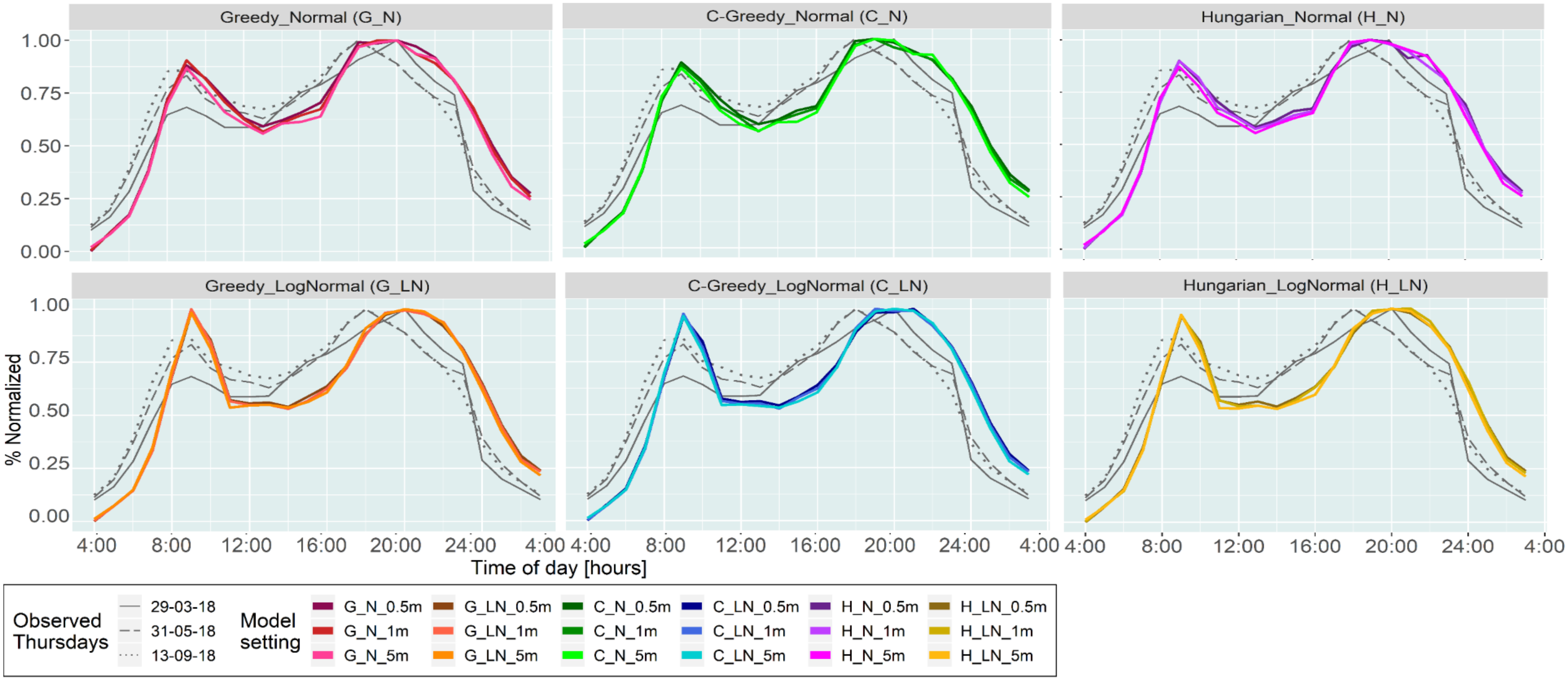
- Key metric for policy analyses of negative externalities, and to assess operational performance:
  - VKT by state.
  - Time by state.
  - Efficiency of service provision implicit in “state split”.



Performance Against Wait Time Distribution

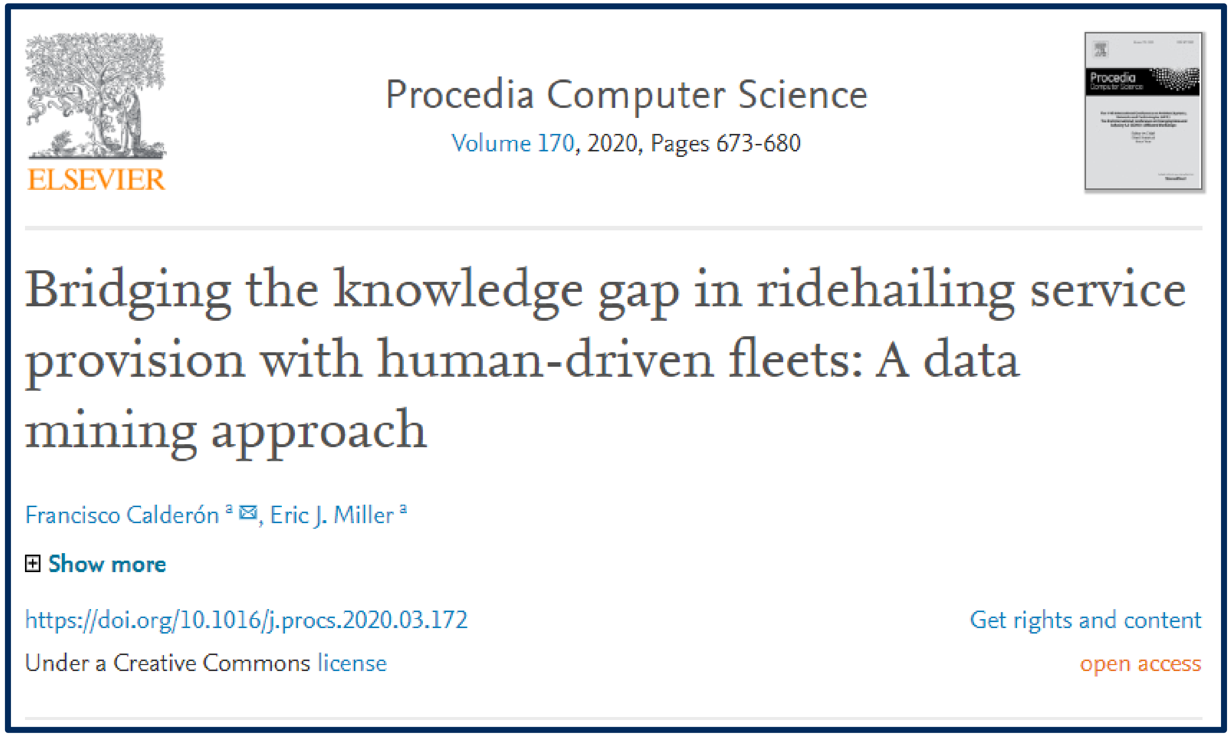


Performance Against Unique Drivers per Hour



Towards a full-blown model: Data mining

- **Next steps**: formal driver activity modelling and more elaborate representations of service providers´ operational activities
- Richer dataset required
  - RideAustin: much smaller sample, **but** it includes driver IDs and en-route variables



ELSEVIER

Procedia Computer Science

Volume 170, 2020, Pages 673-680

Bridging the knowledge gap in ridehailing service provision with human-driven fleets: A data mining approach

Francisco Calderón [a], Eric J. Miller [a]

Show more

https://doi.org/10.1016/j.procs.2020.03.172

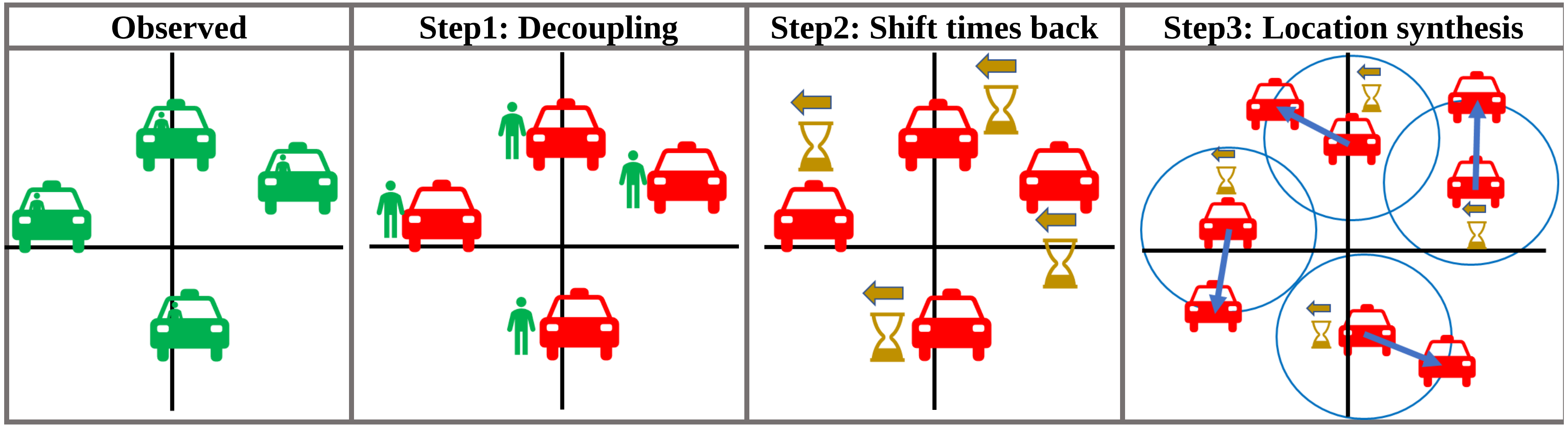
Get rights and content

Under a Creative Commons license

open access

Data mining: matching application

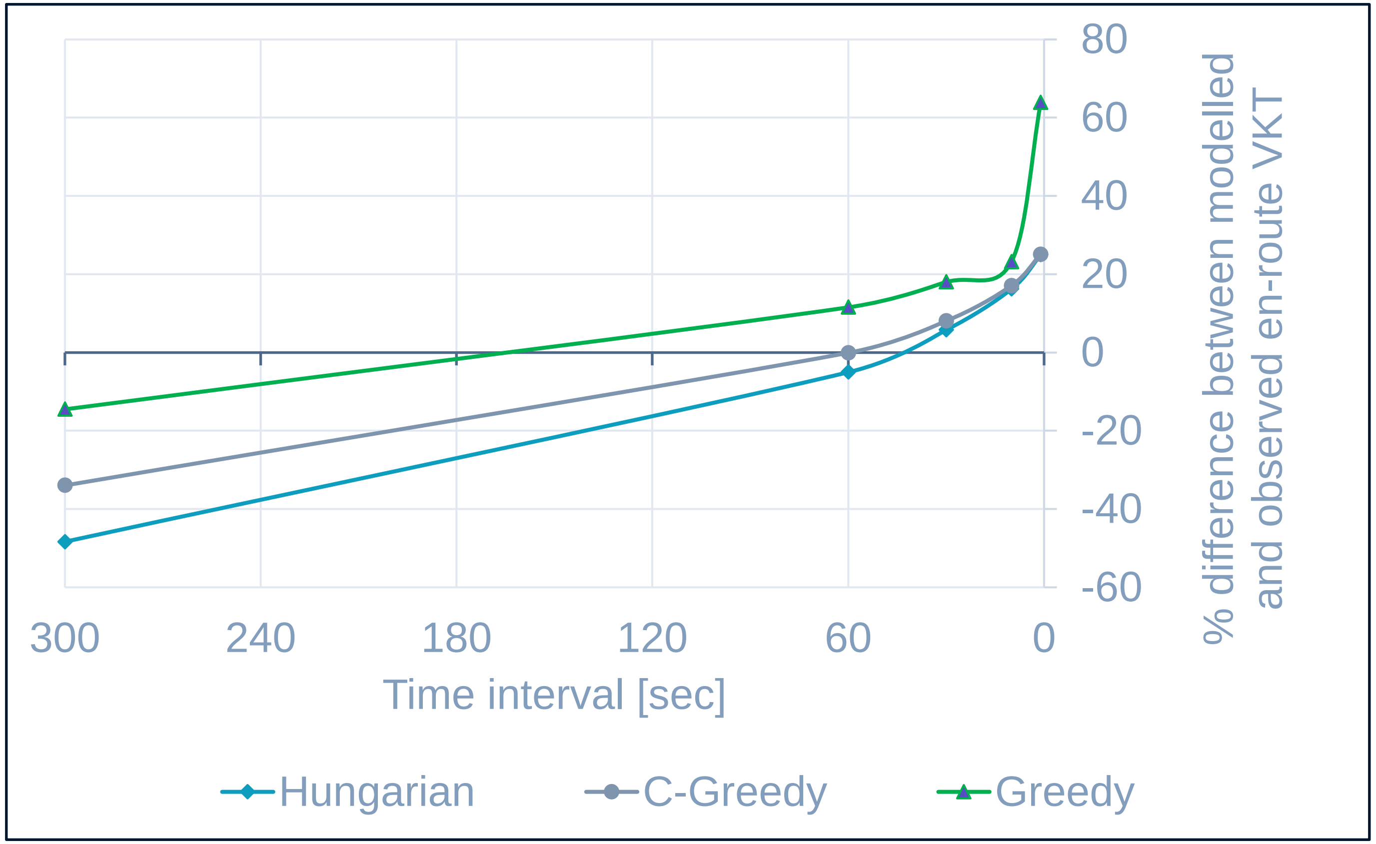
Infer vehicle locations



In-depth matching analyses (to be published)

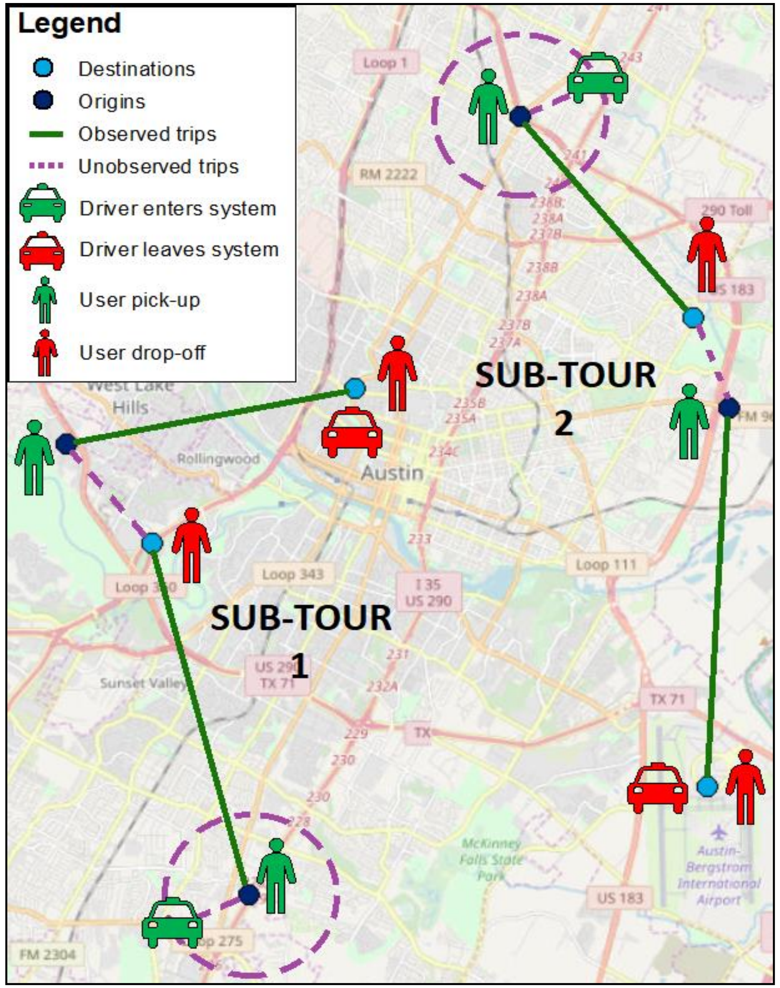
- Impacts of algorithm, time step, overall problem size and unmatched agents
- Performance metrics considered include en-route VKT and computation times.
- Trade-offs among time interval, computation time, and degree of optimality.

Data mining: matching application



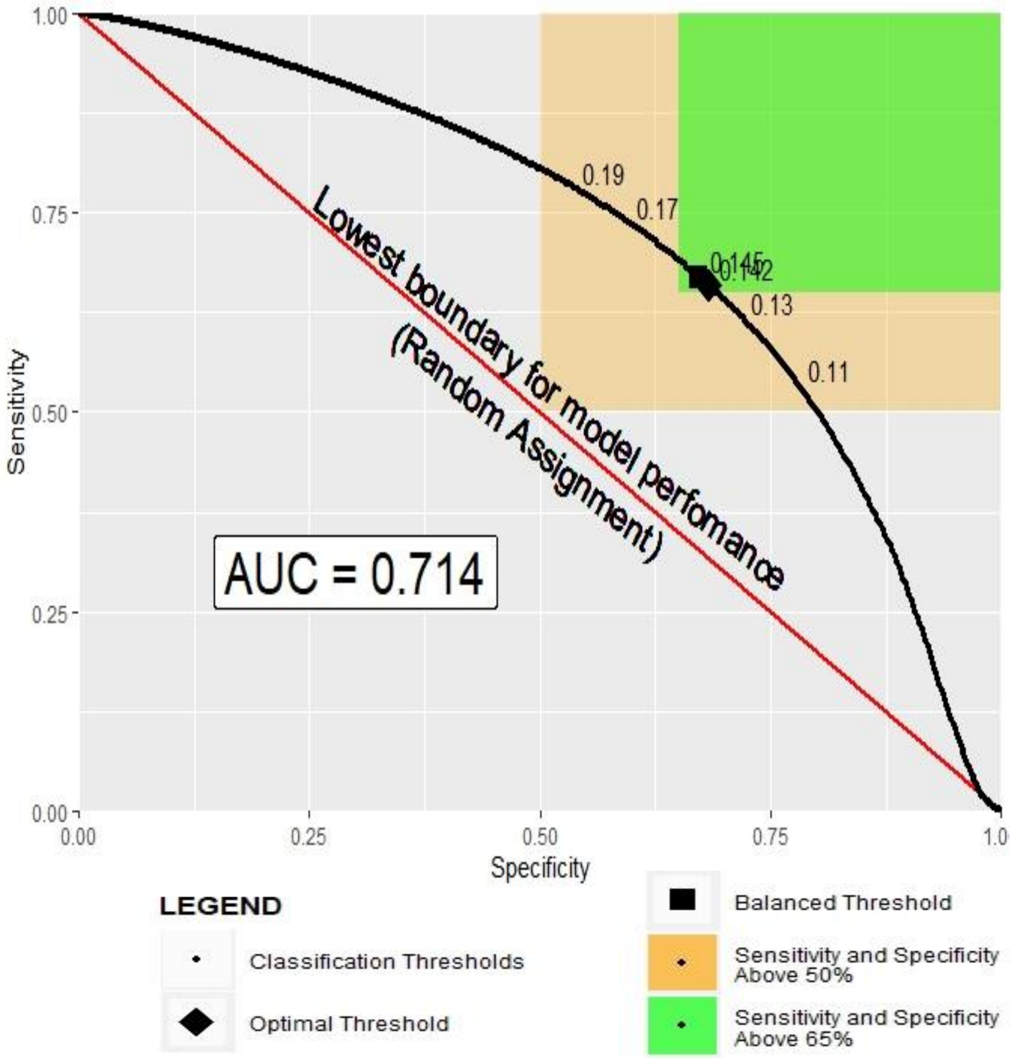
Data mining: driver activity application

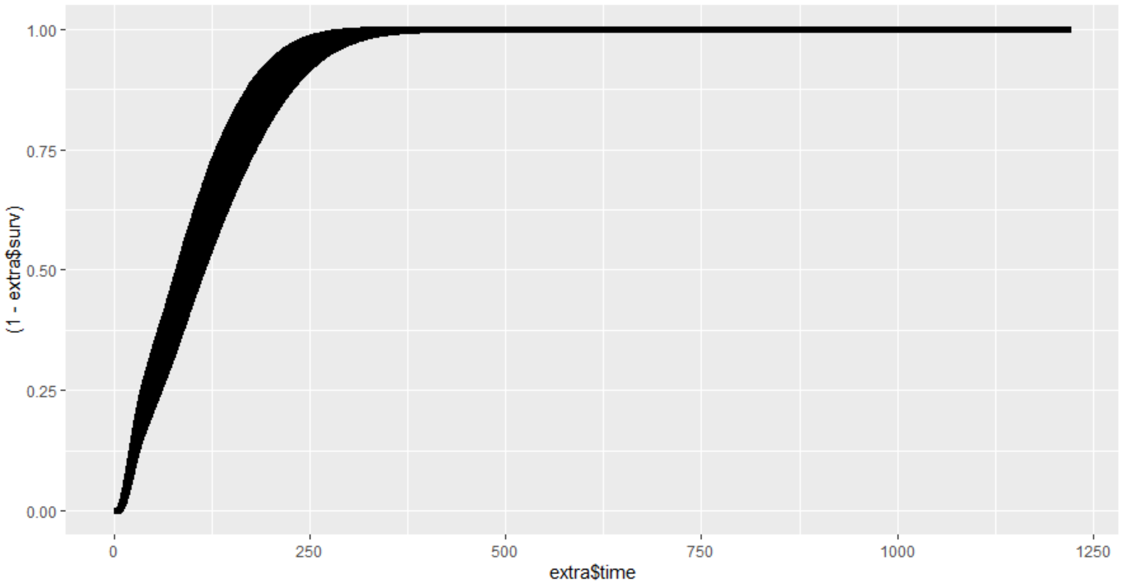
Generate driver activity logs



- Critical data input for **driver activity** modelling
- Hazard/Logit models for drivers' decisions/time to: enter and leave the system (to be published). Depend on several system-level and agent-level variables.

Data mining: driver activity application

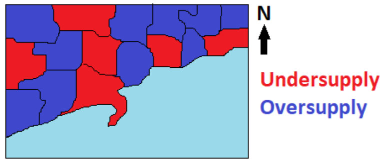




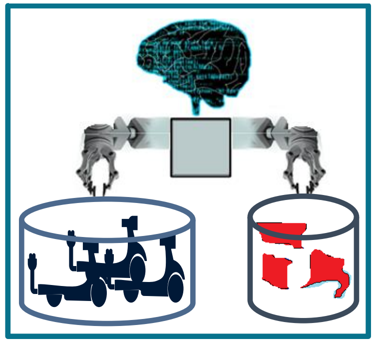
Data mining: rebalancing first steps

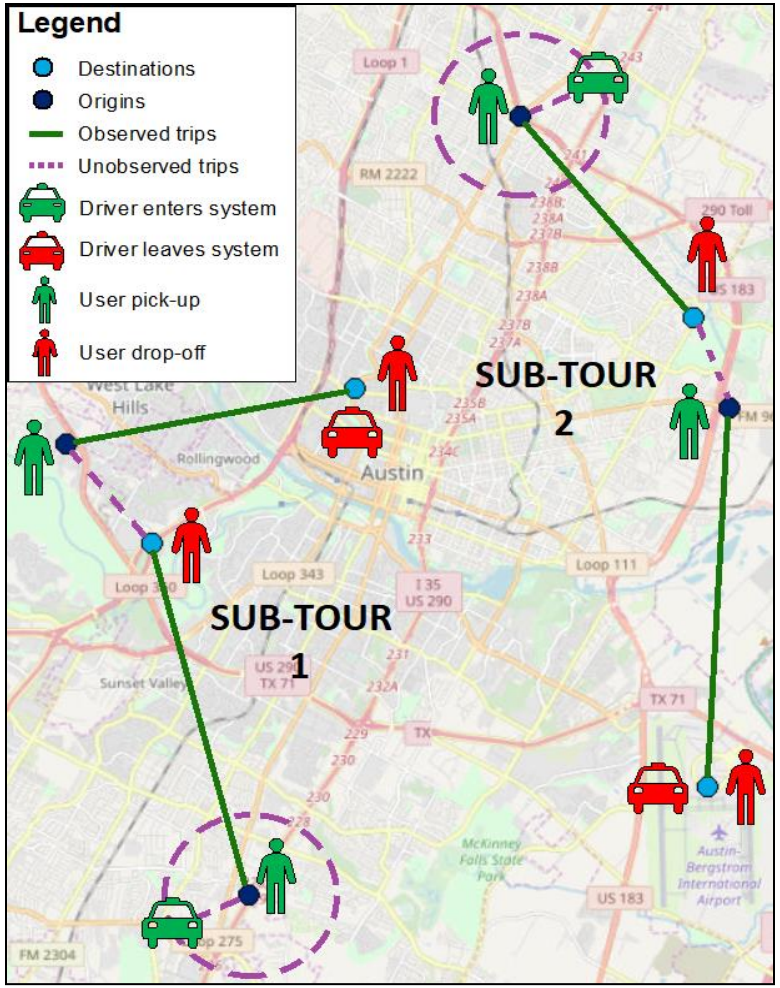
Identify potential rebalancing trips

- **Idle time:** e.g. >15 and <60 minutes
- **En-route speed:** e.g. >15 Km/h
- **Subsequent trip attributes:**
  - **Distance:** e.g. >8 Km
  - **Originates at a "hotspot"?**



- Ground truth information/data about rebalancing is very scarce currently, realistic modelling is not yet possible. However…





Applications

- VKTs
- Emissions
- Congestion impacts
- Spatial analyses (equity and accessibility)
- Policy and regulation (test scenarios)
- Performance and operational assessment
- Impacts of emerging technologies (AVs and EVs)

Future Work

- Higher-order matching algorithms
  - “Pooled” services
  - Non-myopic mechanisms
  - Reassignment of matches
- “Migrating” public transit into the service provision component
- MaaS implementations
- Implement more emerging mobility services, likely starting with bikesharing and e-scooters.

Thank You!

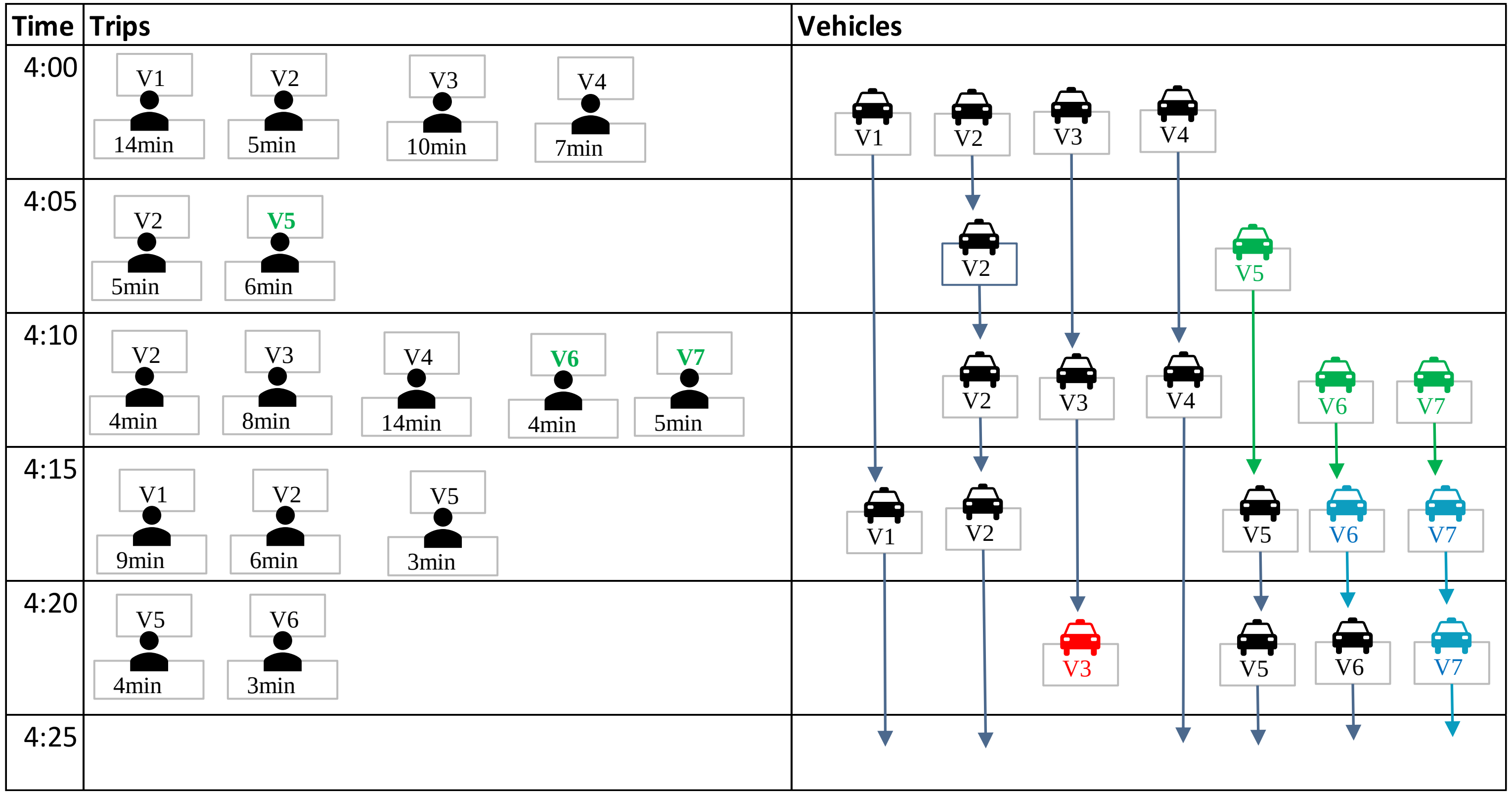
Questions/Comments

pancho.calderon@mail.utoronto.ca

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute

Credit: https://www.reddit.com/r/BeAmazed/comments/6041sn/aerial_view_of_Toronto

A small example…



UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute