



Fleet Relocation for Communauto Free-Floating Car-Sharing System

MGSC 662 Decision Analytics

Group 8:

Atrin Morteza Ghasemi

Chelsea Hon

Fatima Nadeem

Hadyan Fahreza

Jingyuan Wang

Communauto
FLEX

A photograph showing a woman in a grey coat and sunglasses pushing a teal stroller. A young child in a pink cap and patterned pants stands next to her. In the background, a silver car with a large green circular logo on its side and the words "Communauto FLEX" is parked. The setting appears to be a park or a residential area with trees and other cars in the background.

Agenda

1 Introduction

2 Pain Points & Our Solution

3 Optimization Model Formulation

4 Parameters & Data Preprocessing

5 Results & Insights

6 Way Forward

Communauto and the Car-Sharing Industry



2,000

vehicles in
Montreal &
Quebec City

15M

annual sales
revenue in CAD

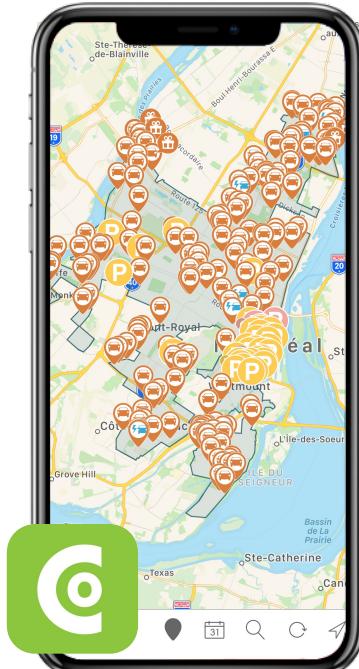
3rd

key player in car
sharing Canada

Founded in 1994 and is the oldest in North America

Canadian car-sharing company headquartered in Montreal, Quebec

Operating in 5 provinces and 16 major cities in Canada and in Paris, France



1/3

vehicles are in
free-floating
service (one-way)

One-Way
Flex

Services Offered

Round
Trip

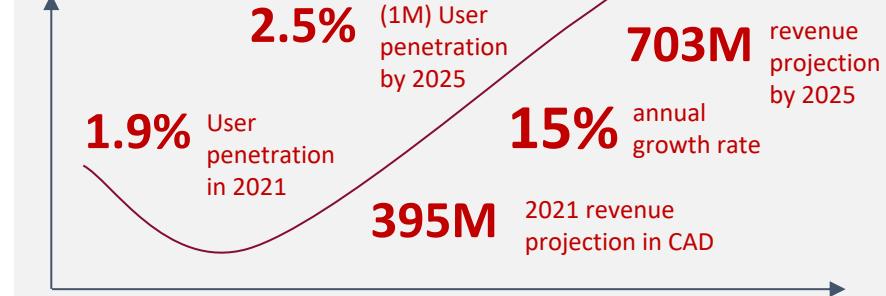
- 2 types of services to maximise efficiency & coverage
 - Montrealers were the first to benefit from this dual offer
 - Degressive rates at 35-40¢/min, \$12/hour or \$50/day, gas & insurance inclusive

2/3

vehicles are the
station-based
(round trip)



Growing Opportunities in Car-Sharing



Unbalanced Industry Demand & Supply

2021

Car-pocalypse

"America's number 1 travel problem of 2021"
- Forbes

2021

Shortage of rental vehicles

Worldwide supply chain issues & global
microprocessor chip shortage

2020-21

Surge in Demand

Ease in pandemic restrictions

2019

Plunge in Demand

During pandemic, rental operators across
Canada sold off 30-40% percent of their
fleets on average

Challenges in Rebalancing Flex-Cars to Meet Demands



Ratings and reviews ⓘ



2.9

★★★★★ 440

★★★★★ 8/28/21

Even though this is the cheapest Carshare in Toronto it's not worth it. Cars will be clustered in one area or there won't be ANY available. The application is extremely glitchy so I often end up just calling. Cars are often dirty, under fueled and with lots of damage. Last straw for me was being sent on a goose chase which ended up with me spending 3 hours one morning going all over the city to get a car due to lack of cars and issues with their app/system.

★★★★★ 11/1/21

I have a terrible experience with this application . It was the second time that I booked a car, but when I arrived to the station, I could not find the car and I lost my important meeting. The interesting point is that each time, I have been charged for 0 km distance trip. I called the support team, each time stayed in the line for more than 30 minutes no one answered. I sent them an email, got no response.

Challenges Associated with One-way Free-Floating Service:



Customers



Communauto

- Flex cars available but not in my region
- Unreliable availability (Flex 'ghost' car)



- Idleness of cars in low demand areas
- Unmet demands in area of intensive use
- Difficulties maintaining fuel and cleanliness

Business priorities



Relocation cost



Revenue loss



Service level



Customer experience

Optimizing Relocation



Current State & Pain Points

Minimal incentive to avoid idleness

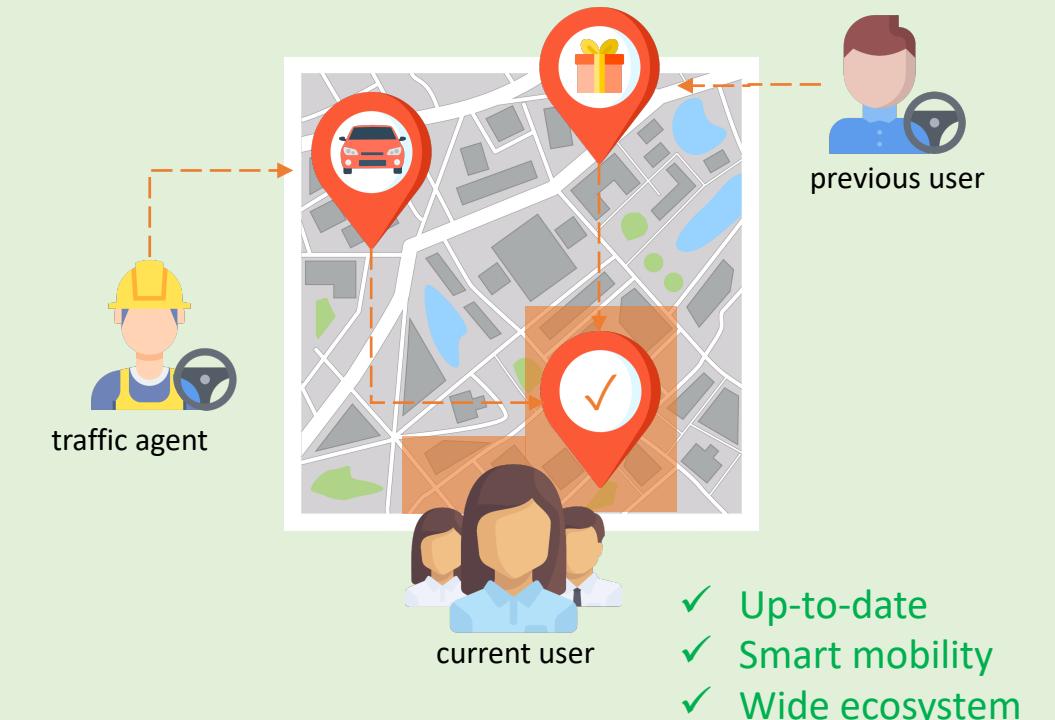
- Reward customers 30-min relocation credit if returned vehicles marked with gift icon in fixed area of intensive use



Solution – Optimization Relocation

Optimal supply-demand based relocation

- Employ traffic agents for movement of fleets
- Reward customers if returned vehicles marked with gift icon in dynamic areas of high demand
- (and ultimately flexible reward system for all)



Transition to Smart Mobility End-State



Our Scope

...

Objective

Focus

Underlying Principles

Centralized Staff Deployment

Address the pressing need of free-floating service by deploying traffic agents from a centralized point to move vehicles from low demand to high demand regions one-off

Base model that minimizes the costs associated with fuel, wage and distance to relocate vehicles based on demand; Montreal region

- 20% demand fulfillment per region
- 1-hr relocation lead time from availability to demand
- Employers are deployed from Communauto headquarter
- Relocation incentive for customers does not incur direct cost. Take-up and revenue impact is to be considered

Multiple Relocation by Staff

Operationalize multiple relocation of vehicles by travel agents to meet demand threshold using real-time locations of Flex cars

Enhanced model that improves accuracy from vehicle region to exact location and supports subsequent relocation to any region by one agent

- Staff assignment based on their present location
- Availability of Communauto vehicle availability and usage internal data
- Demand per postal code data specific to Communauto region

Smart Mobility & Flexible Reward

Transform to flexible reward system that encourage stakeholders in the ecosystem to create and fulfill demands – ‘Smart Mobility’

Ultimate model that diminishes the staff-customer boundary into mover-driver with dynamic freelancer rewards, and enhances practicability

- Predictive analysis to forecast demand based on past trends
- Varying customer incentives to bridge demand and supply gap, potentially with separate UX/UI for mover and driver
- Availability of real-time geo data (e.g. Parkopedia), weather-based demand data, etc.

Optimization Model Formulation (1/3)



Decision Variables

$X_{i,j}$: Number of cars moved from **region i** to **region j**

$S_{i,j}$: Number of staff who will move the cars from **region i** to **region j**

$C_{i,j}$: Number of customers who will move the cars from **region i** to **region j**

Y : Dummy binary variable



Objective Function

Minimize:

$$\sum_i \sum_j Distance_{i,j} * fuel_cost * X_{i,j} + \underbrace{\sum_i \sum_j wage/person/hour * S_{i,j}}_{\text{wage cost for an hour of relocation}} + \underbrace{\sum_i \sum_j distance_hq_i * fuel_cost * S_{i,j}}_{\text{fuel cost from headquarter}}$$

fuel cost moving from one region to another

wage cost for an hour of relocation

fuel cost from headquarter

Optimization Model Formulation (2/3)



Constraints

- 1 Fulfill 20% of the demand for each region

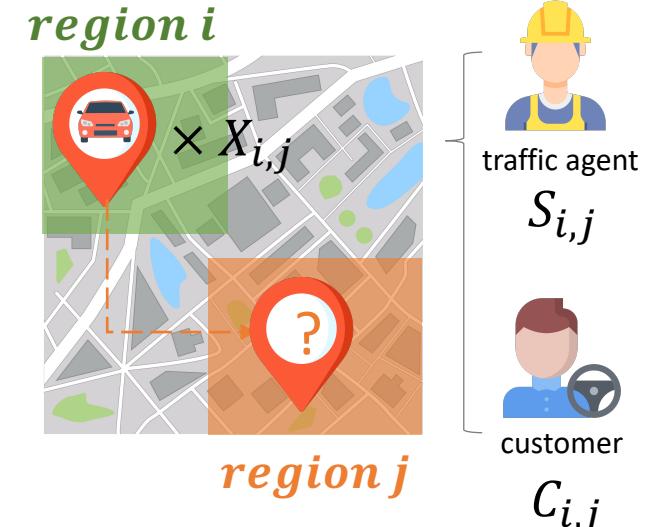
$$\sum_i X_{i,j} \geq 20\% * Demand, \text{ for all } j \in \text{postal_code}$$

- 2 Each car can be moved by either staffs or customers

$$C_{i,j} + S_{i,j} = X_{i,j}, \text{ for all } i, j \in \text{postal_code}, i \neq j$$

- 3 Number of cars moved from a region must match the initial availability of cars in that region

$$\sum_j X_{i,j} = Availability_i, \text{ for all } i \in \text{postal_code}$$



Optimization Model Formulation (3/3)



Constraints (cont'd)

- 4 Number of staffs assigned to move cars cannot exceed the number of staff

$$\sum_i \sum_j S_{i,j} \leq S_T$$

- 5 Utilize staff before employing customers incentive approach to relocate the cars:

$$S_T - \sum_i \sum_j S_{i,j} \leq M * Y$$

$$M * (1 - Y) \geq \sum_i \sum_j C_{i,j}$$

- 6 Non-negativity and binary constraints:

$$X_{i,j}, S_{i,j}, C_{i,j} \geq 0, \text{ for all } i, j \in \text{postal_code}, Y \in \{0,1\}$$



Data and Estimation Method (1/2)



National Usage

Commuauto Usage in MTL

Daily Regional Demand

Hourly Regional Demand



shared car users projection in Canada: 800,000 users in 2022; Communauto market share: 10%

9K Montreal users based on population
 $= \text{Canadian Users} \times \frac{\text{MTL Flex Region Population}}{\text{Canada Population}}$

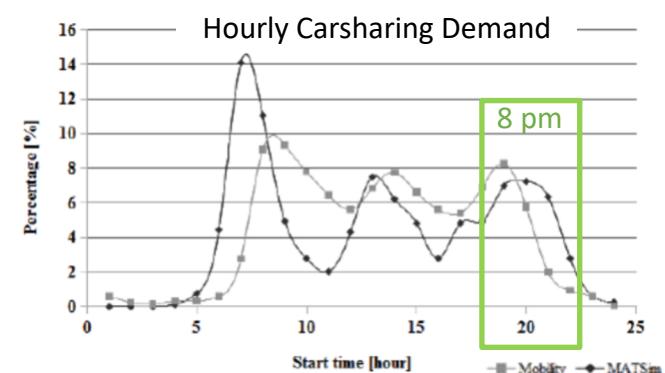
Daily demand in 1-1 relationship with # users
 $= \text{Montreal Users} \times \frac{\text{Population}_i}{\sum_i \text{Population}_i}$

Hourly demand projection based on Zurich shared-car demand data
 $= \text{RegionalDemand}_i \times \text{Hourly Demand Projection}$

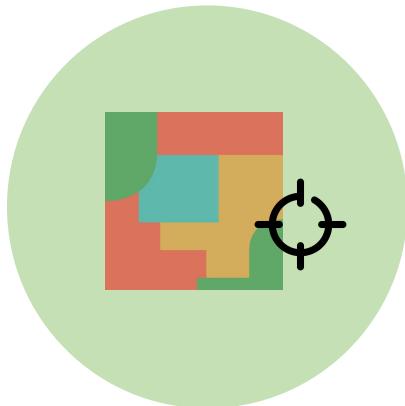
Estimated demands/hour in 48 Montreal postal code regions (forward sortation area FSA) at 7 pm

Mean : 14.4
 Std : 5.5

Max : 30
 Min : 3

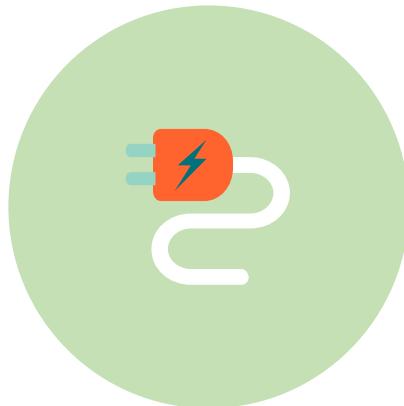


Data and Estimation Method (2/2)



Montreal FRA Regional Data (first 3 letters of postal code)

- Geometry information of region centroid (latitude, longitude)
- Population data per FRA
- Location information of Communauto head quarter (latitude, longitude)
- Extension: Traffic/population flow for each region at specific hour



Average Fuel Cost

- Fuel consumption: 8.9 litres of gasoline per 100 kilometres (L/100km)
- Gas pricing: 1.55



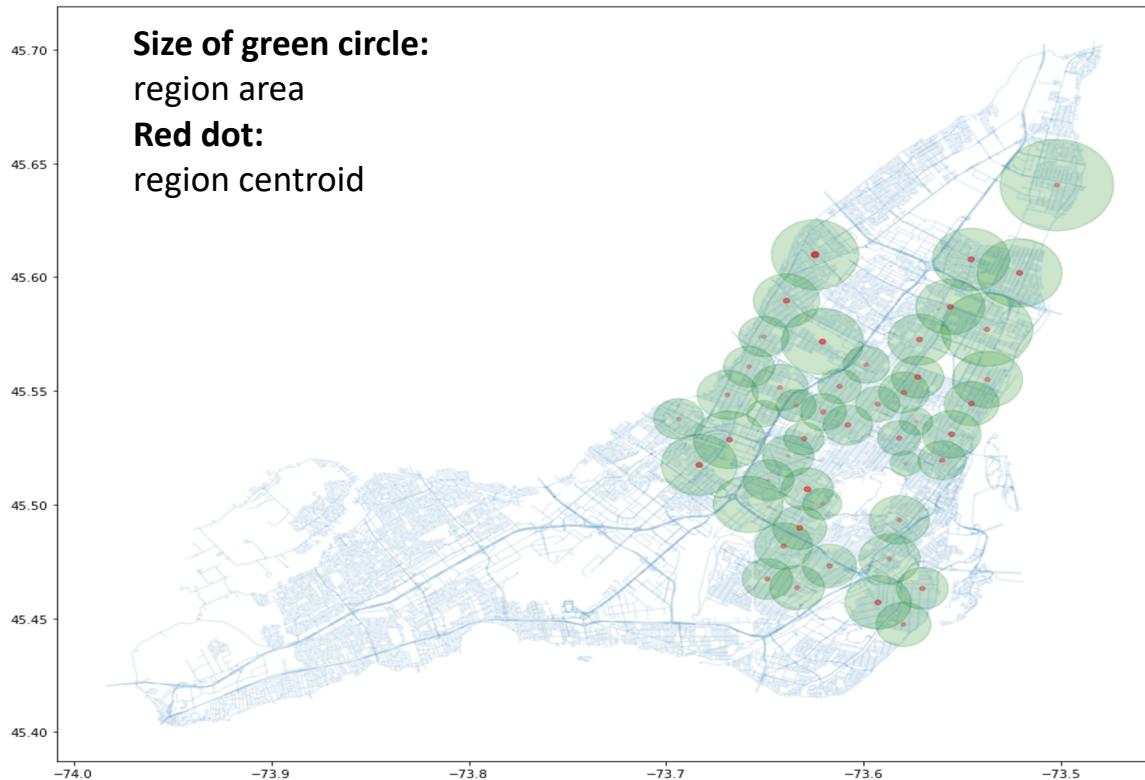
Wage Information

- 15\$/hour for a Communauto travel agent
- Number of travel agents: 32

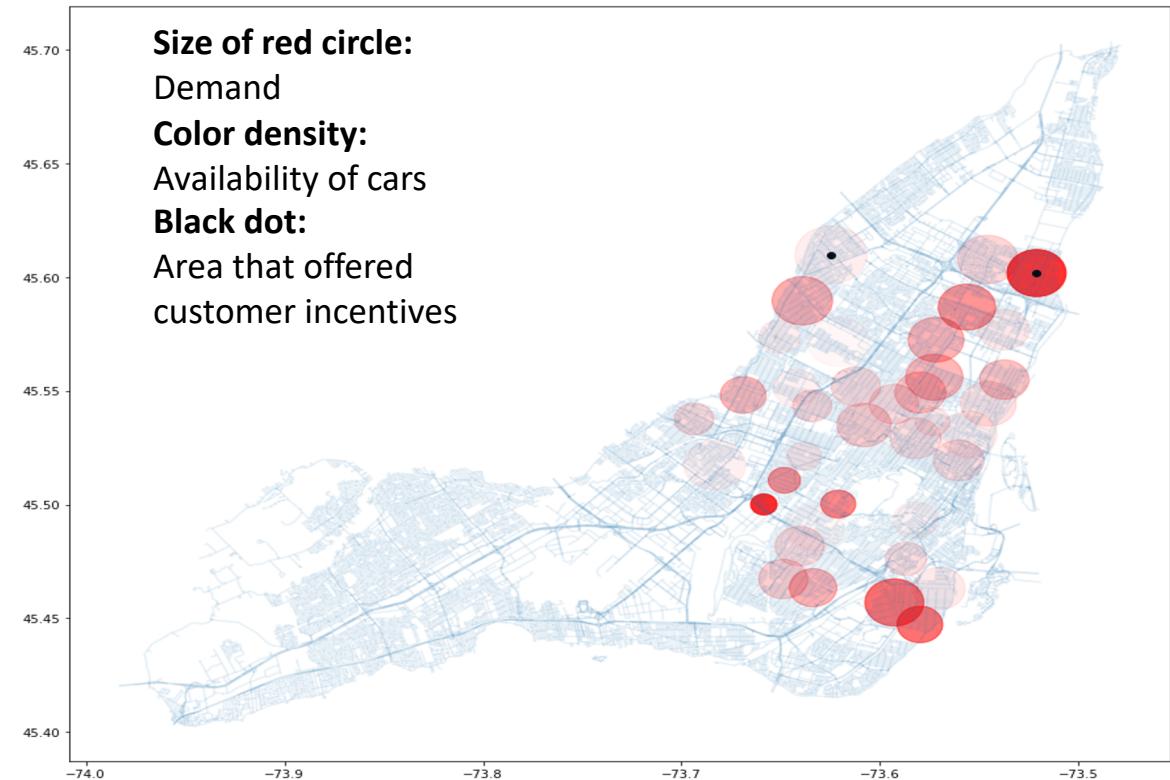
Visualizing Demand & Supply



Communauto Montreal Service Region



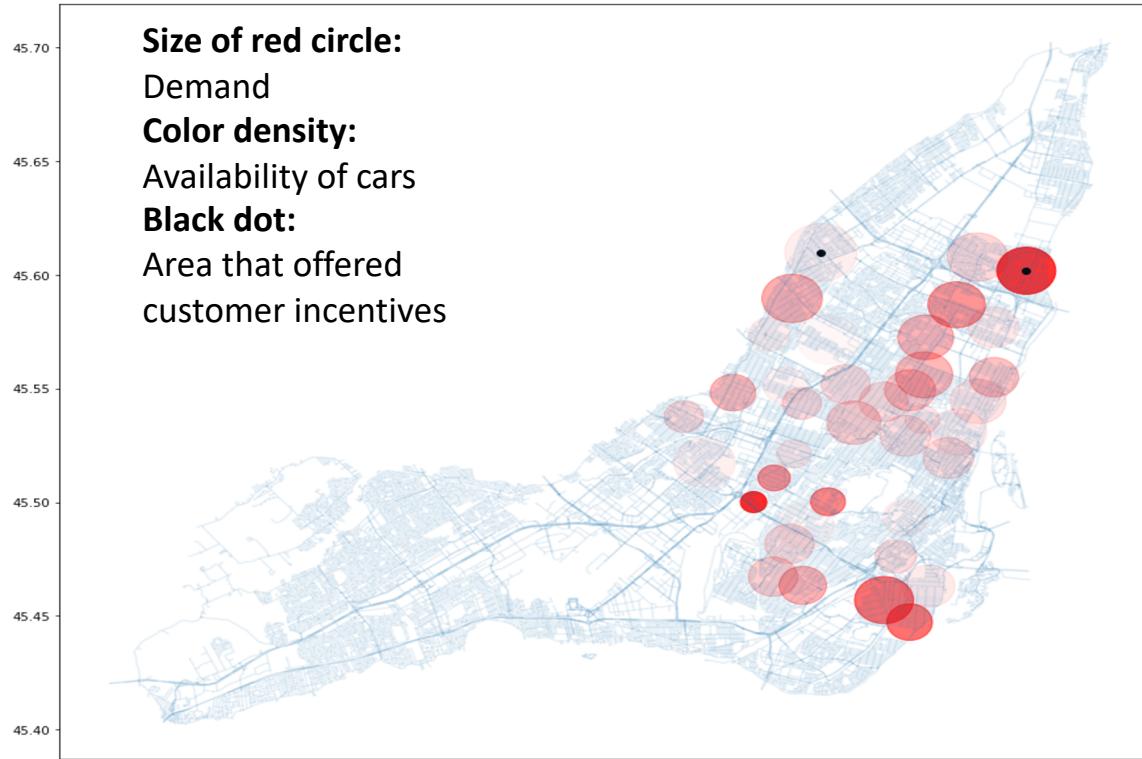
Communauto Demand vs Availability at 7pm



Results & Insights (1/2)

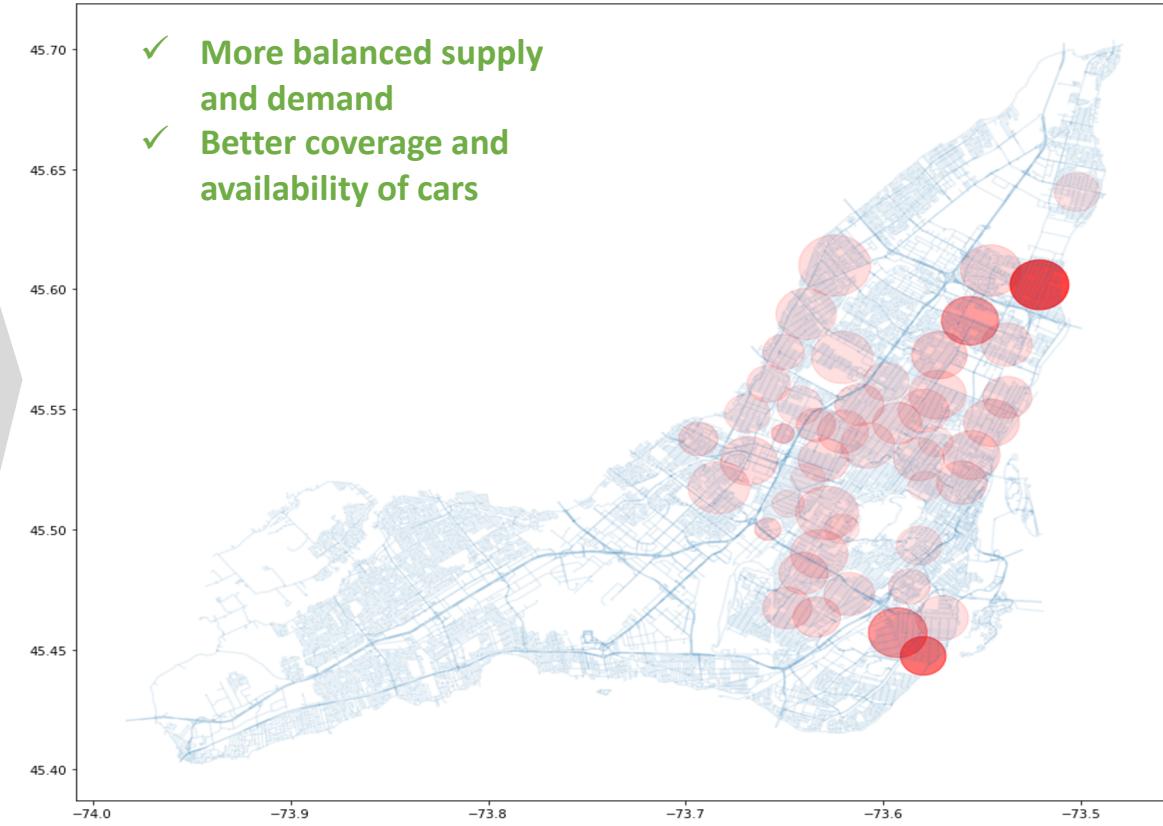


Communauto Demand vs Availability Before Shuffling



(from previous slide)

Communauto Demand vs Availability After Shuffling



Results & Insights (2/2)



Baseline Model Results

Total cars moved between regions	64
Number of staff used	32
Total Cost Incurred:	\$516.62
Total distance covered by staff	50.62 km
Total potential distance covered by customers	84.73 km
Total additional cost incurred for staff than customers (Wage + Fuel cost to get to region i from headquarters)	\$17.95

Insights & Learnings



We will meet the maximum demand possible through the deterministic relocations from our staff and the rest will be carried by the customers



Allocation is done in a way that staff do the relocations which are closer to the headquarters and the incentives are promoted for the relocations which are further



The maximum customer incentive value we could set would be the average additional cost incurred for staff compared to customers (wage + total cost/number of staff = \$15.56)

- Revenue optimization with % fulfilment of dynamic regional demand
- Service level optimization with dynamic staff & customer mover capacity
- Reward strategy – movie take-up optimization with credit / cash rewards

Way Forward



Geofence Refinement

Improve accuracy from vehicle region to coordinates



Multiple Relocation

Meet demand threshold using latest car locations



Distribution Pathway

Utilize traffic agent for subsequent relocations



Parking

Determine through geo spatial/ real time data - mention about getting IoT to be able to get real-time data



More External Data

Analyze lucrative business scenario with data such as holidays and extreme weather

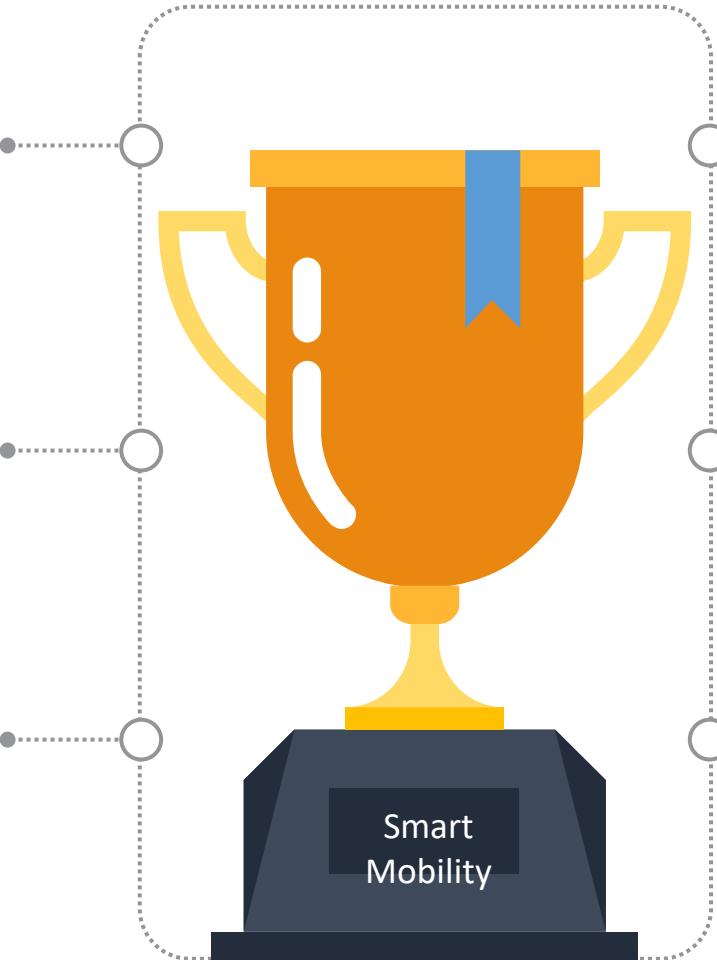


Flexible Reward Strategy

Vary user incentive with demand urgency and establish mover-rider ecosystem



Smart
Mobility

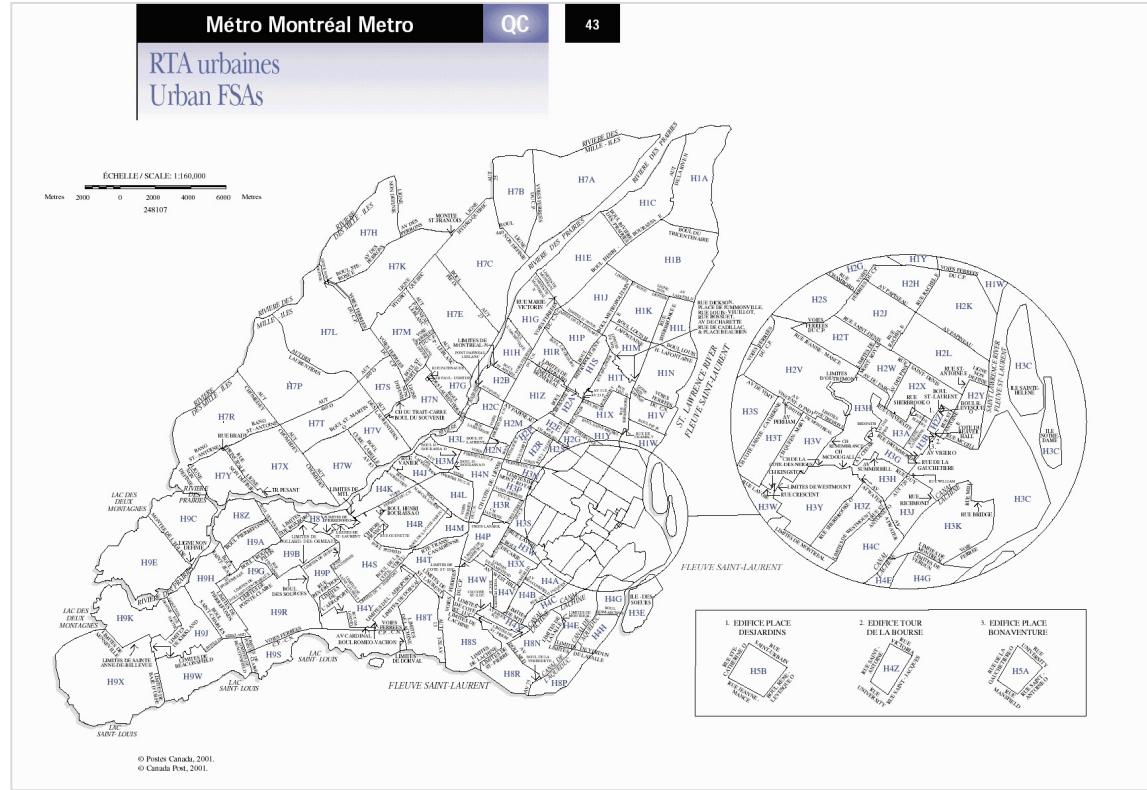


Thank You

Converting RFA to Centroid

Approximation for car relocation meeting regional demand

Communauto Montreal Service Region (RFA Region)



Communauto Montreal Service Region (Centroid-based)

