Smart Mobile Locker in tandem with City Buses (SML-CB) to Reduce Illegal Parking of Delivery Trucks

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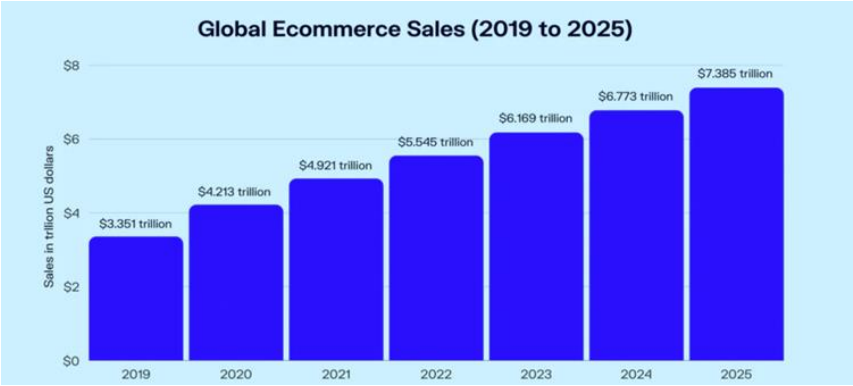
27th of May 2022

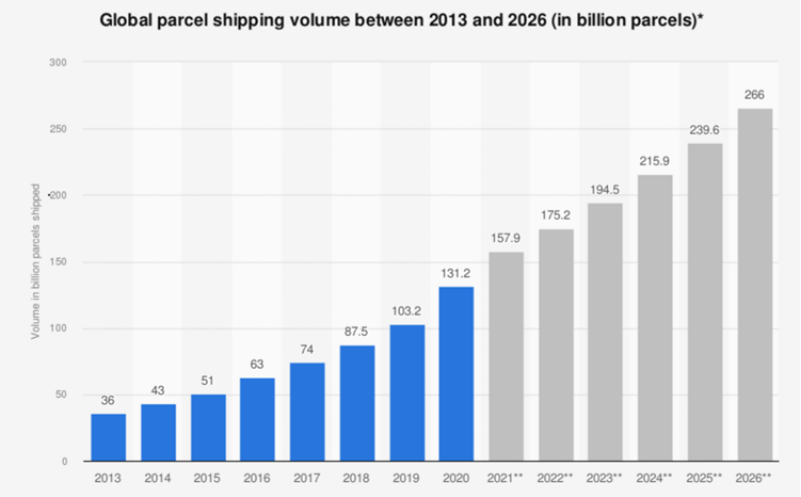
9th International Urban Freight Conference

Background

- **E-commerce and delivery trends**
  - Global e-commerce retail sales is projected to increase of 220% by 2025 compared to 2019
  - Global parcel shipping volumes is projected to increase of 232% by 2025 compared to 2019



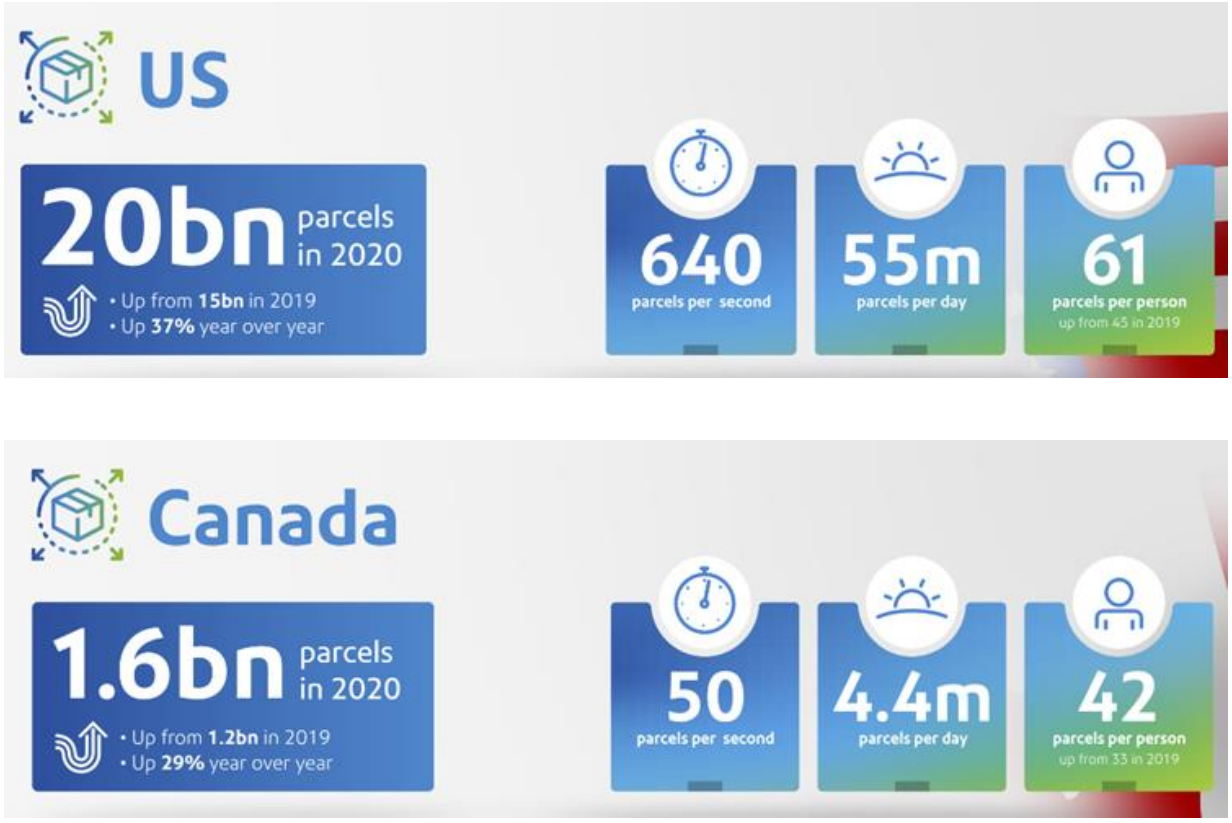
Source: Shopify



Source: Statista

Background

- **E-commerce and delivery trends in North America**



Source: Pitney bowes

Background

Delivery through trucks: Issues

- Gap between parking demand and supply
- Demand: Explosively increased traffic activities; Seasonally demand fluctuations.
- Supply: Shortage of delivery truck parking spaces: “Ontario lost close to 1,000 truck parking spaces in recent years with the closure of private truck stops and rest aeras.”[1]
- **Delivery trucks are ‘forced’ to park illegally for parcel dispatch, which results in:**
  - Traffic jam
  - Parking tickets
  - Inconvenience to disadvantaged groups [2]

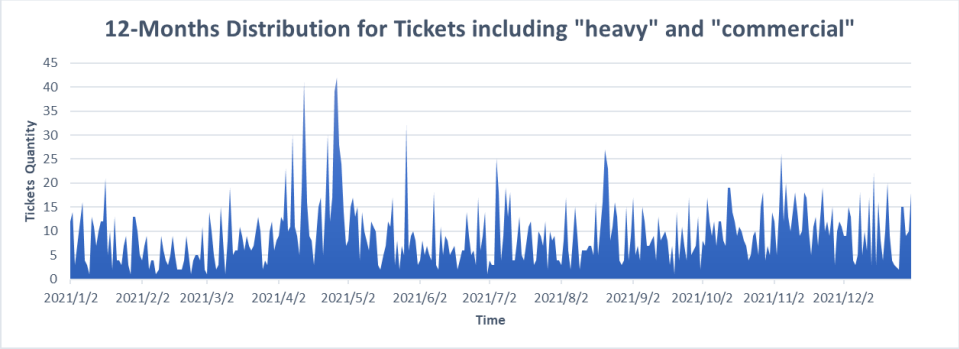
Photo Credit To Patrick Sisson / CURBED

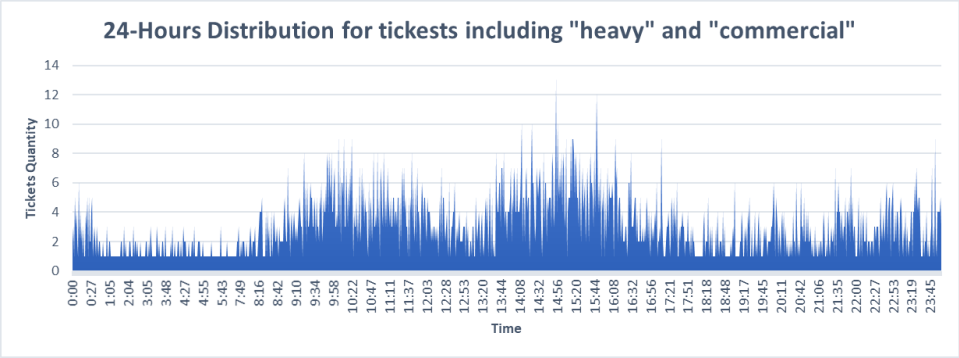
Photo Credit to Lee Flannery Planetizen

Source: 1. ontruck.org. 2. i-park-like-a.co.uk

Illegal parking – A case in Canada

- **Mississauga City**
  - Mississauga parking tickets 2021:134224 [1]
  - Estimation of parking tickets related to delivery truck parking after filter: 3386
    - Filter: include “heavy”, “commercial”
  - Pattern of illegal parking behaviors

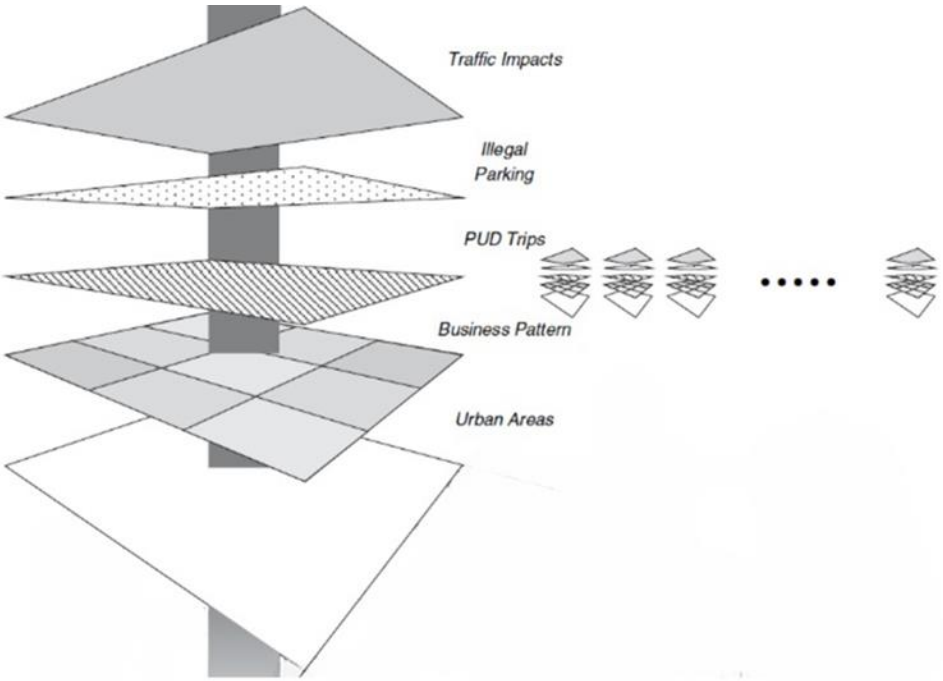




Source: 1. Data.mississauga

Illegal parking – Traffic impact

- **Traffic impact due to illegal parking**
  - **A geographically based combinatorial model** from Lee D. Han et al (2010) to estimate the traffic impact resulting from illegal parking of delivery trucks.
  - Five layers: Urbanized Areas Layer, Employment and Business Pattern Layer, PUD Trips Layer, Illegal Parking Layer, and Traffic Effects Layer.
  - Han identified PUD activities as the third significant traffic effects.
  - Reduce traffic impact due to illegal delivery truck parking: Layers of illegal parking and PUD trips.



Current solutions

- **Technological innovation**
  - Fixed/Mobile parcel lockers
  - Small drone/drone-truck systems
  - Autonomous freight delivery truck

Photo credit to DAN SYMONDS Parcel and Postal Technology International

- **Parking regulations[1]**
  - Park in certain designated zones for a specific period
  - Special courier delivery zone pilot project on selected streets
  - Permit which allows longer parking time and no fine

Photo credit to My parking sign

1. toronto.ctvnews.ca

Our solution

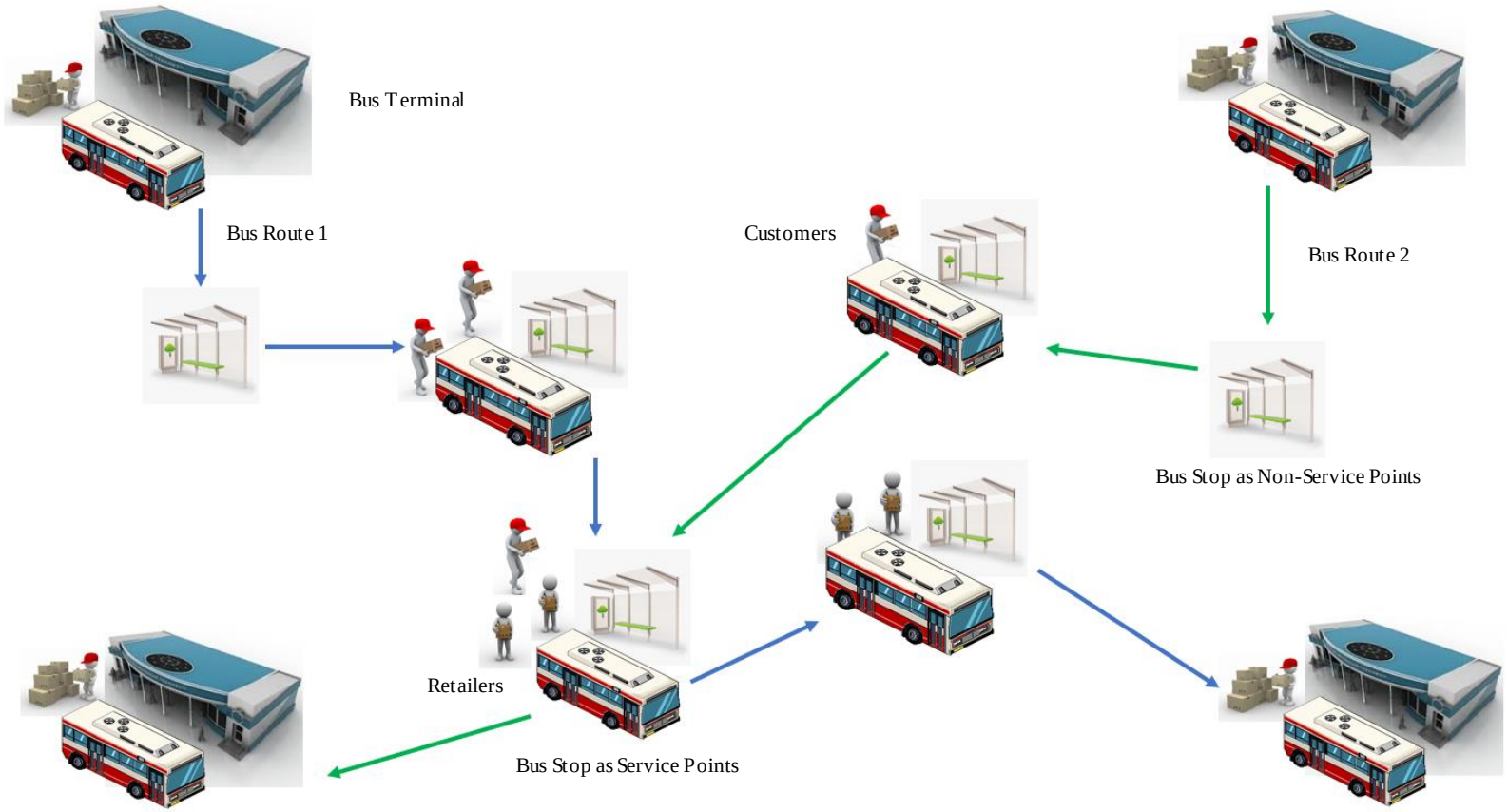
Smart Mobile Lockers (SMLs) in tandem with City Buses (SMLs-CB)

(a) Back view.

(b) Side view.

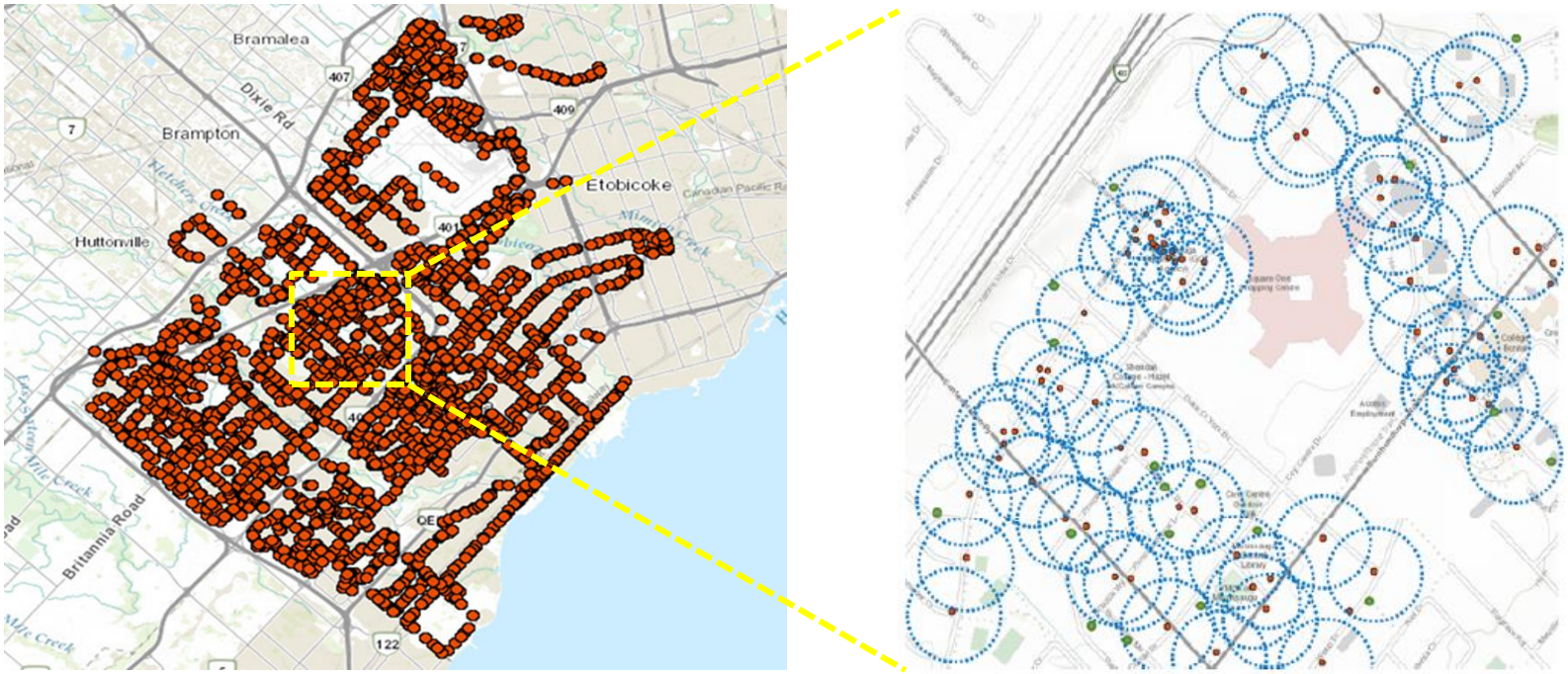
(c) Top view.

Operational details

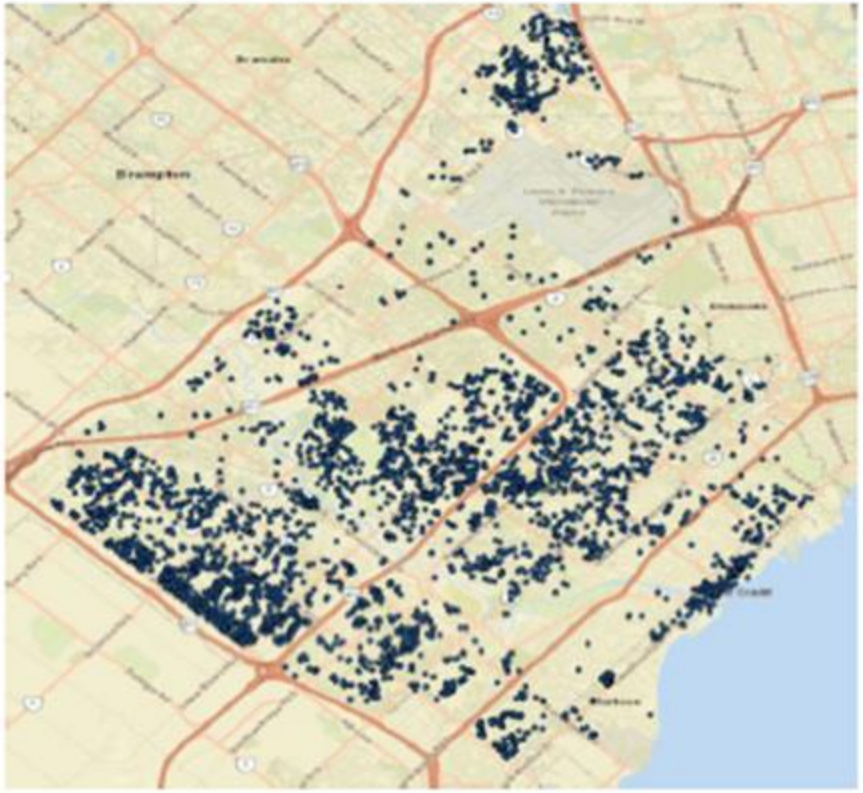


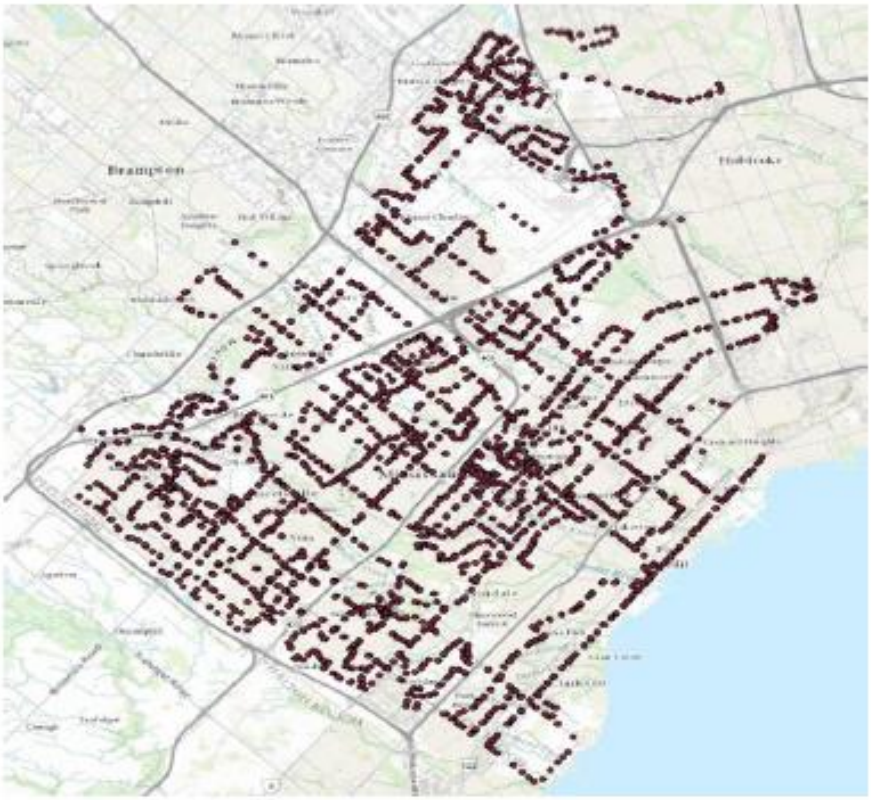
Proof of Concept

RQ1: Is the concept feasible?



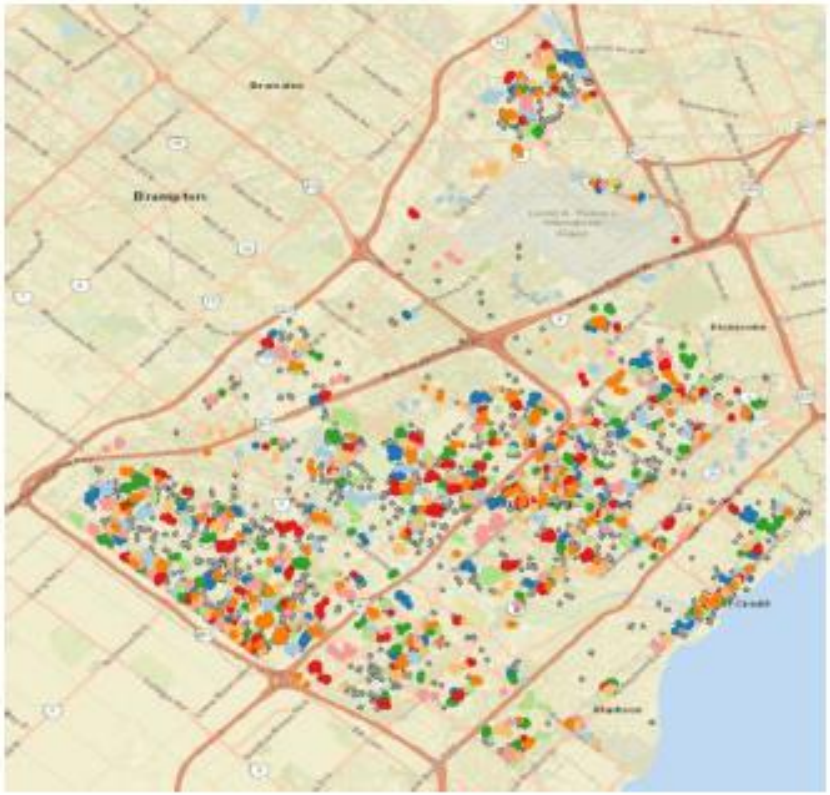
Data visualization

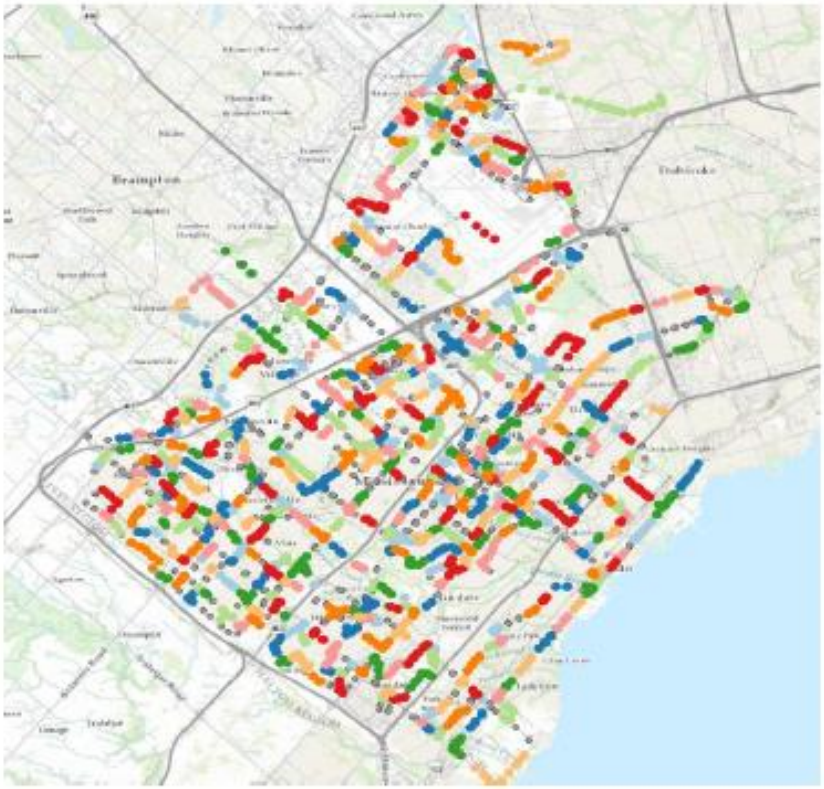




Data clustering

- **Method:** The density-based clustering: self-adjusting (HDBSCAN)





Delivery demand

RQ2: How much can the SML-CB reduce illegal parking of delivery trucks?

- **Current methods of freight delivery estimation**
  - **Delivery frequency**: U.S. National Household Travel Survey (NHTS) data to investigate the freight trips generated by residential units (Xiaokun Wang et al., 2015).
  - **Total number of packages received in each census tract:** the 2012 Household Diary Study (HDS) rate of packages received per week as a function of household income and 2012 ACS 5-Year estimates for "Household Income in the last 12 Months" by census tract (Quanquan Chen et al., 2017).
  - **Limitations of current methods**

Delivery demand

- **Our freight delivery estimation method**
  - Simple: A combination of census and surveys
    - Population: 763600 (Peelregion.ca, 2016)
    - Digital buyer penetration in Canada: 75% (Statistia.com)
    - Willingness to use locker in general: 38% (Our Smart Freight Centre survey delivered in 2020)
  - Result: number of potential customers: 217626

  - **Cases:**
    - If each truck contains 70 parcels, Weekly: **31089** Packages Per day (Case #1), Bi-weekly: **15545** Packages Per day (Case #2), Monthly: **7254** Packages Per day (Case #3).
    - If each truck contains 200 parcels: Weekly: **31089** Packages Per day (Case #4), Bi-weekly: **15545** Packages Per day (Case #5), Monthly: **7254** Packages Per day (Case #6).
    - Less truck will result in less truck activities

Traffic impact estimation

- **Assumptions** [1-3]
  - Parcels contained in each truck: 70-200
  - Number of packages to be delivered per stop (mean): 4
  - Violation Rate: 25%
  - Parking time per stop (mean): 15 min.

- **Results of delivery truck illegal parking**

Case number	Total traffic delay in vehicle hours
1,2	1942.5 vehicle hours per day
3,4	971.5 vehicle hours per day
5,6	453.4 vehicle hours per day

1. Kazuya Kawamura et al. 2014. 2. Habib et al. 1980. 3. Xiaokun Wang et al. 2017

Expected traffic impact reduction

- **Performance of SML-CB**
  - Traffic impact: delays $$D_u = \sum_b \left(\bar{D}_{u,b} \times E_{u,b} \times R_b \times B \times W \right)$$
  - Results of SML-CB pilot plan under **different operating parameters**

Case	# of lockers	Operation frequency/day	# of slots [1]	Locker utilization rate [2]	# packages	Reduction in impact
1,2	50	4	15	80%	2400	7.7%
1,2	100	4	15	80%	4800	15.4%
1,2	100	8	15	80%	9600	30.8%
3,4	50	4	15	80%	2400	15.4%
3,4	100	4	15	80%	4800	30.8%
3,4	100	8	15	80%	9600	61.6%
5,6	50	4	15	80%	2400	30.8%
5,6	100	4	15	80%	4800	61.6%
5,6	100	8	15	80%	9600	100%

1. S lw an et al., 2015

Challenges

- **Customers' willingness to use the SML-CB**
  - Assignment: optimize the assignment of customers to lockers and the lockers to bus routes (work in progress)
  - Pricing and revenue sharing management: optimize the revenue share between different stakeholders of the SML-CB to lower the delivery cost for customers (work in progress)
- **Prototype deployment**
- **Safety issues**

Future work

- **Data selection**: Trade-off between data representation and availability
- **Driven factors**: Identify dominant factors for the illegal parking behaviors of delivery trucks based on selected data
- **Model modification**: Improve the traffic impact model based on identified factors
- **Extend performance evaluation**: Explore the reduced capacity loss and saved parking cost

Smart Freight Center

- The Smart Freight Centre is a center of excellence for goods movement.
- Goods movements span municipal boundaries in the Greater Toronto and Hamilton Area (GTHA), and the issues require innovative, interdisciplinary teams, as well as experts drawn from across municipal boundaries.
- The SFC is a collaborative network established by the Region of Peel, McMaster University, University of Toronto, York University, Ryerson University.
- Current chair of SFC: Prof. Elkafi Hassini
- We are open to any collaborations!
- Link: https://smartfreightcentre.ca/

Dr. Elkafi Hassini, Professor and Chair, Operations Management, DeGroote School of Business


Thank you