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

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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
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]

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

Photo Credit To Patrick Sisson / CURBEd

Photo Credit to Lee Flannery Planetizen
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

![12-Months Distribution for Tickets including "heavy" and "commercial"](image1)

![24-Hours Distribution for tickets including "heavy" and "commercial"](image2)

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.
  - 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

- **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

[^1]: toronto.ctvnews.ca

Photo credit to DAN SYMONDS Parcel and Postal Technology International

Photo credit to My parking sign
Our solution

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

Bus Terminal

Bus Route 1

Customers

Bus Route 2

Bus Stop as Service Points

Retailers

Bus Stop as Service Points

Bus Stop as Non-Service Points
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**

<table>
<thead>
<tr>
<th>Case number</th>
<th>Total traffic delay in vehicle hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>1942.5 vehicle hours per day</td>
</tr>
<tr>
<td>3,4</td>
<td>971.5 vehicle hours per day</td>
</tr>
<tr>
<td>5,6</td>
<td>453.4 vehicle hours per day</td>
</tr>
</tbody>
</table>

# Expected traffic impact reduction

## Performance of SML-CB

- Traffic impact: delays
  \[
  D_u = \sum_b (\bar{D}_{u,b} \times E_{u,b} \times R_b \times B \times W)
  \]

- Results of SML-CB pilot plan under different operating parameters

<table>
<thead>
<tr>
<th>Case</th>
<th># of lockers</th>
<th>Operation frequency/day</th>
<th># of slots [1]</th>
<th>Locker utilization rate [2]</th>
<th># packages</th>
<th>Reduction in impact</th>
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</thead>
<tbody>
<tr>
<td>1,2</td>
<td>50</td>
<td>4</td>
<td>15</td>
<td>80%</td>
<td>2400</td>
<td>7.7%</td>
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<tr>
<td>1,2</td>
<td>100</td>
<td>4</td>
<td>15</td>
<td>80%</td>
<td>4800</td>
<td>15.4%</td>
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<tr>
<td>1,2</td>
<td>100</td>
<td>8</td>
<td>15</td>
<td>80%</td>
<td>9600</td>
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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