Last-mile Delivery with Crowd-shipping and Mobile Depots

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Trends in E-commerce

- **E-commerce revenue is expected to increase 48% from 2018 to 2023.**

- **A research survey for logistics providers and retailer, showed that 87% of respondents would make use of crowd-sourced delivery by 2028 compared to 30% in 2019!**

- **A new data from IBM's retail index shows that the covid-19 pandemic has accelerated retail and e-commerce trends by around 5 years!**

Crowd-shipping

Sharing and using existing individuals' spare time and/or vehicle capacity for delivering goods.

PiggyBee

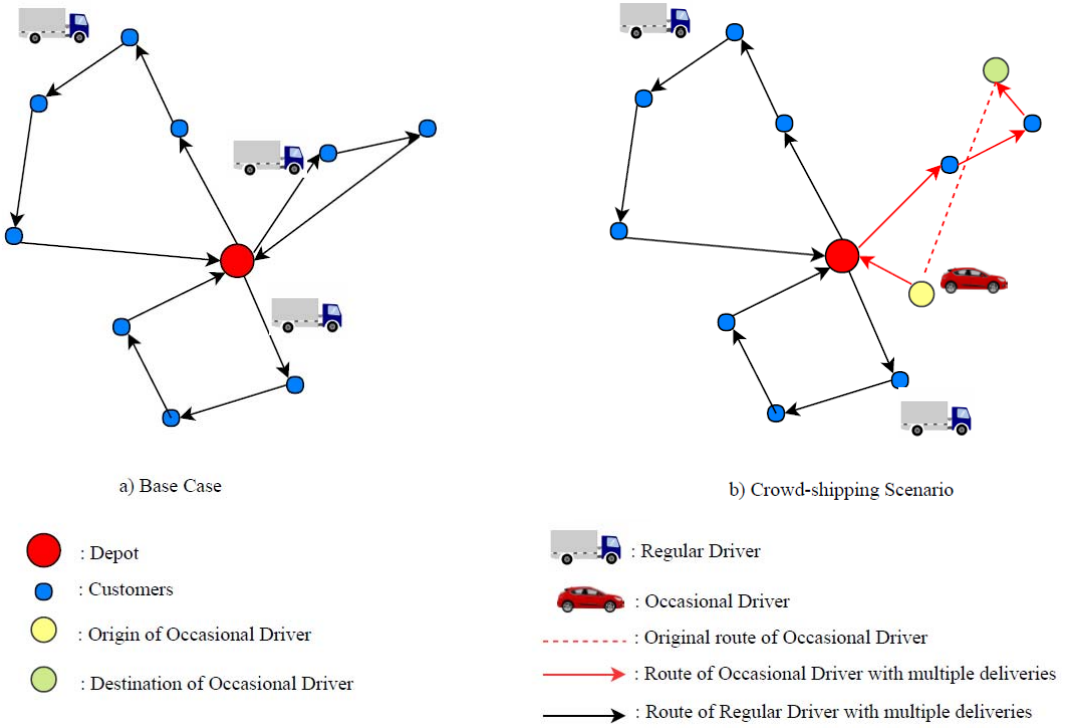
MYWAYS

ShipperBee™

amazon FLEX

Postmates

Example of operation in crowd-shipping



Motivation

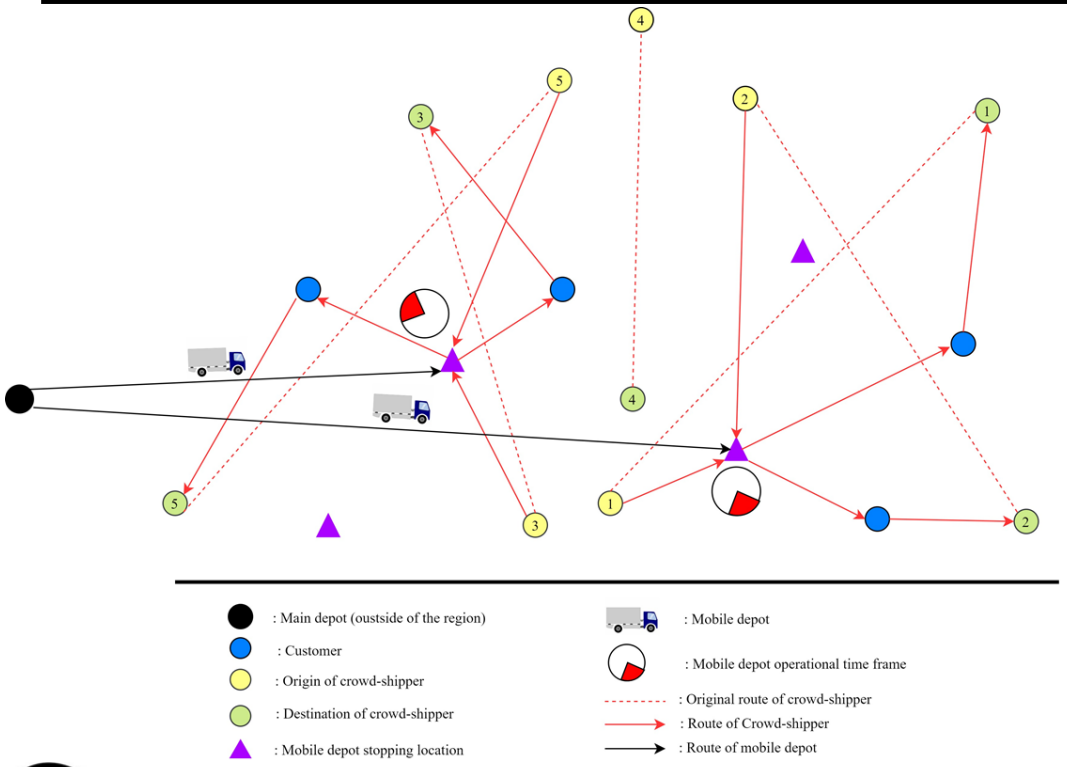
- Most warehouses are outside urban areas:
  No access to majority potential crowd-shippers

- More crowd-shippers :
  More cost-efficient operation

- Establishing fixed facilities usually requires large investment:
  - **Not desirable for many startups**

Decentralization and mobile facilities can be an option!

Crowd-shipping operation with mobile depots



Problem description:

- Selecting mobile depot stopping locations.
- Assigning customers to mobile depot.
- Assigning customers to crowd-shippers.
- Decision on serving or rejecting customers
- Minimizing total operational cost.

The Problem is formulated as an integer program

Study area (Toronto, Canada)

Customer

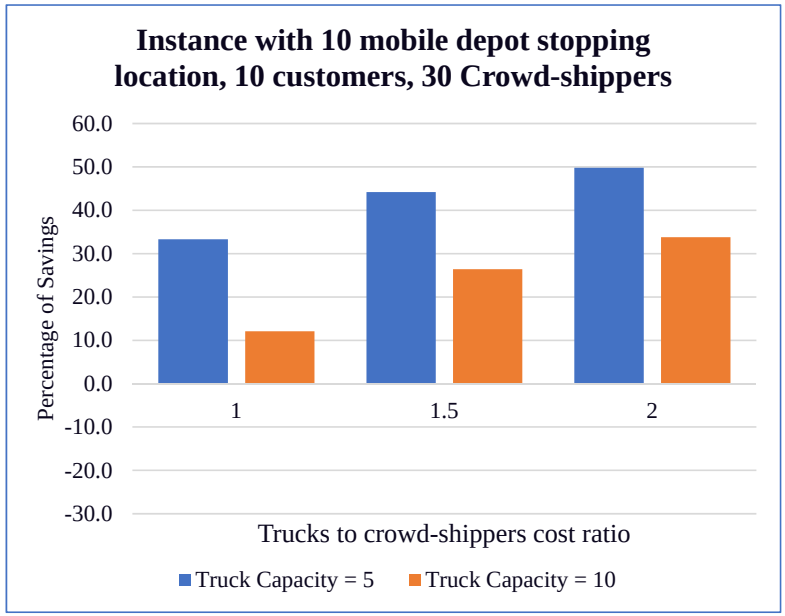
Parking (mobile depot locations)

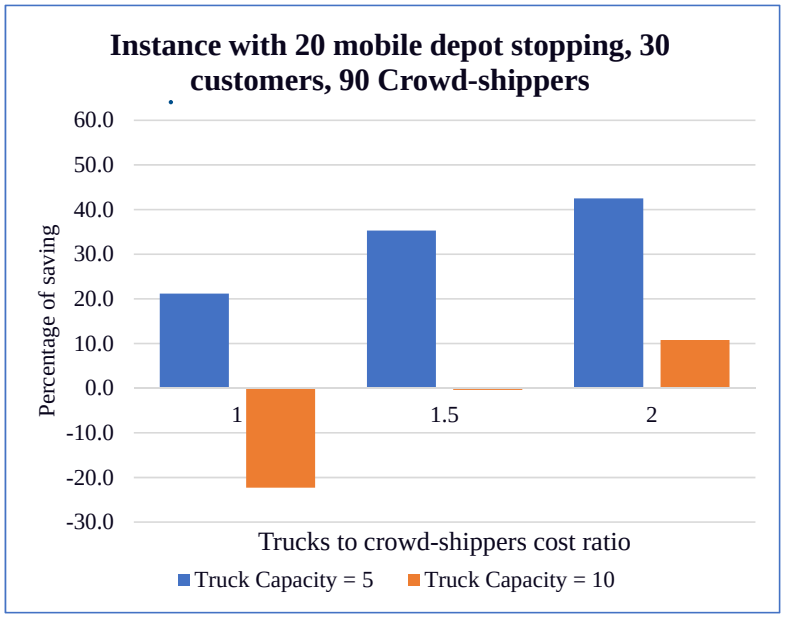
Main Depot

Data

- Based on TTS (Transportation Tomorrow Survey) 2016
- Customers locations are randomly generated in proportion to the population of each traffic zone
- Crowd-shippers are randomly generated based on TTS demand for origin-destination pairs
- Mobile depot stopping locations (parkings) are selected by considering proximity into neighborhood centers and availability of large outdoor parking lots

Cost Saving: Deterministic model vs CVRP





Mobile Depot Capacity is fixed to 10

Stochasticity matters

- Uncertainty in input data.
  - Availability of crowd-shippers are highly uncertain.
- Exact data is unavailable or expensive – data is uncertain, specified by a probability distribution.
  - Availability of crowd-shippers follow a probability distribution
- Want to make the best decisions given this uncertainty in the data.
  - Where and when to send mobile depots

Incorporating stochasticity

Two-Stage Stochastic Integer programming model:

- First-stage decisions:
  - Where and when set up mobile depots
    - Assignment of customer packages to mobile depots
    - Decision on serving customers

After revealing the crowd-shippers availability

- Second-stage decisions:
  - Assigning crowd-shippers to customers

Choose first-stage decisions to minimize:

(First-stage cost) + (Expected second-stage operational cost).

Solution Method and Value of Stochasticity

- Solving the stochastic model with the methods in optimizers such as CPLEX is computationally prohibitive for medium and large instances!

- Benders decomposition algorithm is introduced for solving the stochastic model enabling us to solve the stochastic model for medium and large instances.
- The stochastic model results in an average 6% percent cost saving compared to deterministic model for the largest instance.

Conclusion

- The new Crowd-shipping operation has more cost efficiency than CVRP!
- The model favors urban areas that has access to potential crowd-shippers!
- Stochasticity in availability of crowd-shippers is incorporated in our model.
- Benders decomposition algorithm is introduced for solving the model.
- Value of Stochastic Solution is shown.

Thanks you!

More details about this work can be found below:

Mousavi, K., Bodur, M., & Roorda, M. Stochastic last-mile delivery with crowd-shipping and mobile depots (2020). *Available at optimization-online. org*, *276*.