Average e-commerce revenue per online shopper

- United States: $1,804
- United Kingdom: $1,629
- Sweden: $1,446
- France: $1,228
- Germany: $1,064
- Japan: $968
- Spain: $849
- China: $626
- Russia: $396
- Brazil: $350
Omni-Channel Retailers
Shopping and Fulfillment Options

Company

Warehouse

online

In-Store

online

In-Store
Innovative Service Models for Last Mile Delivery

- Customers can provide multiple time windows at different locations
- Retailer can choose to deliver to the location that minimizes costs
- Reduced delivery times, and increased flexibility for the customer
Audi, Amazon, DHL easy delivery service
Multi-depot vehicle routing problem with time windows and alternative delivery locations

MDVRPTWADL
MDVRPTWADL

(1) Objective function (min cost)
\[ \min \sum_{k} \sum_{i \in C \cup W} \sum_{j \in C \cup W} c_{ij} x_{ijk} \]

(2) Customer visited at 1 location
\[ \forall i, i+n \in C \]

(3) Vehicle capacity constraint
\[ \forall k \]
\[ \sum_{i \in C} \sum_{j \in C \cup W} x_{ijk} \leq q \]

(4) Tours start/finish at depot
\[ \forall k \]
\[ \sum_{i \in W} \sum_{j \in C} x_{ijk} = 1 \]

(5) Conserves flow
\[ \forall h \in C, \forall k \]
\[ \sum_{i \in C \cup W} x_{ihk} - \sum_{j \in C \cup W} x_{hjk} = 0 \]

(6) Determines stop arrival times
\[ \forall i, j \in C \cup W, \forall k \]
\[ s_{ik} + t_{ij} - M(1 - x_{ijk}) \leq s_{jk} \]

(7) Checks time windows
\[ \forall i \in C, \forall k \]
\[ \left( \sum_{j \in C \cup W} x_{ijk} \right) a_i \leq s_{ik} \leq \left( \sum_{j \in C \cup W} x_{ijk} \right) b_i \]
\[ a_i \leq s_{ik} \leq b_i \]
\[ x_{ijk} \in \{0, 1\} \]
Numerical Example

• Scenario 1: Home delivery

- One Depot
  - Total delivery cost is 67

- Two Depot
  - Total delivery cost is 58
  - Total delivery cost decreases by 13% by adding new depot
Numerical Example

• Scenario 2: Home or alternative location delivery

One Depot

Total delivery cost is 54
(20% less than home delivery only)

Two Depot

Total delivery cost is 40
(31% less than home delivery only)
Case Study of Toronto
Case Study of Toronto

• Optimal tours for home delivery

Delivery route length for home delivery is 58 km
Case Study of Toronto

• Optimal tours for home or alternative address delivery

delivery route length is 33.7 km, about 40% reduction
Key Findings

• If customers provide the retailer where they will be at different times of the day:
  ▪ retailer can choose to deliver to the location that minimizes its costs.
  ▪ It can reduce the number of vehicles needed for delivery.
  ▪ It can reduce congestion and pollution in urban areas.
  ▪ It can increase customer satisfaction by providing them the opportunity to conduct their daily schedule.
Future Work

• Consider real demand scenarios data from partner firm
• Merge with activity patterns of individuals
• Consider inventory level at each depot
• Consider facility costs
• Solution algorithms for larger problems
Questions

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