The integrated order batching and routing problem in online grocery retail with dynamic demands

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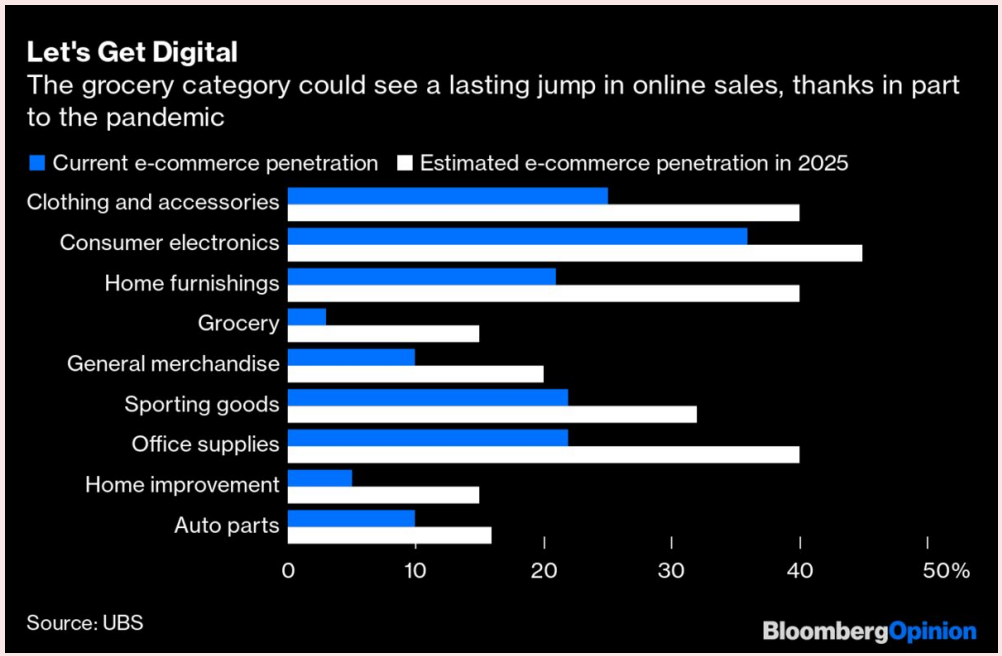
December 14th, 2020

Plan

Market growth and challenges

- Online grocery shopping is a massive, rapidly growing market



- Many challenges are faced by online grocery services:
  - Customer satisfaction
  - High operating costs

Online grocery retail in Canada

- Many actors in the market

- A survey conducted by Deloitte Canada from March 16 to 18, 2020
  - interviewed 1,000 Canadian consumers
  - 8% of have increased their spending in the past 30 days
  - 15% say they will spend more in the coming weeks
  - 21% of expect to spend more on groceries

Online grocery post-COVID

Will Online Grocery Shopping Continue Post-COVID?

Yes, according to experts and analysts

General overview of the processes

Operational problems

- Discrete picking may not be efficient
- Processes are traditionally approached as individual problems

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Benefits of integration

- Improved customer service
- Cost-saving potentials

Literature review

- Introduced by Schmid et al. [2013]

Table: Problem characteristics in publications of integrated order picking and vehicle routing problems [Schubert, 2020]

Publication	Order picking			Vehicle fleet			Interm. Storage	TW restrictions			Planning
	SOPP	OBP	ZPP	VRP-HC	MTVRP	VRPSD		Hard	Semi-hard	Soft	
Schubert et al. [2018]	X				X				X		Static
Moons et al. [2018]	X			X				X			
Ramaekers et al. [2018]	X				X			X			
Moons et al. [2019]	X				X			X			
Schubert et al. [2020]	X					X		X			
Kuhn et al. [2020]		X			X				X		
Ostermeier et al. [2020]	X		X	X			X	X		X	

Problem description 1/2

- Set of n customer orders to deliver such that:
  - Orders arrive dynamically
  - Each customer order consists of a set of items
  - A release time R_r for each order
  - Two problems must be solved: Order picking + VRP

Order picking problem

- Picking customer orders in a supermarket
- A set of identical capacitated picking devices
- Ordered items are located in different places
- Orders must be grouped into batches –> Order batching
- Same picker picks all items of the same order

Problem description 2/2

Vehicle routing problem

- Assigning orders to vehicles
- Planning routes for each vehicle
- A set of identical capacitated vehicles
- TWs are associated to customer locations

Interconnection and Objective

- OBOP and VRP are interconnected by:
  - The release times of orders by order pickers
  - The start times of vehicles
- The objective can be to minimize:
  - Routing cost, tardiness, routing cost + tardiness
  - Others

Periodic re-optimization

Algorithm Dynamic Optimization Algorithm

1: Create a solution S that contains the initial requests
2: **Do**
3: Add the new requests to S
4: $ExecuteALNS(S)$
5: **While** there are new events

Adaptive Large Neighborhood Search

ALNS overview

- Removal and insertion operators compete to change the solution
- Operators are selected based on their past performance
- Removal and insertion operators treat one sub-problem at a time

Removal and insertion operators

- Vehicle routing
  - Removal operators: Random removal, Worst removal, Related removal, Time-oriented related removal
  - Insertion operators: Greedy insertion, regret insertion, random insertion
- Order picking
  - Removal operators: Random removal & Worst removal (Applied to orders and batches)
  - Removal operators + neighborhood-based shaking moves
  - Insertion operators: Greedy insertion, regret insertion, random insertion

Enhanced ALNS

General Adaptive Large Neighborhood Search

- A local search procedure is applied after the the repair heuristic
- A local search is applied with a certain probability
- It outperforms ALNS in solving the static problem [Kuhn et al., 2020]

Expected results

Fleet exploitation strategy

- 1st strategy: New requests are assigned to vehicles at the depot
  - Cost-effective and ensures high service quality
  - Large-size fleet
- 2nd strategy: New requests can be assigned to on-service vehicles
  - More flexibility in serving customers using less number of vehicles
  - Increasing routing cost and possible violation of TWs

Large TWs vs Tight TWs & Hard TWs vs Semi-Hard TWs

- Effects of TWs on Picker and Vehicle fleet size

Highlights

- Described a rich problem
- Proposed the 1st dynamic algorithm for this problem
- Enhanced ALNS by using local search
- Presented expected results

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