Emerging problems and challenges in routing

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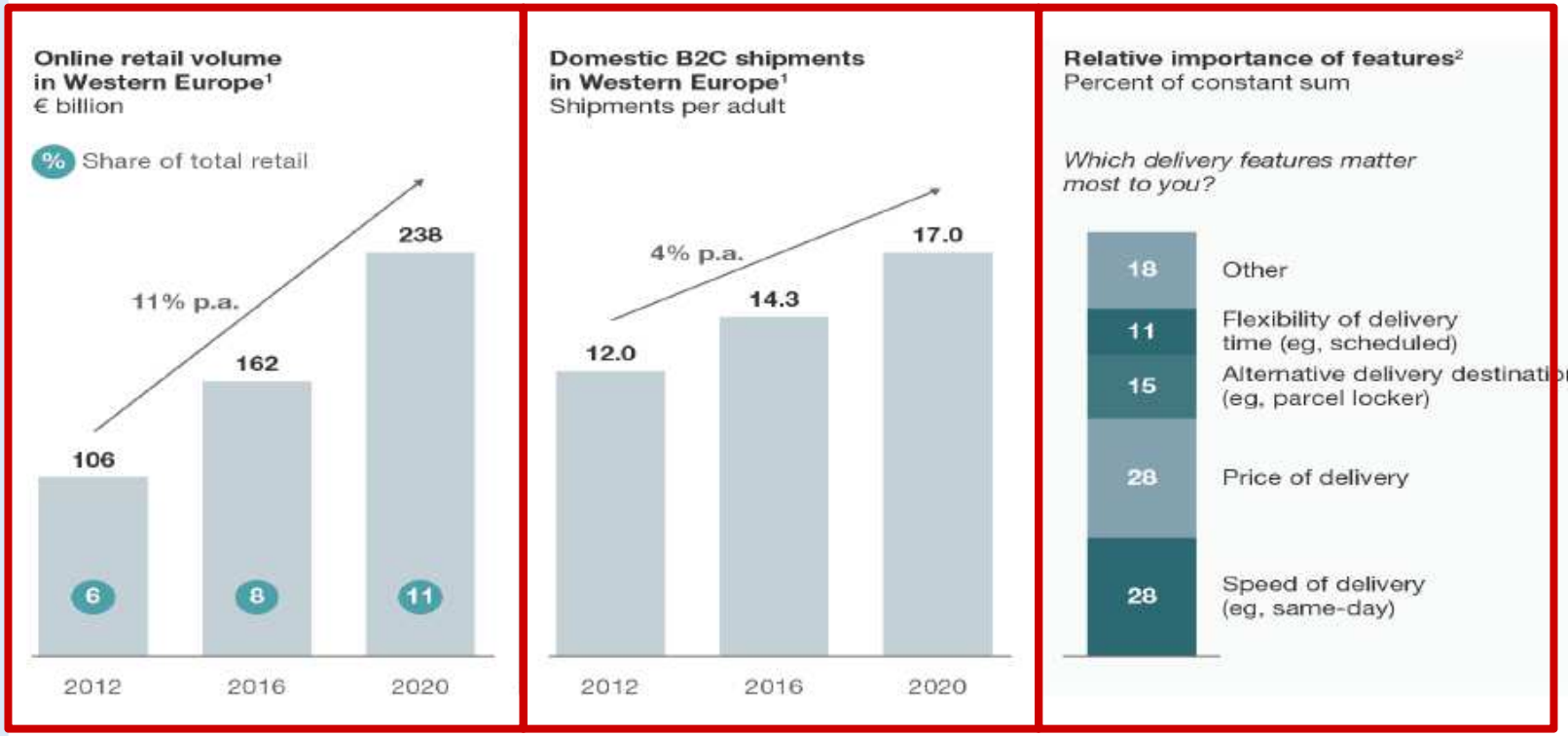
Outline

- E-commerce
  - Recent trends
  - Customer requirements
- Last-mile delivery
  - Issues
  - New strategies / technologies
- Emerging challenges in routing
  - Release and due dates
  - Routing and crowdshipping
  - Time windows management
  - Dynamic pricing

Explosion of e-commerce

E-commerce boom and preference for convenience drive demand for new delivery options and features.



[1]Included countries are Austria, Belgium, Denmark, Finland, France, Germany, Netherlands, Norway, Sweden, Switzerland, UK.
[2]Only delivery features included, not general delivery conditions (eg, goods not broken).

McKinsey&Company | Source: Forrester; Datamonitor; online survey conducted in June 2013, n = 1,016 (UK, France, Germany, and Sweden)

Same-day delivery

Why is same-day delivery exploding?

- Black et.al (2015) “the majority of the people buy in-store because they have the ability to touch and feel the products and to gain the instant gratification of walking out with the purchase”
- Same-day delivery allows to receive the goods bought after a few hours from the placement of an order
- Side (2017) “Millennials are not spending as much time looking for a deal as they are looking for instant gratification”

Same-day delivery

The New York Times

Last-Minute Shoppers Increasingly Trust Only Amazon to Deliver

Same-day delivery

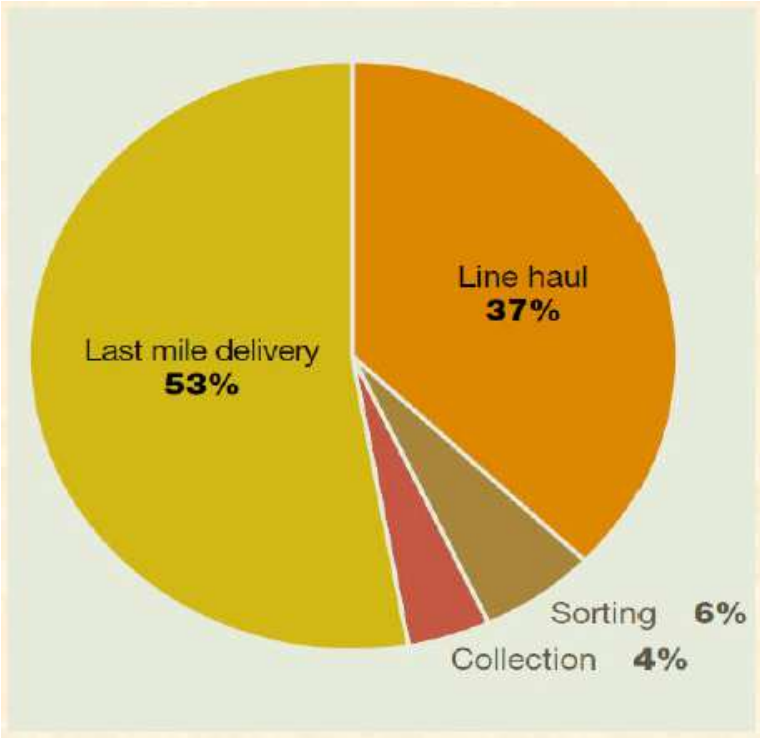
Los Angeles Times

Those types of arrangements are increasingly important to retailers, analysts say, because they give the retailers greater control over customers' deliveries. One late Christmas delivery can be enough to ward off shoppers, says Sriram Sridhar, chief executive of LateShipment.com, who advises retailers to preemptively inform customers if it looks like their items will be delayed.

Last-mile delivery

The final leg in a B2C delivery service whereby the consignment is delivered to the recipient, either at the recipient's home or at a collection point

Distribution cost in same-day delivery

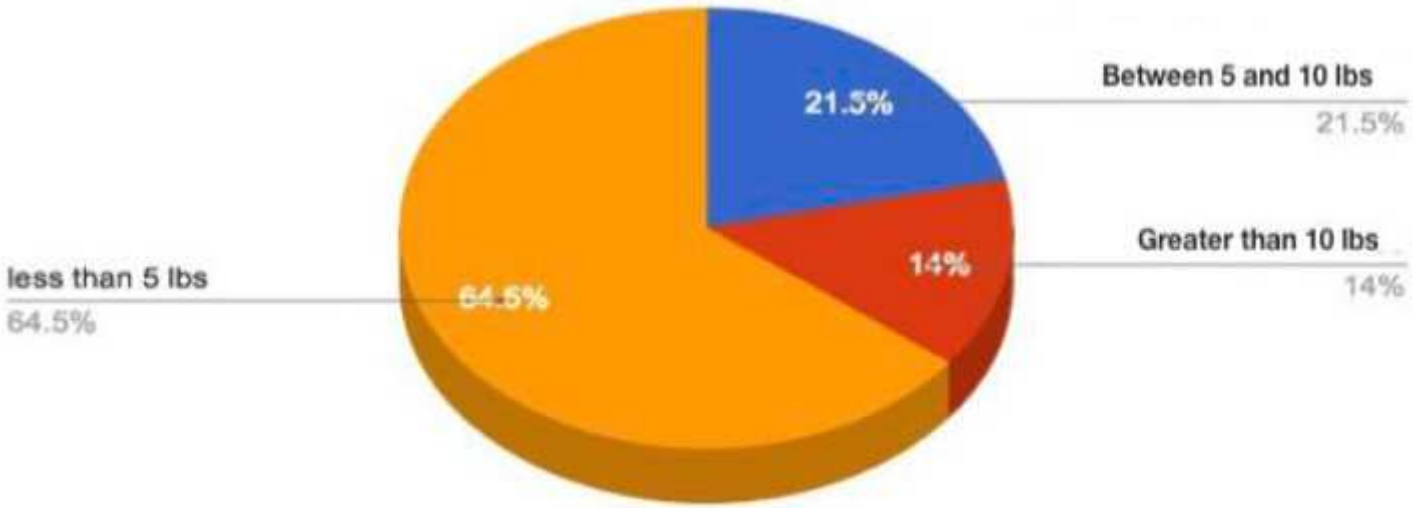


Same-day delivery and last-mile delivery

IT IS NECESSARY TO REDUCE LAST-MILE COSTS IN ORDER TO DEVELOP AN EFFICIENT SAME-DAY DELIVERY POLICY

Technologies for last-mile delivery

Weights of parcels delivered by Amazon



Technologies for last-mile delivery

Autonomous Ground Vehicles

Technologies for last-mile delivery

Droids

Technologies for last-mile delivery

Drones

Technologies for last-mile delivery

Trunk delivery

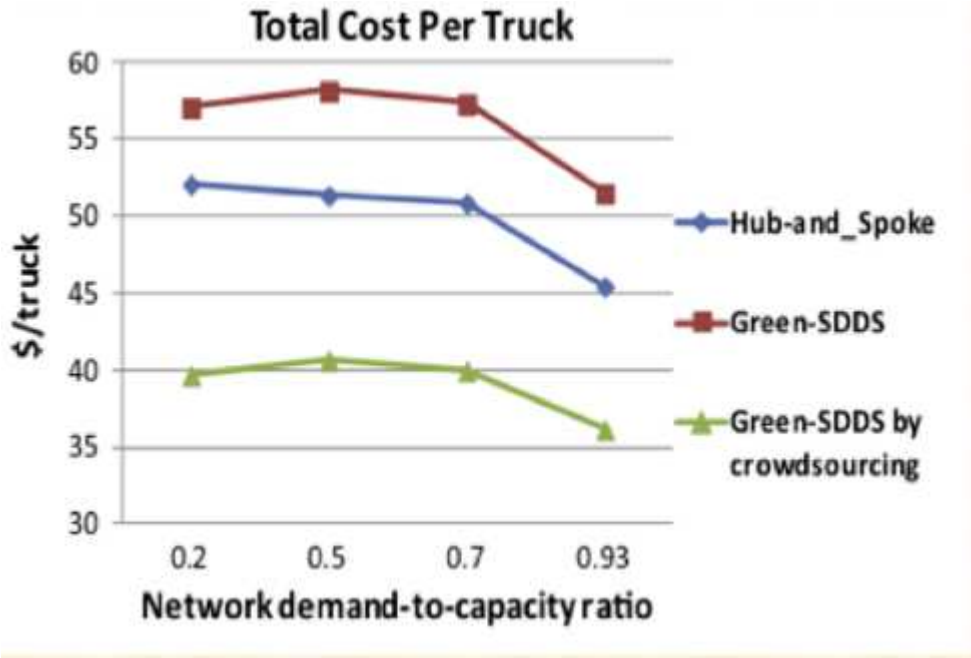
https://incardelivery.volvocars.com/

Strategies for last-mile delivery: crowdshipping

- Crowdsourcing is a concept derived from the notion that a business can outsource certain functions to the crowd (Howe, 2006).
- Crowdsourced delivery (crowdshipping) utilizes personal vehicles to deliver packages to residents and/or business
- Crowdsourcing provides an effective way of matching demand (orders) and supply (vehicle capacity) and thus improving transportation efficiency (Bocken et al., 2014).

Cost savings from crowdsourcing

Crowdsourcing implies very low overhead costs to operate. The cost savings are on average of 29.7%



Routing problems and last-mile delivery

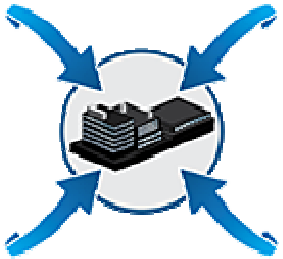
New problems emerge

- Routing with Drones
- Trunk delivery
- ….
- Routing with release dates
- Routing with crowdshipping
- Time windows assignment
- Dynamic pricing

ROUTING PROBLEMS WITH RELEASE DATES

Background and applications

Consolidation centers



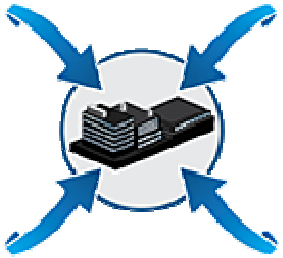
Goods are sorted, consolidated and delivered to final customers

Background and applications

Arrival

Sorting

Distribution



Background and applications

Arrival and distribution times are overlapping

Contrary to what happens in classical

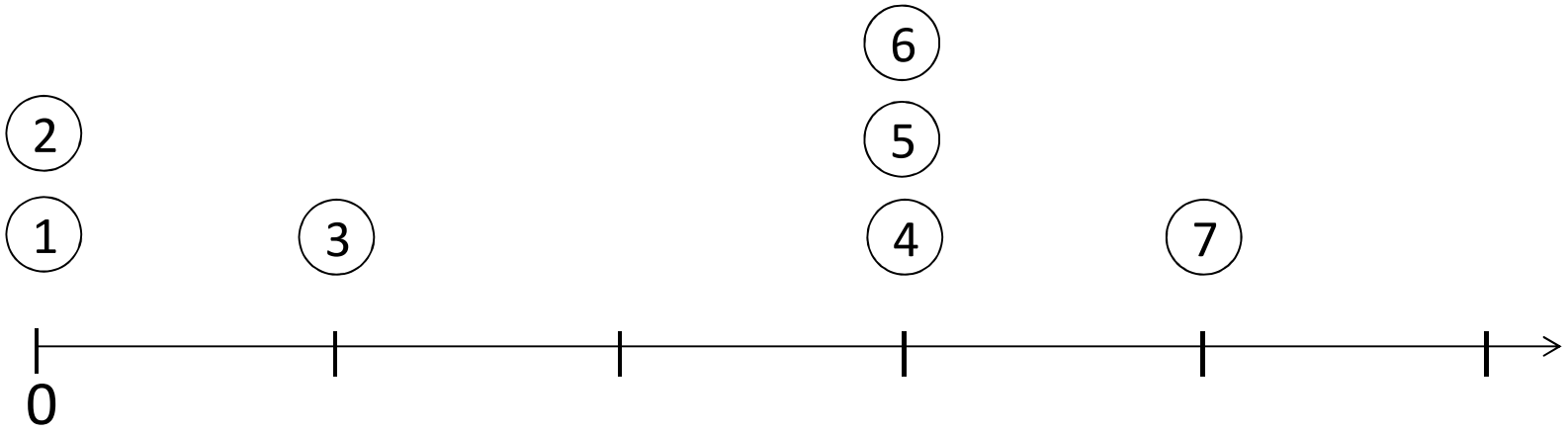
- VRP
- VRPTW
- IRP
- …

NEW DECISION: SHOULD I STAY OR SHOULD I GO?

The traveling salesman problem with release dates (TSP-rd)

Archetti, Feillet, Mor, Speranza, Dynamic traveling salesman problem with stochastic release dates, EJOR 2020

- A complete directed graph *G(V,A)*
- A traveling time t_{ij} associated with each arc
- A release date r_i is associated with each customer *i*, with $r_i < r_j$ for $i<j$



TSP-rd

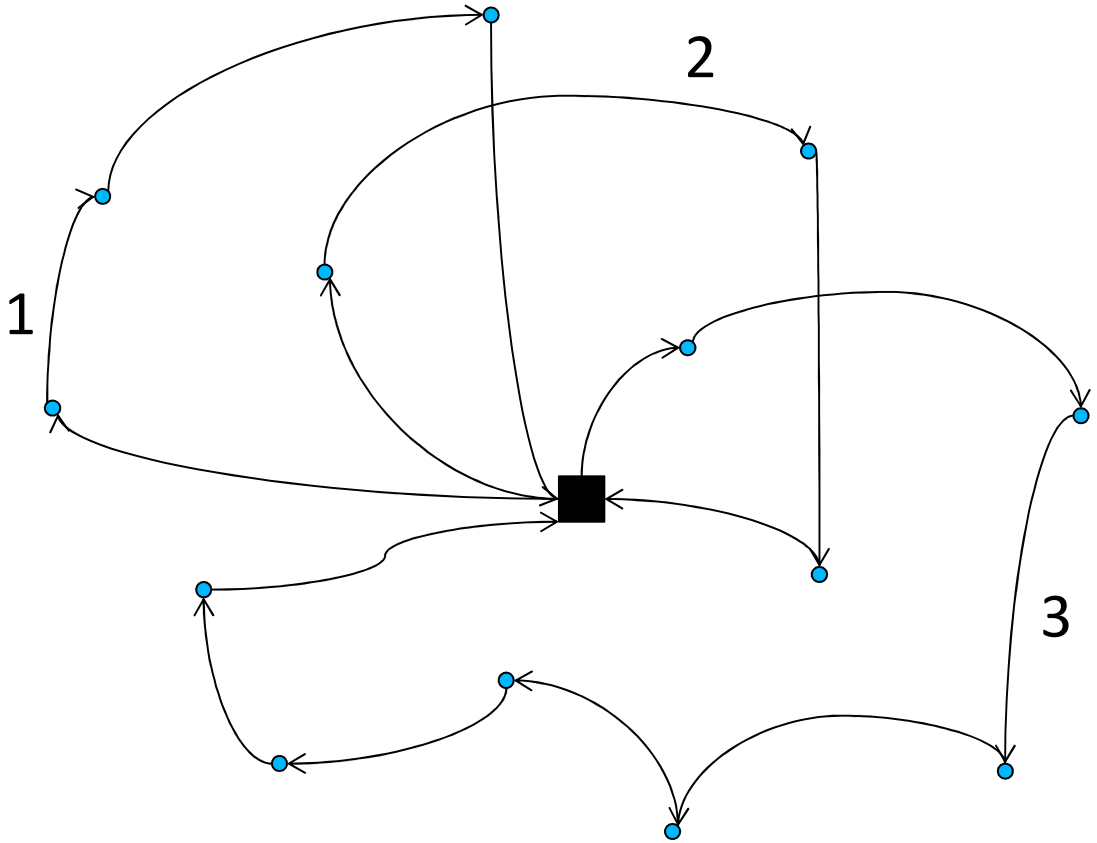
- No capacity constraint
- One vehicle
- Objective

Minimize the maximum completion time:

Traveling time +

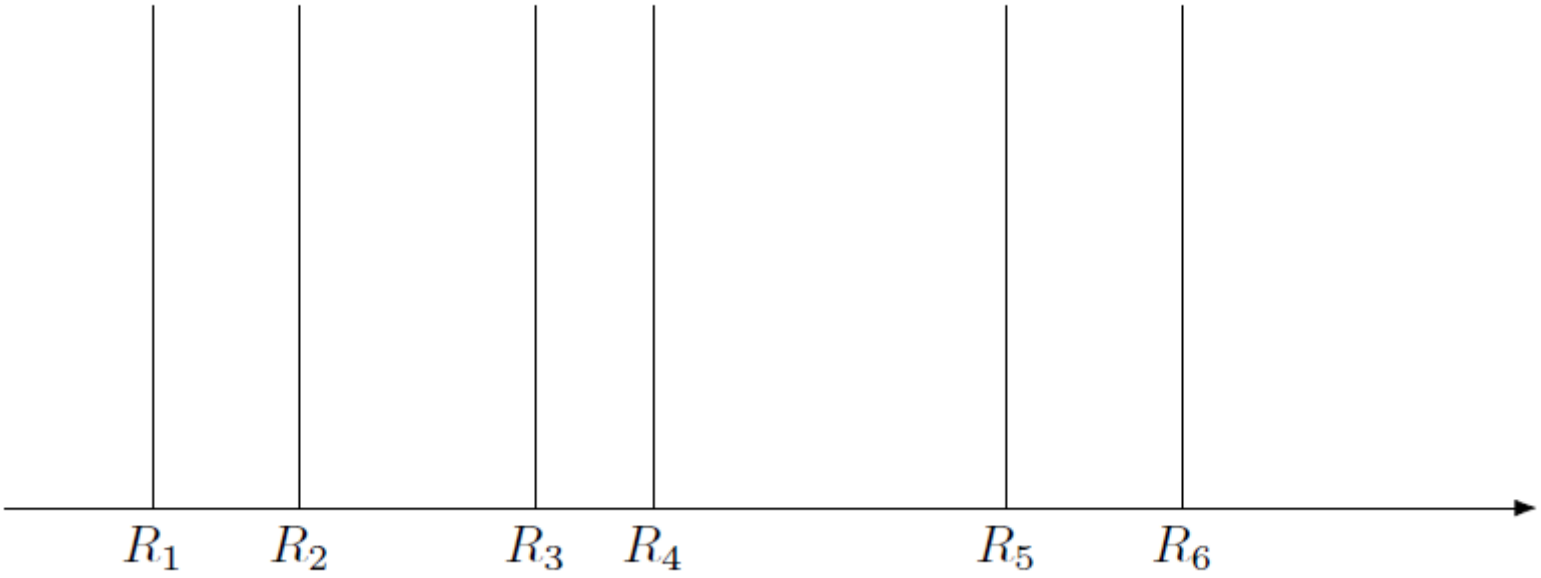
Waiting time at the depot

TSP-rd



Different routes with, possibly, waiting time in between

Deterministic release dates

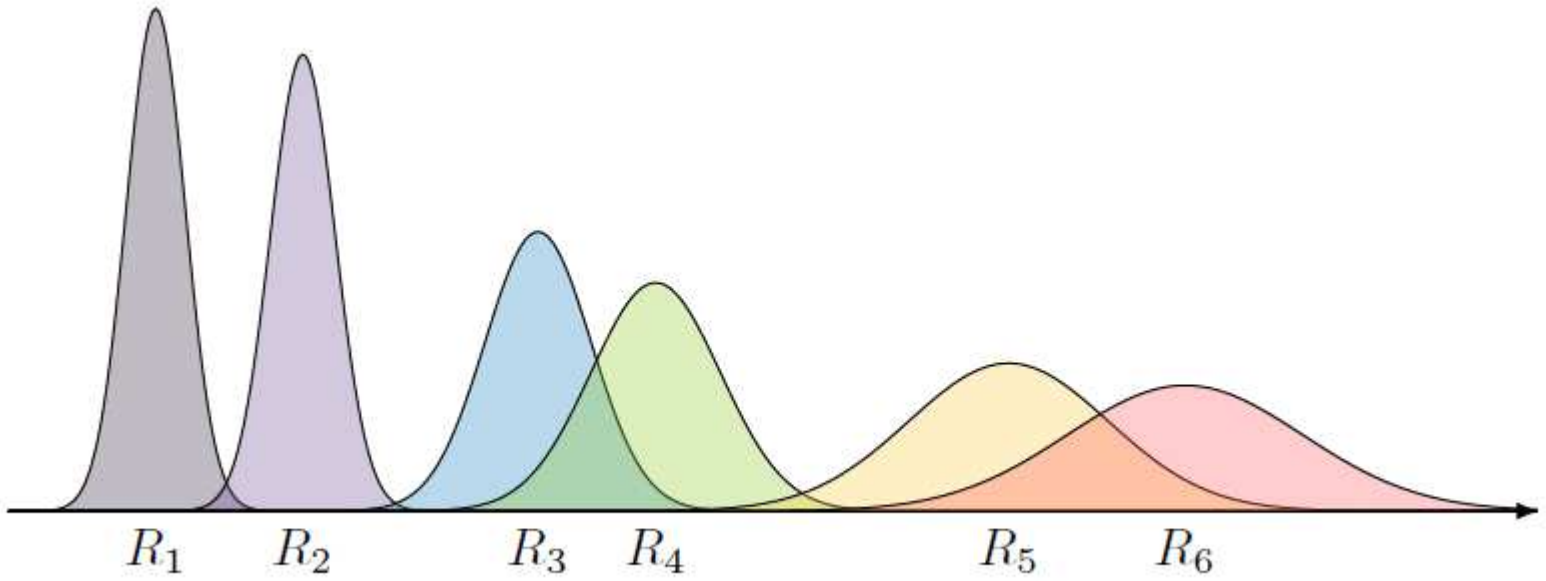


Is it realistic?

- Release dates represent the time at which the parcels that have to be delivered to customer arrive at the depot
- These parcels are transported by vehicles departing from suppliers and traveling to the depot
- These vehicles may face unexpected conditions affecting the traveling time

RELEASE DATES ARE NOT DETERMINISTIC!

Stochastic release dates

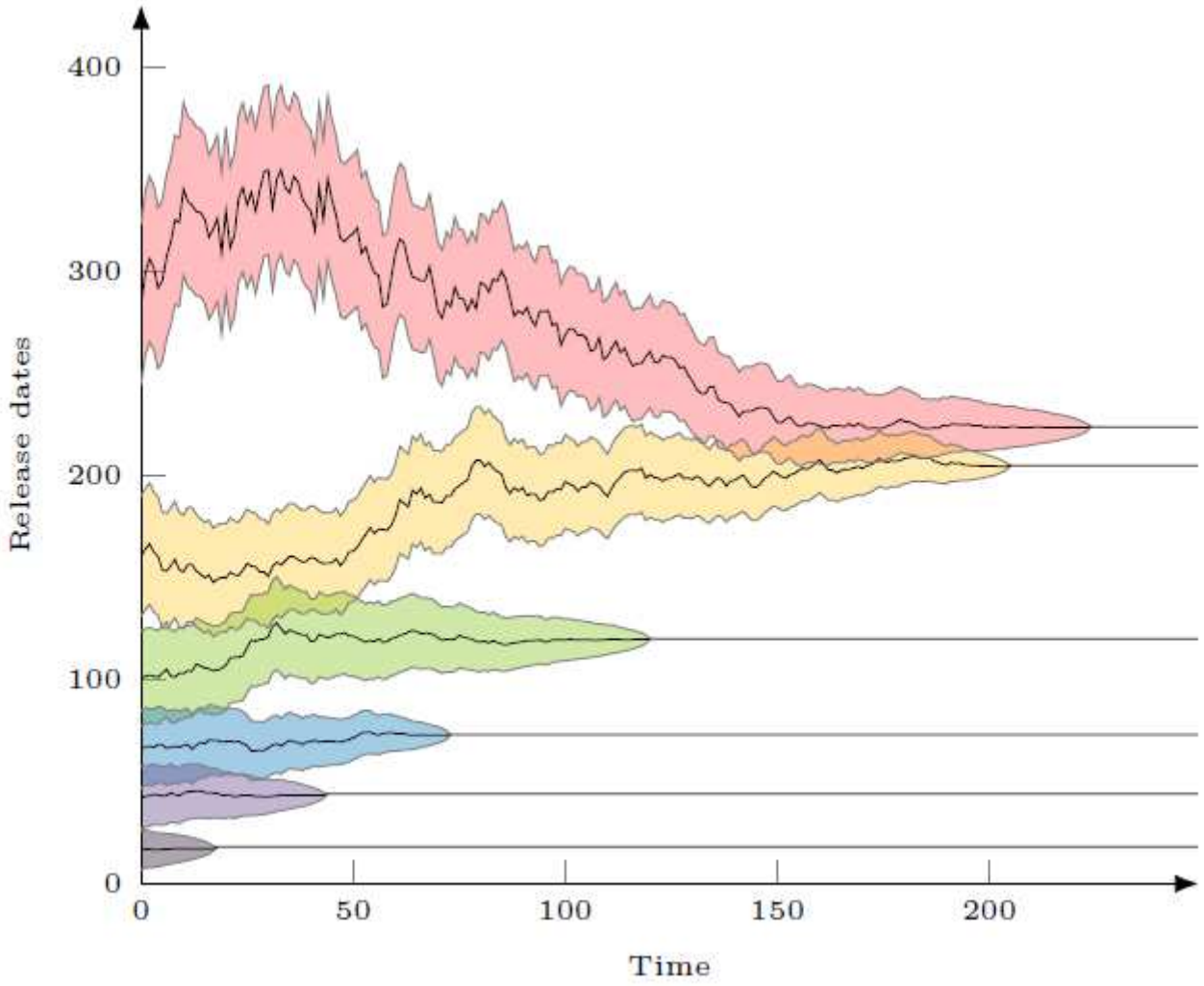


Is it realistic?

- You may assume to have an estimation of the distribution of the traveling time
- Once you know that the vehicle has departed from the supplier, you may estimate the release date
- And what about GPS-equipped vehicles?

STOCHASTIC AND DYNAMIC RELEASE DATES

Stochastic and dynamic release dates



Objective function

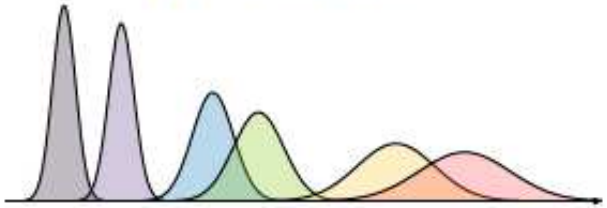
MINIMIZING THE EXPECTED COMPLETION TIME

Recursive formula

Solution approach: reoptimization + ILS

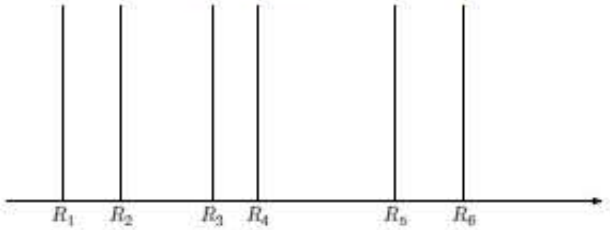
Stochastic

Full probabilistic information



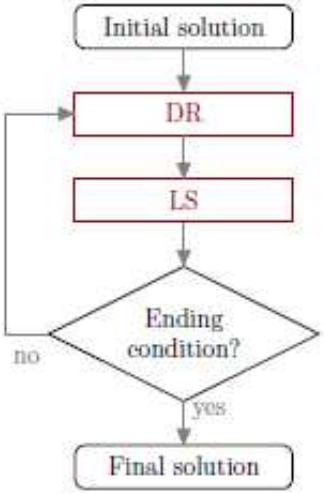
Deterministic

Conditional expected value



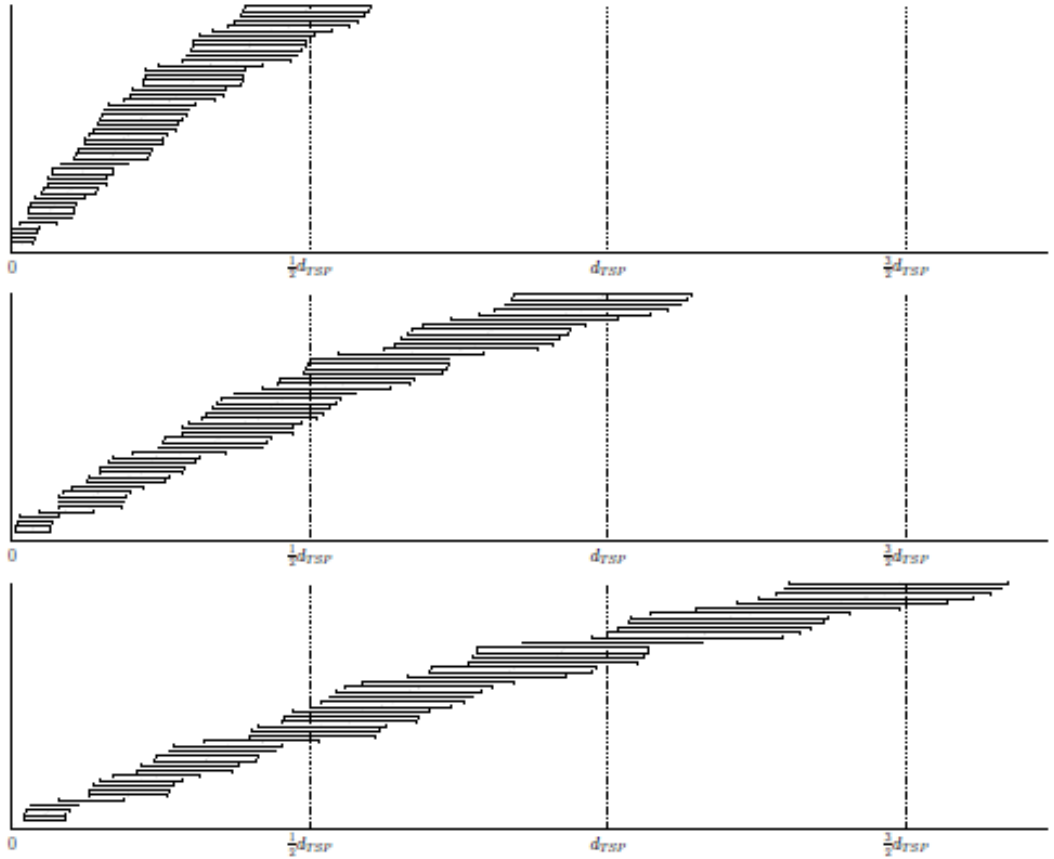
How?

Iterated Local Search



Computational tests

- Different widenesses of release dates and percentage of customers with dynamic and stochastic release dates



Computational tests

- Compare stochastic and deterministic model
- Evaluate a myopic policy where the vehicle starts as soon as a parcel is available at the depot

Results: gaps from BK

	Avg. Deterministic	Avg. Stochastic	Avg. "myopic"
$\delta = 0$	2.69	0.72	11.96
$\delta = 0.5$	2.96	1.40	14.74
$\delta = 1$	3.10	1.34	10.85
$\beta = 0.5$	1.91	1.28	24.22
$\beta = 1$	3.79	0.90	11.10
$\beta = 1.5$	3.05	1.29	2.23
Avg.	2.92	1.16	12.52

Results: number of ILS iterations in 5 minutes

	Number of iterations	
Size	Deterministic	Stochastic
50-46	718	18
45-41	715	63
40-36	-	201
35-31	613	226
30-26	2248	500
25-21	1765	500
5-1	500	500

Interesting hints

- The stochastic models provides better results but it is much more time demanding than deterministic
  - Probably not suitable for online setting
- The myopic approach is comparable to the other two approaches in one setting
  - No comparison in terms of computing time!

Interesting hints

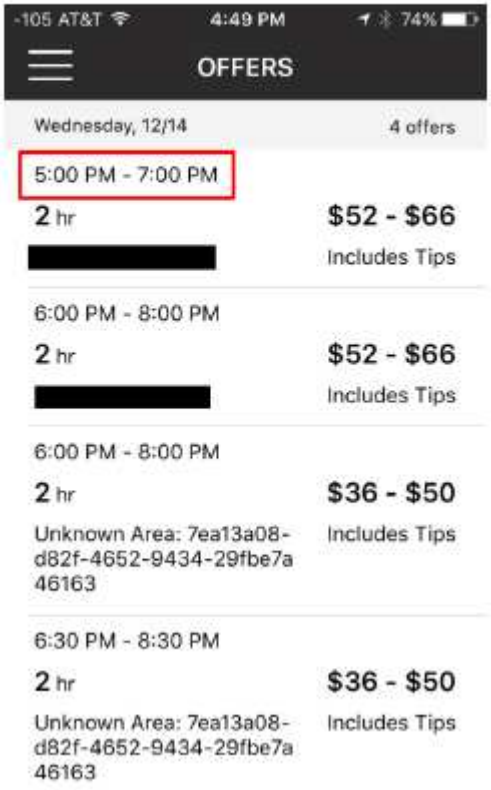
The suitability of a solution approach highly depends on the practical setting

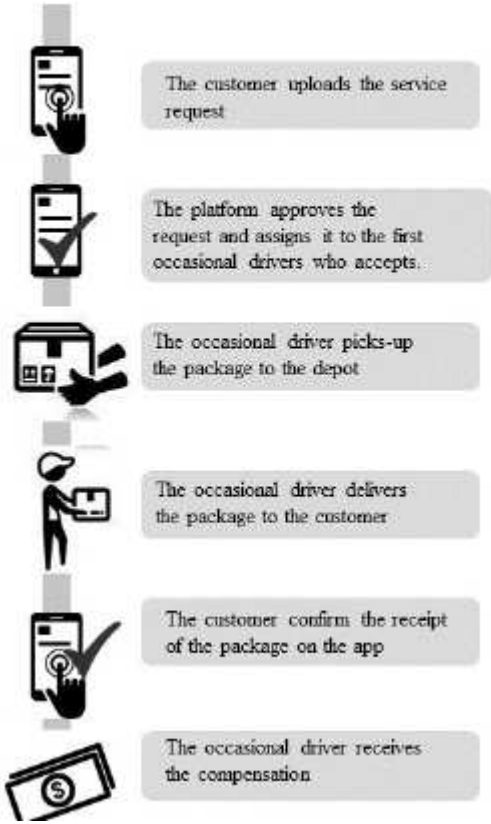
ROUTING AND CROWSHIPPING

Background

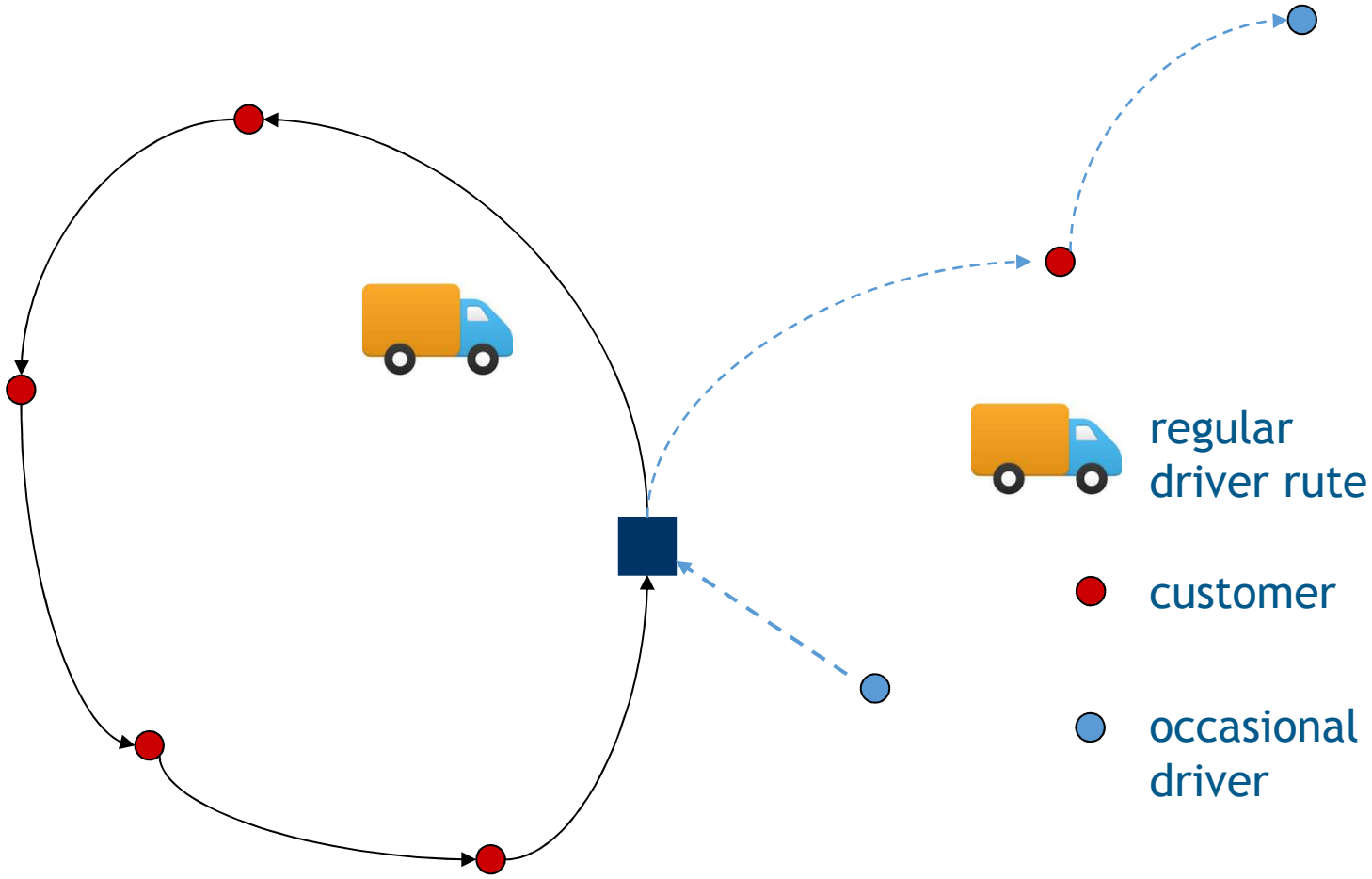
amazon FLEX

ON-LINE Process





Background



The (offline) vehicle routing problem with occasional drivers (VRPOD)

Archetti, Savelsbergh, Speranza, The vehicle routing problem with occasional drivers, EJOR, 2015

- Set of customer orders
- Fleet of vehicles → Routing cost
- Set of ODs → Compensation

Two compensation schemes:

1. Based on tour length
2. Based on detour

The VRPOD

OBJECTIVE

Minimize the sum of the cost incured by regular drivers (routing cost) and occasional drivers (compensation)

Solution approach: matheuristic

MATHOD

Multi-start matheuristic

- Tabu Search for routing
- MILP for the assignment of customers to ODs

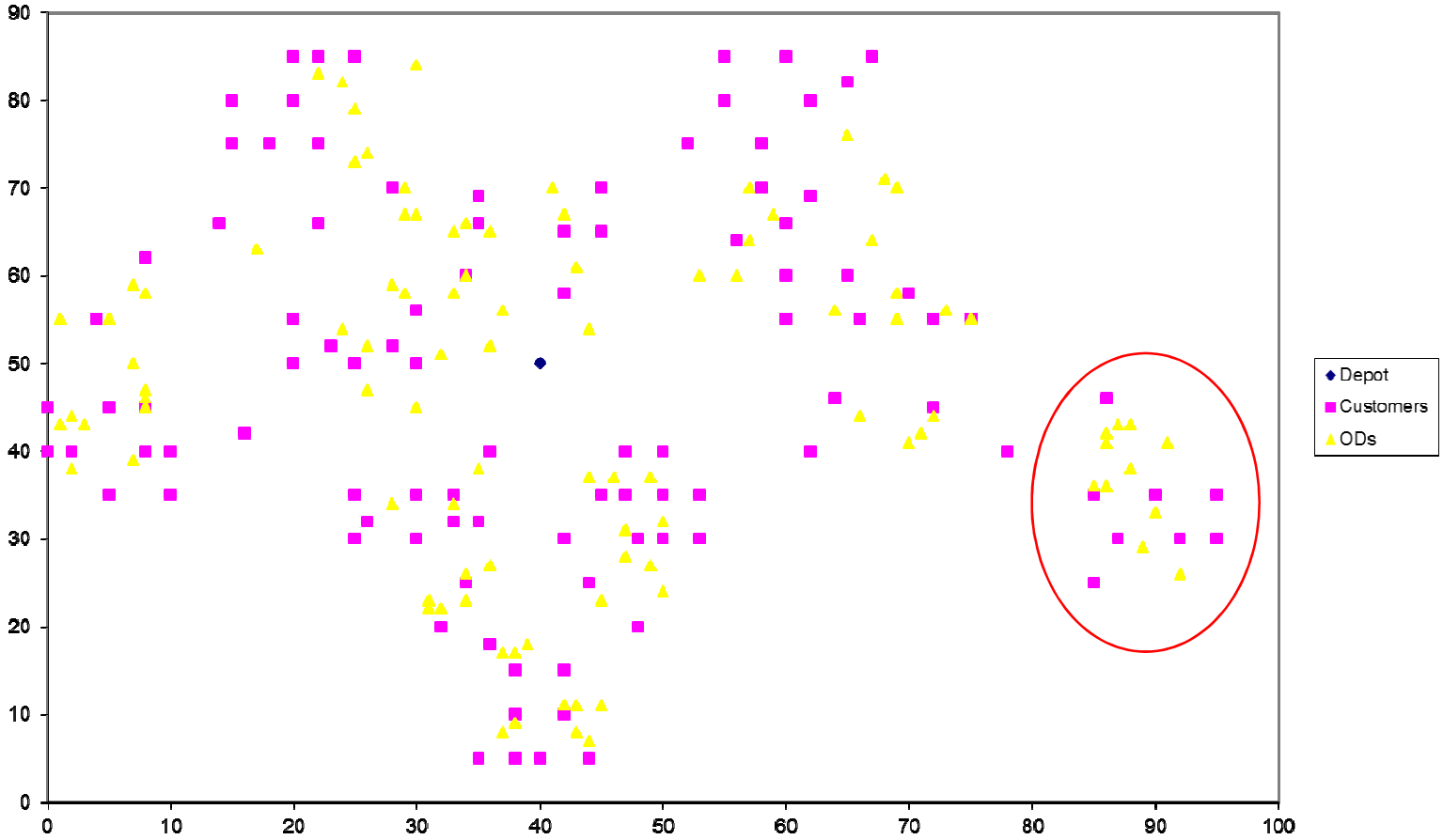
Computational study

MAIN GOAL

Gain initial quantitative insights in the potential benefits of crowdshipping for last-mile delivery

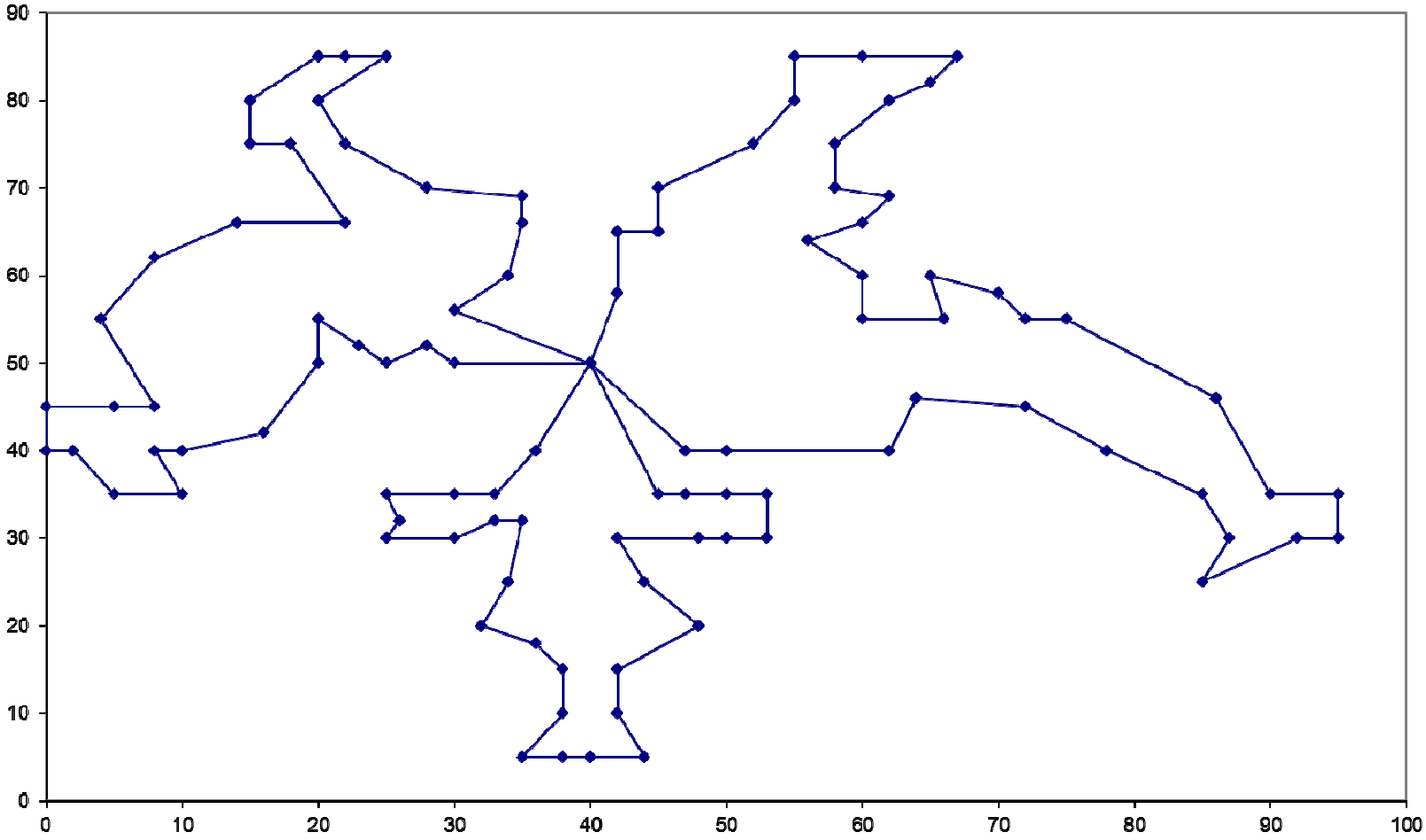
Analysis of a specific instance

Instance C201 with $|K| = 100$



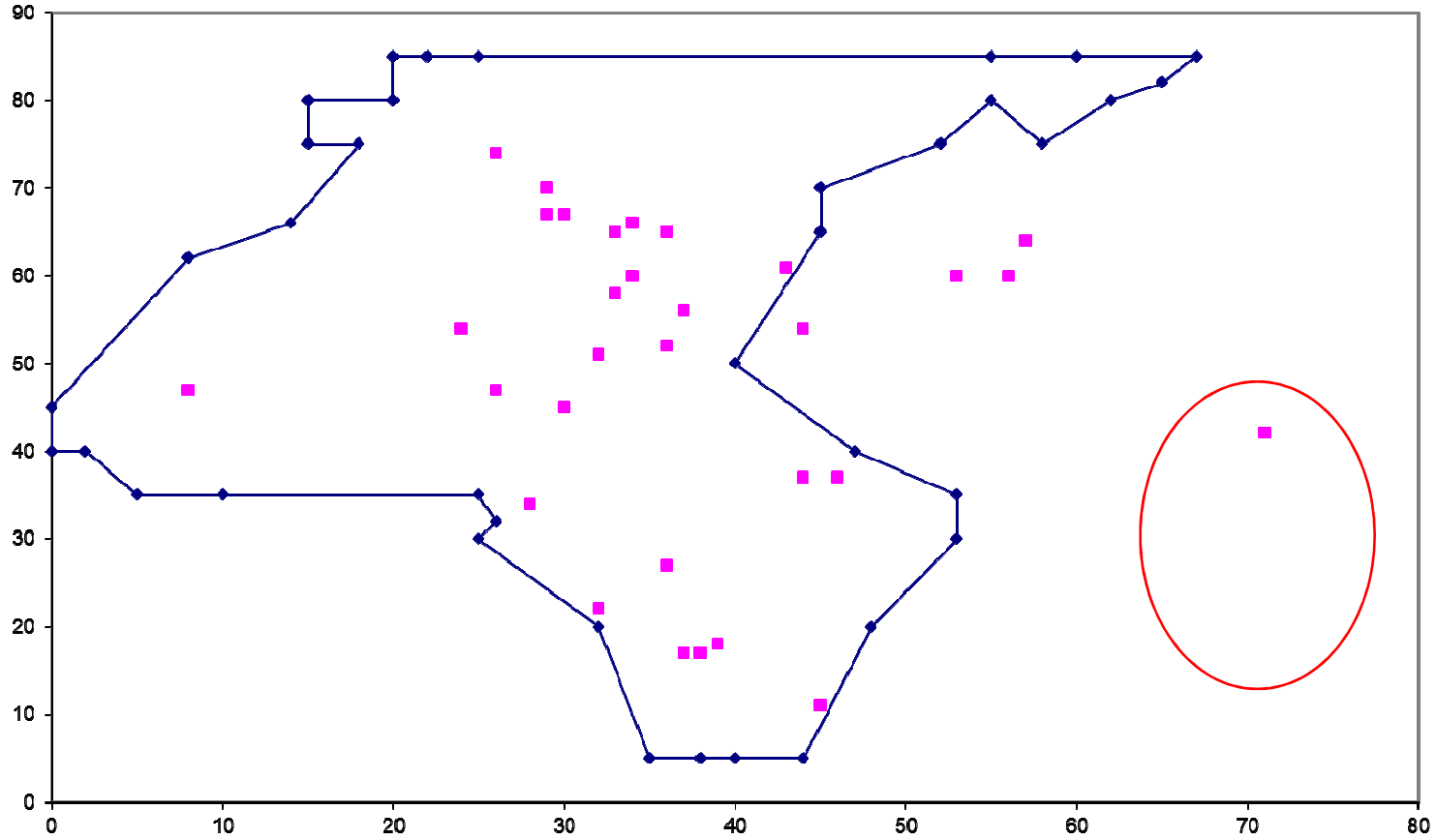
Analysis of a specific instance

VRP solution



Analysis of a specific instance

Routes and destinations of ODs not used



Results over all instances

	% cost reduction w.r.t VRP	% routes reduction w.r.t. VRP	% OD used	% OD cost w.r.t. total cost
1° comp. scheme	31.21	56.83	75.22	30.17
2° comp. scheme	33.72	56.47	70.75	20.54

More realistic setting

Customer orders arrives online, while the delivery is taking place

HOW TO FACE THIS?

The (online) vehicle routing problem with occasional drivers (O-VRPOD)

Archetti, Guerriero, Macrina, The Online Vehicle Routing Problem with Occasional Drivers, submitted

Same seeting as before with the exception that

- Each OD can serve more than one customer
- TWs are associated with both Ods and customers
- Customer order arrives online!

What can you do?

Simple insertion heuristic

vs.

Insertion + route reoptimization

Gainings of route reoptimization

# customers	Max gaining
25	4.93%
50	4.67%
100	11.82%
200	10.85%

! High benefits from route reoptimization

Remarks

- Crowdshipping might help in facing the challenges related to reduced delivery times in last-mile delivery
- Substantial cost savings
- Great business opportunity

WHAT IS THE RIGHT COMPENSATION FOR ODs?

ATTENDED HOME DELIVERIES

Background

Still the most widely diffused delivery option

Challenges

Most people would like to be served in the same time slot (typically after work)

→ High peak of requests

→ Unbalanced workload

What to do?

Challenges

One possibility could be to offer wide time windows slots:

- Customers are required to stay at home waiting for their parcel for long
- This increases the probability of failed delivery

→ Not a good option

So…

Improve the management of short time windows slots!

- Time windows management
- Pricing

Time windows management

Possible strategies:

- Restrict the set of time window slots offered to customers
- Assign the time slot to each customer (no choice for the customer)
- Customers clustering

Pricing

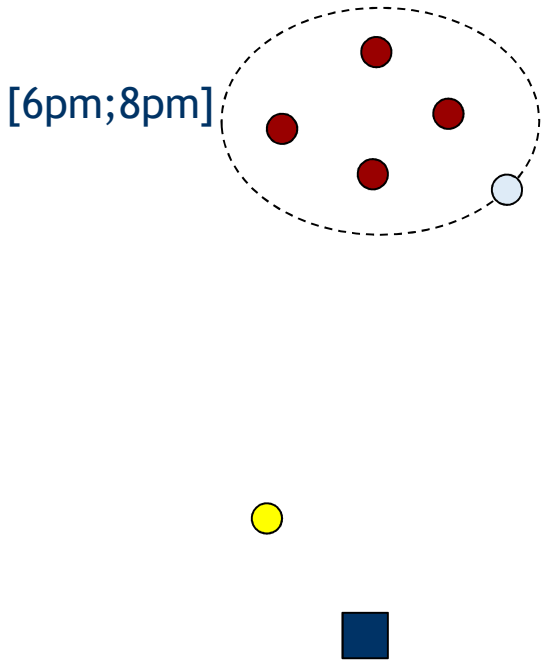
What if the previous strategies does not work?

PROVIDE INCENTIVES TO CHOOSE THE RIGHT TW!

EXTREMELY FASCINATING AND CHALLENGING TOPIC

Dynamic pricing

The main idea is to link the price of delivery to customer to the opportunity cost



Dynamic pricing

- The literature is growing
- How to determine the opportunity cost?
- Modeling customer behavior (behavioral OR)
- Extremely challenging and completely innovative topic

CONCLUSIONS

- The explosion of e-commerce gives rise to enormous challenges and provides a fertile and promising ground for excellent research
- Great opportunity for exploring fascinating new routing problems
- Ad-hoc solution techniques needed

ESSEC BUSINESS SCHOOL

THANK YOU FOR YOUR ATTENTION