Evaluating the Benefit of Mixed Fleet using Agent-based Modelling and Simulation

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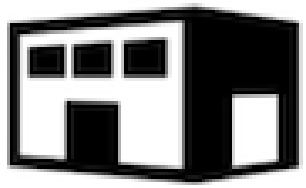
Motivation and Objectives

- Last-mile delivery operations are complex, and using a single mode of delivery (e.g. van) is not necessarily an efficient strategy (Nguyên et.al 2019).
- Bike is promising because it can take shortcut and produce almost no emission.
- The objective of this project is to determine the most optimal mixed fleet setup which is able to deliver & pick-up parcels in a given city at the lowest possible cost.
- To achieve this goal we must be able to:
  - Determine the cost and efficiency impact of incorporating multiple delivery modes, e.g bikes, in inner city delivery operations
  - Identify the ideal combination of bikes and vans which has the minimum operating cost per package and stop, without negatively impacting efficiency
  - Determine the reduction in emission and congestions, by switching to EVs and bikes from the current fleet

Nguyên, Thu Ba T., et al. "Optimising parcel deliveries in London using dual-mode routing." *Journal of the Operational Research Society* 70.6 (2019): 998-1010.

The Case Study

Main distribution centre



Small parcel; closer to main distribution centre

City centre area

Closer to consolidation hub but; big parcel

Consolidation hubs

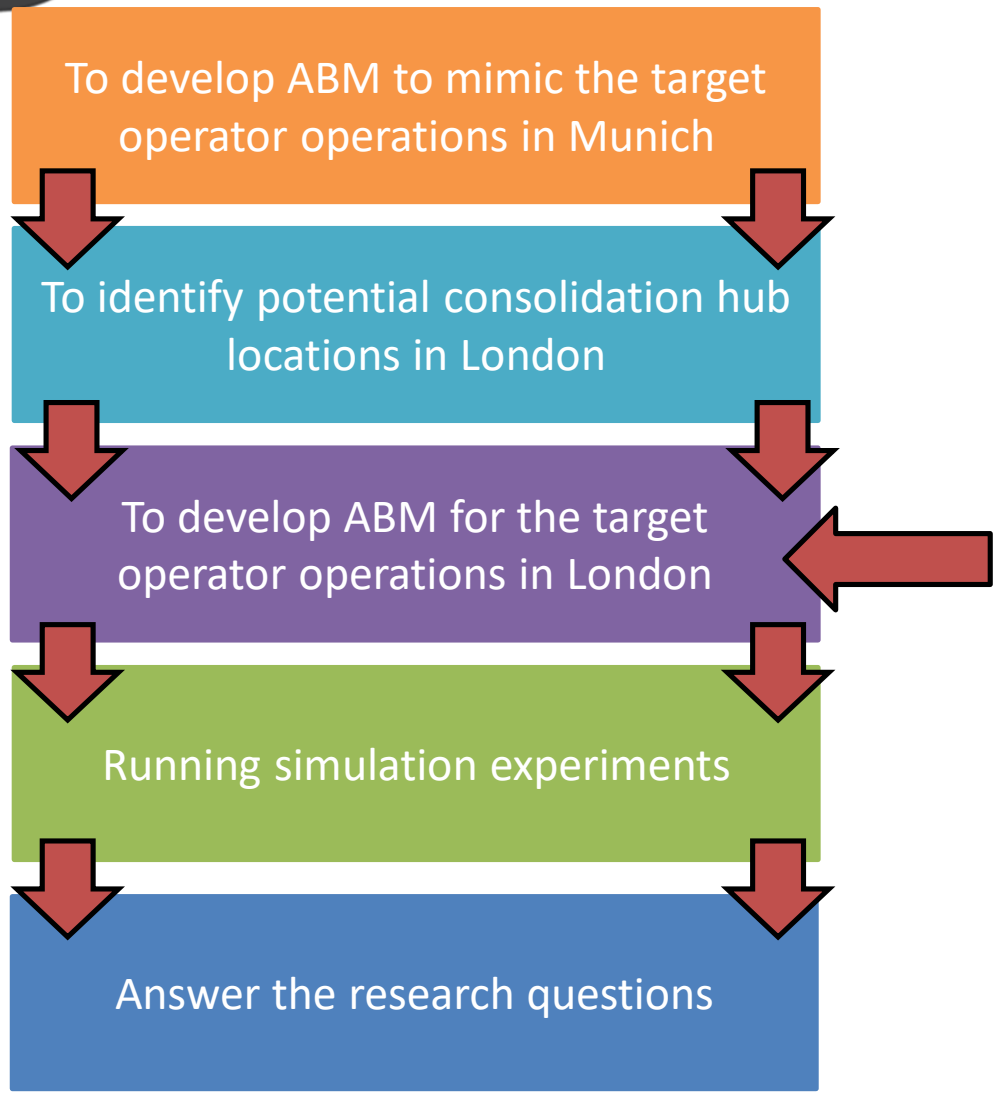
Closer to consolidation hub & small parcel

Target operator is a real world parcel company

Munich operation
Bike & Van

London Operation:
Only van

Methodology (1)



progress up to this point

Methodology (2)

To develop ABM to mimic the target operator operations in Munich

To identify potential consolidation hub locations in London

To develop ABM for the target operator operations in London

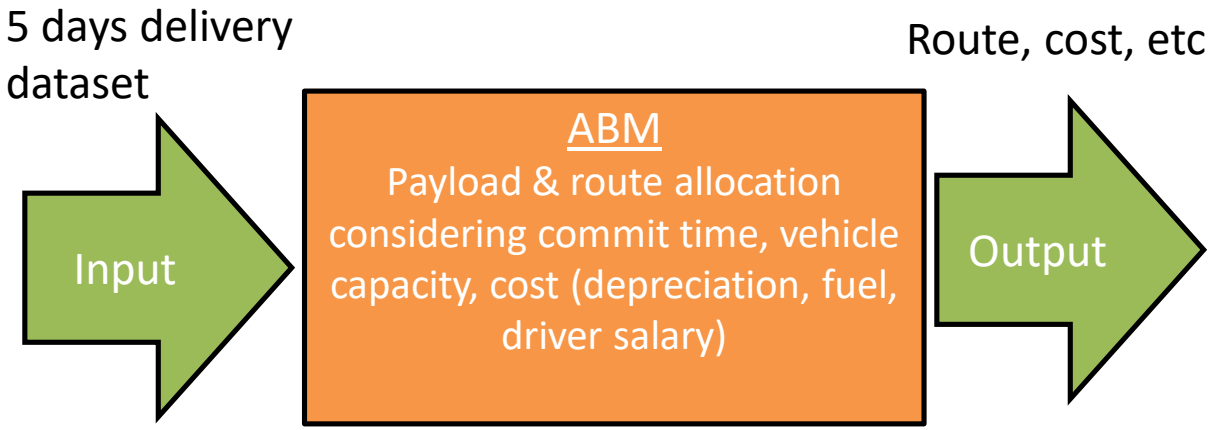
Running simulation experiments

Answer the research questions

The aim is to examine whether the mechanisms proposed in the ABM are representative is for the target operator's operation. (To validate the ABM)

Analyse 5 days dataset from Munich operation

- Geographical distribution of the distribution centres, consolidation hub, and the customers
- The quantity and size of the parcels
- The frequency of delivery
- The characteristics & cost structure of each vehicle



Methodology (3)

To develop ABM to mimic the target operator operations in Munich

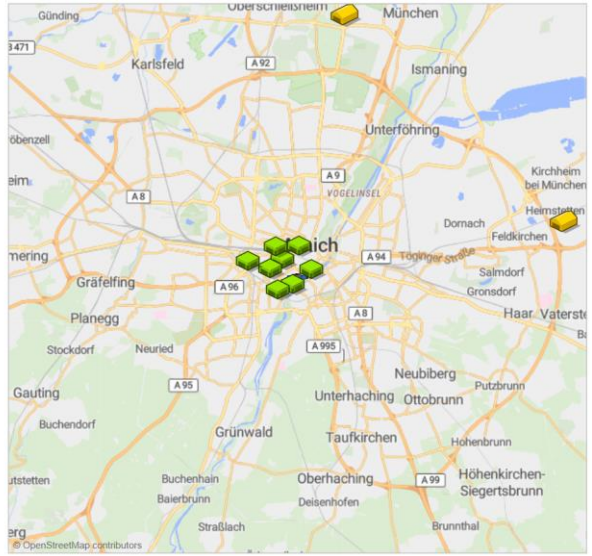
To identify potential consolidation hub locations in London

To develop ABM for the target operator operations in London

Running simulation experiments

Answer the research questions

Screen Capture of the Munich ABM



Validation: not significantly different from reality and slightly cheaper

Parameter	Real	Simulated
Total operational cost per day	48,879 € / day	48,181 € / day
Average cost per route	398 € / route	358 € / route
Average number of van used	113 vans / day	113 vans/day
Average number of bike used	20 bikes / day	21 bikes / day

Suitable to describe the impacts of future scenarios

Methodology (4)

To develop ABM to mimic the target operator operations in Munich

To identify potential consolidation hub locations in London

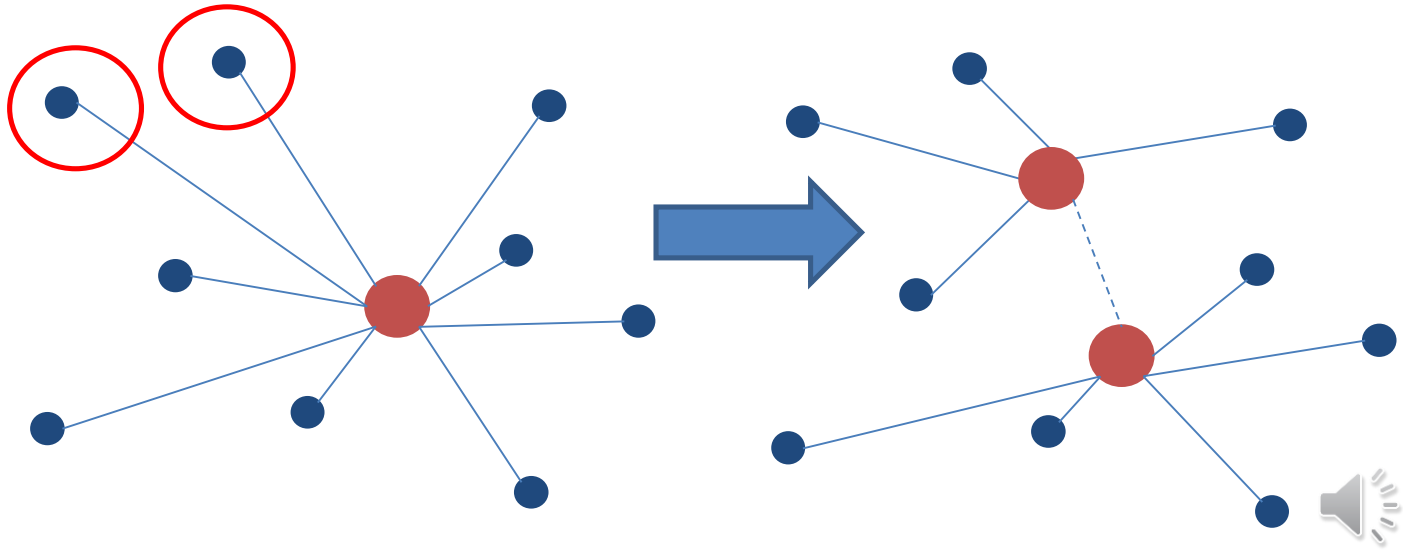
To develop ABM for the target operator operations in London

Running simulation experiments

Answer the research questions

Central of Gravity Approach:

1. Identify customers' location in London.
2. Filter out customers whose parcels are too big / heavy for bike delivery.
3. Calculate the centre of gravity (CoG) of all customers, using the delivery frequency as a weight.
4. Check whether all customers are within 5 km away from the CoG
5. If not, add a new CoG and repeat step 3 & 4



Methodology (5)

To develop ABM to mimic the target operator operations in Munich

To identify potential consolidation hub locations in London

To develop ABM for the target operator operations in London

Running simulation experiments

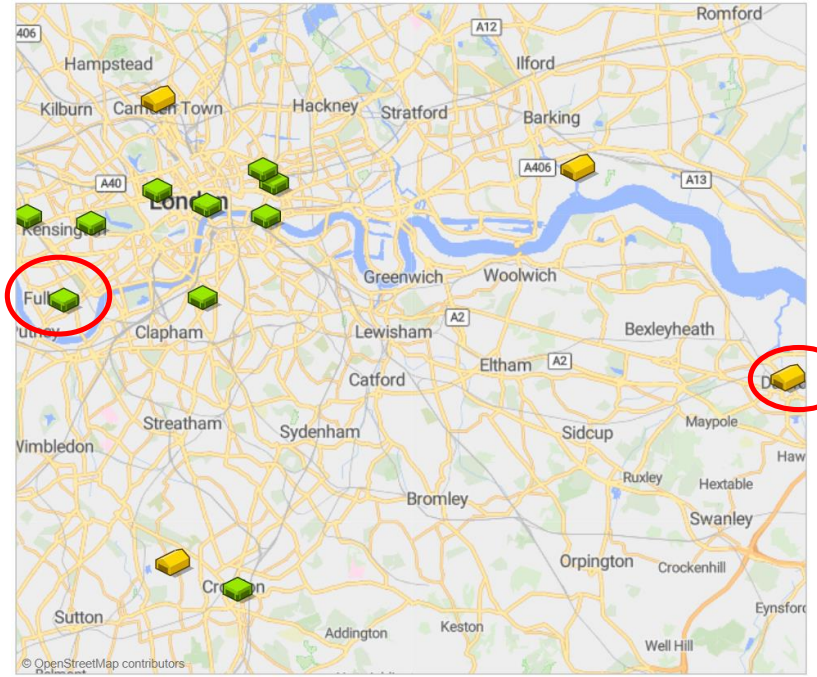
Answer the research questions

Results:

- 238 potential consolidation hub locations in London
- Filter 46 locations that can serve 80% of the delivery
- Filter 17 locations that can serve 60% of the delivery

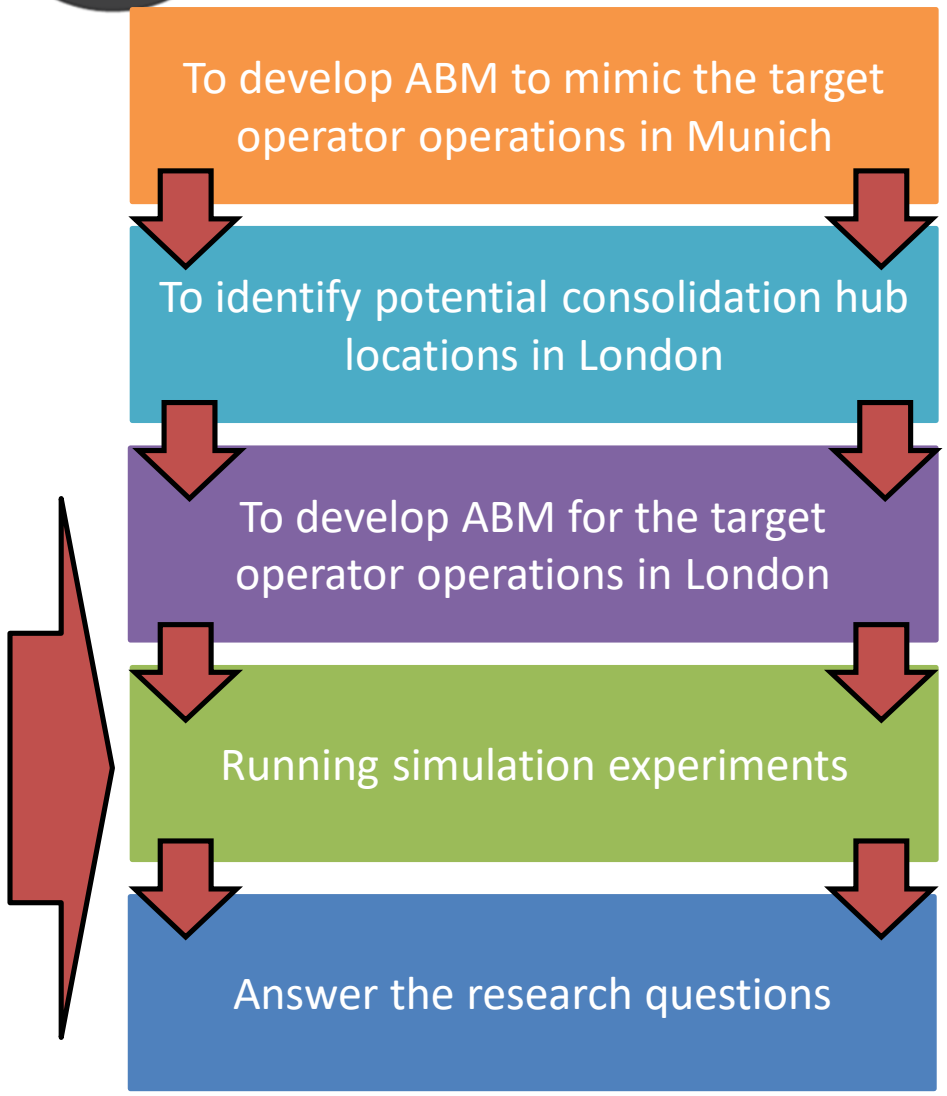
Visualisation of the proposed location that have been validated by the experts

Potential consolidation hub location



Distribution centre location

Methodology (6)



We are, currently implementing the algorithm for London case study

Proposed scenarios in the computer experiment

# Cond Hubs	# Vans	# Bikes	Yearly Cost (£)	Total Emission
none	100	0	xxxx	Xxxx
1	100	3	xxxx	Xxxx
2	95	6	xxxx	Xxxx
…	…	…	…	…

Involve historic and synthetic delivery data

Running the experiment requires us to:

- Access high performance computer
- Develop our own modelling platform

Conclusions & Further Research

- We have proposed ABM of two tiers parcel delivery system by combining vans and bikes
- We have validated the base model using historical data.
- Future Research
  - Propose how to operate mixed fleet in London
  - Running computer experiment on a high performance computer
  - Develop our own modelling platform
  - We expect to finish this project by the end of this year

Thank You

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