Strategic Redesign of Urban Mail and Parcel Networks at La Poste

Group 4

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INTRODUCTION

- For postal operators delivery network becomes very important while delivering different items ranging from small envelopes to large packages.
- Delivery network effects both the cost and quality.
- Some prefer running single network for a broad range of items, others prefer to operate separate networks for mail and parcel delivery.
- Design of urban delivery network becomes strategically important as mail volume declines and small-parcel volume increases due to new technologies.
- Because of this number of mail La Poste handled decreased 14.5 Million to 13.7 Million. But package shipping activities has increased.

- Network that is going to be created must be robust with respect to possible shifts in item-size distribution.
- Also network should offer delivery-speed flexibility especially for larger cities.
- To sum up the goal is to develop cost-saving opportunities and prepare the organization for changes in mail and parcel delivery.
- While doing this one crucial aspect is the potential either partial or full merger of the urban and parcel delivery networks

PROBLEM DEFINITION

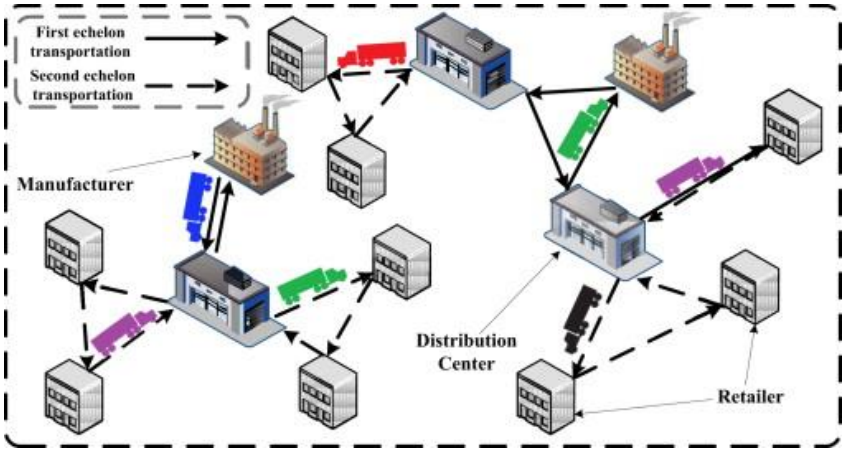
- On a abstract level urban-delivery network design can be categorized as a type of location-routing problem.
- A solution to the urban delivery and routing problem must address the same strategic dimensions in terms of number, type and location of facilities.
- It must also address the same operational dimension with respect to the deployment of different vehicle classes and their optimal routing based on the estimate of the demand of mail and parcel.
- Model must be sufficiently flexible to accommodate the existing infrastructure, such as intermediate depots for mail delivery.

- City’s geography had to be detailed to be sure that it will be useful for decision making
- However a medium sized city might exceed typical instances for heuristics developed in the context of location and routing problem.
- Thus a key requirement was to provide an useful approximation to the routing subproblem.
- The model’s scalability had to be such that one could be able to evaluate bigger cities.

MODEL

- Model will be consist of two echelons, with primary consolidation at CDC and secondary consolidation at ID.
- Model will select either pure single-echelon or two-echelon network structure or a hybrid structure.
- Location routing problem for two echelon created at first works for only small instances. Therefore it is decided to replace vehicle routing by approximating the routing cost. This modification allows to solve large instances.
- It is assumed that points of demand are uniformly distributed over the city.
- For different types of vehicles, different factors are incurred while computing travelling time.

- In addition to that two key extensions had to be implemented for the two network structures that initially coexisted because the mail network often consisted of one CDC and number of IDs whereas parcel distribution consisted of two CDCs only.
- For this particular case model should allow more than one CDC and hybrid structure.
- To satisfy these conditions additions were made into the model.



Objective Function and Constraints

$$\min_{S_{cdij}^{2\text{-E}},S_{cij}^{1\text{-E}},X_c^{\text{CDC}},X_d^{\text{DEP}}} \Bigg\{ \sum_{c\in\mathbf{L}^{\text{CDC}}} \sum_{i\in\mathbf{W}} \sum_{j\in\mathbf{V}} \Bigg(\sum_{d\in\mathbf{L}^{\text{DEP}}} S_{cdij}^{2\text{-E}} \left(K_{dij}^{2\text{-E-E1}} + K_{dij}^{\text{space}}\right) + S_{cij}^{1\text{-E}} \left(K_{cij}^{1\text{-E}} + K_{cij}^{\text{space}}\right) \Bigg) + K^{\text{hand}} + K^{\text{fac}} + \sum_{c\in\mathbf{L}^{\text{CDC}}} \sum_{d\in\mathbf{L}^{\text{DEP}}} K_{cdj}^{2\text{-E-E2}}|_{j=j^{E2}} \Bigg\} \tag{1}$$

subject to

$$\sum_{c\in\mathbf{L}^{\text{CDC}}} \sum_{j\in\mathbf{V}} \Bigg(\sum_{d\in\mathbf{L}^{\text{DEP}}} S_{cdij}^{2\text{-E}} + S_{cij}^{1\text{-E}} \Bigg) = 1 \qquad \forall i \in \mathbf{W}, \tag{2}$$

$$\sum_{c\in\mathbf{L}^{\text{CDC}}} \sum_{j\in\mathbf{V}} S_{cdij}^{2\text{-E}} \leq X_d^{\text{DEP}} \qquad \forall d \in \mathbf{L}^{\text{DEP}}, i \in \mathbf{W}, \tag{3}$$

$$\sum_{j\in\mathbf{V}} S_{cij}^{\text{1-E}} \le X_c^{\text{CDC}} \qquad \forall c \in \mathbf{L}^{\text{CDC}}, i \in \mathbf{W}, \tag{4}$$

$$\sum_{j\in\mathbf{V}} S_{cdij}^{\text{2-E}} \le X_c^{\text{CDC}} \qquad \forall c \in \mathbf{L}^{\text{CDC}}, d \in \mathbf{L}^{\text{DEP}}, i \in \mathbf{W}, \tag{5}$$

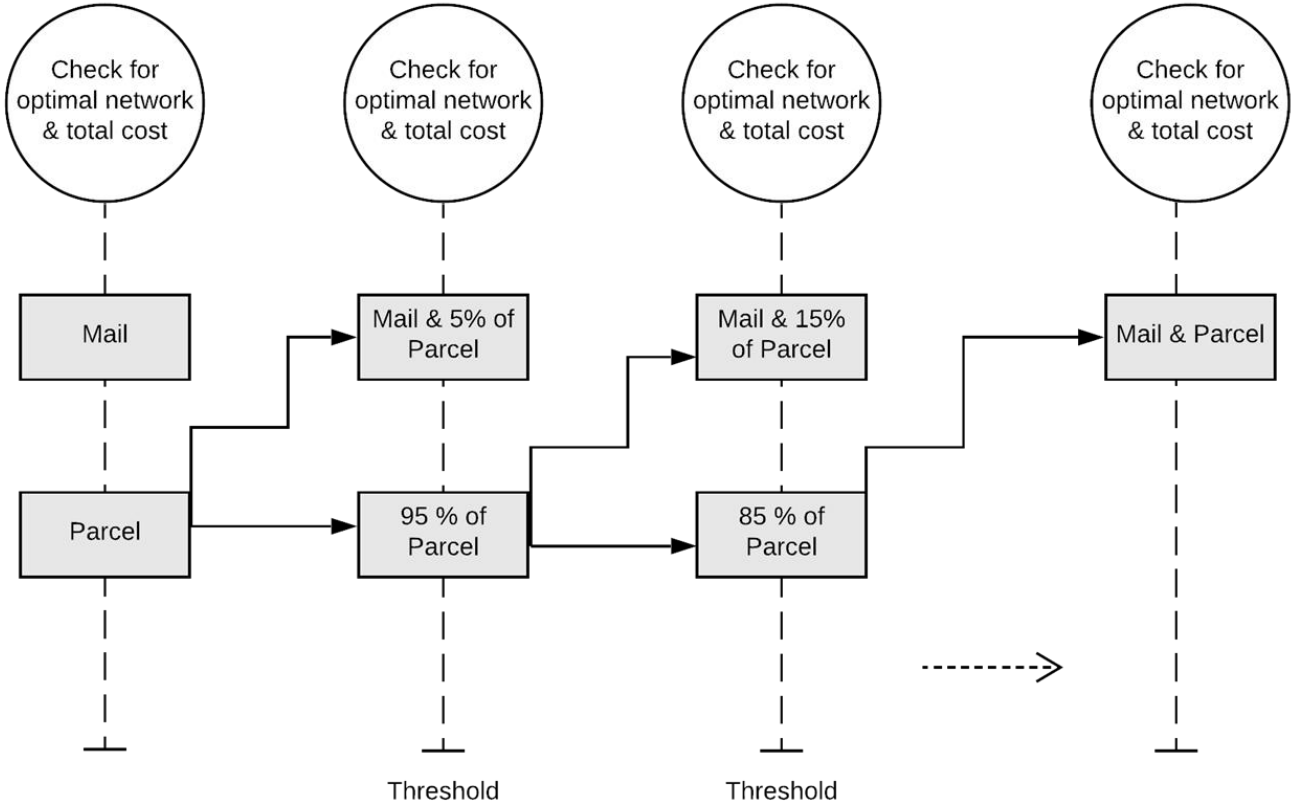
$$\sum_{i\in\mathbf{W}} \sum_{j\in\mathbf{V}} \left(\sum_{c\in\mathbf{L}^{\text{CDC}}} S_{cdij}^{\text{2-E}} \right) \zeta_j^{\text{space}} \left(\sum_{k^{\text{D}}\in\mathbf{K}_i^{\text{D}}} \sum_{k^{\text{P}}\in\mathbf{K}_i^{\text{P}}} \Pr\left(\Delta_i^{\text{D}} = \hat{\Delta}_{k^{\text{D}}}\right) \Pr\left(\Delta_i^{\text{P}} = \hat{\Delta}_{k^{\text{P}}}\right) q_{dijk^{\text{D}}k^{\text{P}}}^{\text{veh}} \right) \le \bar{\zeta}_d X_d^{\text{DEP}} \quad \forall d \in \mathbf{L}^{\text{DEP}}, \tag{6}$$

$$\sum_i \sum_j S_{cij}^{\text{1-E}} \zeta_j^{\text{space}} \left(\sum_{k^{\text{D}}\in\mathbf{K}_i^{\text{D}}} \sum_{k^{\text{P}}\in\mathbf{K}_i^{\text{P}}} \Pr\left(\Delta_i^{\text{D}} = \hat{\Delta}_{k^{\text{D}}}\right) \Pr\left(\Delta_i^{\text{P}} = \hat{\Delta}_{k^{\text{P}}}\right) q_{cijk^{\text{D}}k^{\text{P}}}^{\text{veh}} \right) + \zeta_j^{\text{space}}|_{j=j^{\text{E2}}} \sum_d q_{cd}^{\text{2-E-E2}} \le \bar{\zeta}_c X_c^{\text{CDC}} \qquad \forall c \in \mathbf{L}^{\text{CDC}}, \tag{7}$$

$$X_d^{\text{DEP}}, X_c^{\text{CDC}}, S_{cdij}^{\text{2-E}}, S_{cij}^{\text{1-E}} \in \{0, 1\} \qquad \forall c \in \mathbf{L}^{\text{CDC}}, d \in \mathbf{L}^{\text{DEP}}, i \in \mathbf{W}, j \in \mathbf{V}, \tag{8}$$

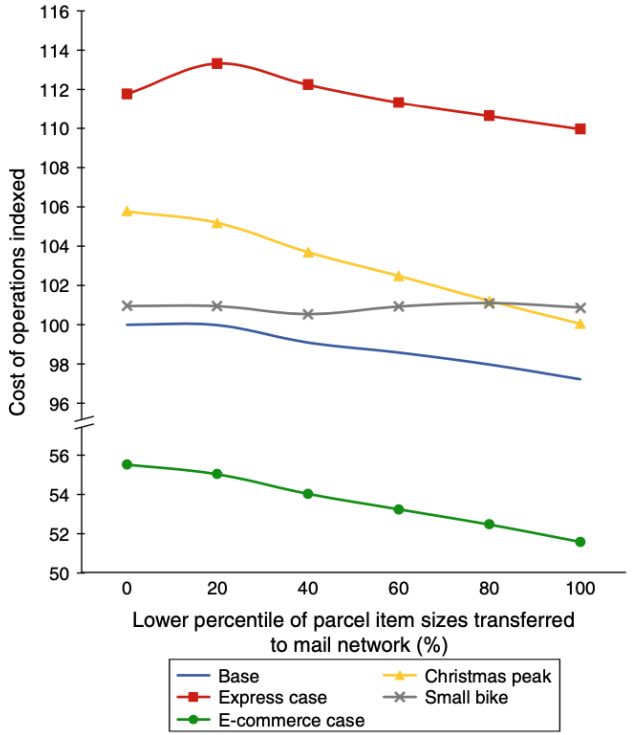
MODEL RESULTS

- The model was basically used to determine the potential cost advantages of merging La Poste’s previously separate distribution networks of mail and parcel delivery.
- Initially, the optimal network structures (and also total costs) have been determined for mail and parcel delivery separately.
- Starting with the smallest parcels, items from parcel network were gradually merged with mail network.
- For given thresholds, total costs were recomputed.
- The merging operation continued until all parcels were merged into mail delivery network.
- By this methodology, optimal level of network consolidation was detected.


Check for optimal network & total cost
Check for optimal network & total cost
Check for optimal network & total cost
Check for optimal network & total cost
Mail
Mail & 5% of Parcel
Mail & 15% of Parcel
Mail & Parcel
Parcel
95 % of Parcel
85 % of Parcel
Threshold
Threshold

MODEL RESULTS

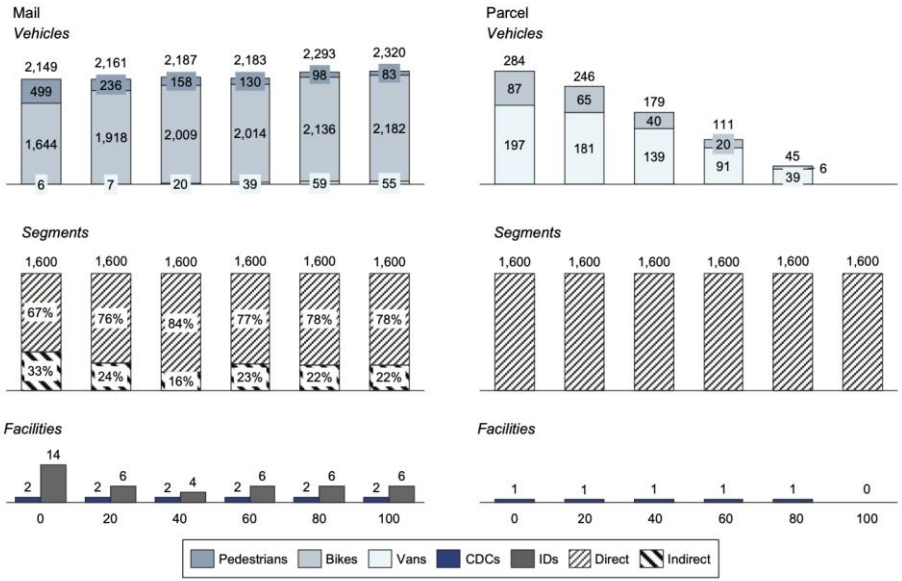
- Scenario analysis was used to take internal and external effects into account while determining optimal level of parcel volume transferred.
- Five cases were considered:
  - The base case
  - Growth of e-commerce
  - Christmas peak
  - Shorter delivery time windows
  - Small cargo bikes
- Maximum cost savings range across scenarios (btw. 3% and 7%).



MODEL RESULTS

The Base Case

- For the base case, cost-optimal solution was found for a complete merger of parcel volumes into mail network.
- Total operating cost decreased by 3%.
- Initially (without merger), 2 CDCs and 14 IDs only for mail delivery.
- When the parcel volume is completely merged, 2 CDCs and 6 IDs are enough for both mail and parcel.
- Prior to merging, there was a total need of 203 vans (mostly for parcel delivery). The number was decreased to 55 with merger.



MODEL RESULTS

The Base Case

Shades:
light: pedestrian
medium: bikes
dark: vans
circles: IDs
triangles: CDCs

The case of two separated networks.
14 IDs and 2 CDCs.
High usage of pedestrian for mail, van for parcel.

One fully merged network.
6 IDs and 2 CDCs.
Less usage of pedestrian and van for both. Usage of bikes increased.

MODEL RESULTS

Growth of E-Commerce

- It is expected that for the upcoming years, parcel delivery will increase and mail delivery will decrease dramatically.
- Experts assumption is that mail delivery will decrease approximately 50% and parcel delivery will increase to 15,500 items at 10,500 stops.
- These assumptions lead to a 7% cost savings in our merged model.
- Interesting fact is since merged network uses both CDC’C and ID’s, number of ID used has decreased. (Differs from the base case.)

MODEL RESULTS

The Christmas Peak

- One of the “must” feature of a network is the ability to handle the demand fluctuations.
- After the simulation of the Christmas period, it is observed that (relying on the assumption) parcel delivery will increase to 28,000 items at 18,000 stops.
- Cost saving is 5%.
- Comparing to the base case, the only thing differs is the number of cars required in the specific type of a fleet. (vans)

MODEL RESULTS

Shorter Delivery Time Windows

- This case is prepared to be able to answer the need of a faster delivery time windows (normally: 4 hours, our model checks: 2 hours)
- Interesting fact is that, after merging only 20% of mail delivery to the hybrid model, cost increased too much.
- As a result, it is understood that increase of the cost in the mail network is more significant than the cost savings in the parcel network.
- From this simulation, it is also understood that the fleet type “van” is the most important vehicle for both mail and parcel delivery.

MODEL RESULTS

Small Cargo Bikes

- Main aim is to check whether the carbon emission is decreased or not by changing the bike liters from 600 liters to 160 liters.
- Results show that changing bike volumes has a bad impact on the cost since the savings earned from the merger disappeared.
- Another important thing is, as the volume decreases in mail delivery bikes comparing to the base case, the number of vans used in the merged network increased, so does the carbon emission.

LIMITATIONS OF THE MODEL

- In the model, the primary concern is to minimize the cost by merging the networks.
- In the future, there might be additional concerns such as the reduction of carbon footprints of the vehicles.
- For different cases, it is observed that the usage of vehicles is decreased, hence, indirectly, the carbon emission of the vehicles is also decreased.
- La Poste might face such a situation that requires them to implement another constraint or change the objective function, which would be difficult to change.

SUGGESTIONS

- Time limit factor
  - *“The La Poste Network has the largest distribution network in France, with more than 17,000 public outlets. It currently allows 97% of the population to travel fewer than five kilometres, or 20 minutes by car, to access La Poste offerings.” (La Poste, 2013)*
- Adding Pick-up points for parcel delivery
  - Additional stations or/and IDs where customer can take their delivery themselves
  - Providing pick-up as an option to the customer beforehand and utilizing this information would prevent de-tours or extra usage of storage space
  - Also it would increase the flexibility while decreasing the carbon emission

- Merging Pick-up network
  - A subsidiary company of La Poste, that provides pick-up and delivery lockers services has its own network that includes more than 10000 points in France. *(Pickup,2020)*
  - For the given problem, merging pick-up network to the existing one, can be an option for improvement.

STUDIES IN TURKEY

- Release Time Scheduling and Hub Location for Next-Day Delivery (Yaman, Hande, et al., 2012)
  - Selecting p centers and allocating demands to hubs
  - Deciding on release time of trucks from each hub
  - Keeping total delivery in a time frame above a certain threshold
- Route Optimization for the Distribution Network of a Confectionary Chain (Inanlı, Anıl, et al.,2014)
  - VRP
  - Heterogeneous fleet
  - Soft and Hard time constraints
- Network Redesign in Turkey: The Supply, Production, and Distribution of Malt and Beer (Köksalan,Murat et al., 2013)
  - MILP
  - Heterogenous fleet
  - Decides location of new facilites for beer and malt production, distribution assignment

CONCLUSION

- Model will provide cost savings of approximately 3 percent when management of La poste decides to merge mail and parcel delivery completely.
- However, verifying the savings that the model predicted is complicated because implementing the merger will take about six months.
- It is decided that fleet of bikes should be used instead of vans because of the traffic and regulations in bigger cities.
- Routes with the larger parcels are now scheduled in the late afternoon to increase the probability of being able to deliver the parcels.
- All the results from different cases show the robustness of the merged mail and parcel delivery in cities.

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