First-mile logistics parcel pickup under disruption

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Mots-clés : *First-mile logistics, disruption, vehicle routing, packing*

1 Introduction

Customers like to shop online and receive their products quickly, and companies and researchers have devoted enormous efforts to developing ever faster and more efficient delivery procedures. However, it is becoming increasingly clear that, by comparison, first-mile pickup, the movement of goods from retailers to a warehouse or distribution center, remains inefficient.

First-mile logistics does not simply mirror the characteristics and strategies of last-mile delivery. On the one hand, retailers are often more geographically disperse than end-customers and delivery strategies and modes developed in last-mile delivery city logistics cannot be applied. On the other hand, retailers may send simultaneously many boxes of different sizes for different customers, and packing constraints, going far beyond simple capacity constraints, must be taken into account.

In first-mile problems, different types of changes can arise in the original data during the course of the routes. We will call each of the data modifications a *disruption*. The pickup process is subject to different disruptions than those arising in last-mile delivery and can react in a very different way. As vehicles are initially empty and progressively filled up, they are more prepared to accommodate new requests or changes to previous requests. It often happens that the exact number and dimensions of the boxes are only known when the vehicle arrives at the retailer.

In this research published in [1], we provide a tool that allows planning the first-mile collection of parcels by a courier or other type of logistics provider, taking into account the uncertainty caused by disruptions and changes.

2 Static problem

In its basic static version, the first-mile pickup problem can be viewed as a vehicle routing problem with packing constraints. Goods produced by a set of retailers must be picked up by a fleet of vehicles of different types and transported to a depot. The location of retailers, their time windows, and the distances between them define a routing problem. The dimensions and weights of the boxes to be picked up and the characteristics of the vehicles define a three-dimensional packing problem, including capacity, stability, and axle weight constraints.

To solve this static problem, we have developed a two-phase algorithm. In the first phase, we resort to a genetic algorithm, based on the Multi-Parent Biased Random-Key Genetic Algorithm with Implicit Path-Relinking (MP-BRKGA-IPR) proposed in [2], which uses as decoder a packing algorithm adapted from [3]. This first phase focuses on minimizing the number of vehicles required. In a second phase, a local search algorithm improves the solution of the first phase in terms of the total distance traveled. Based on computational experiments, this method is able to efficiently solve the static version of the problem, producing competitive results compared to existing procedures for closely related problems.

3 Disruption management

The continuous flow of information and changing roads and even vehicle conditions produce disruptions in the initial data of the problem being solved. Logistics companies can take advantage of the new information arriving when the vehicles are already traveling along the initially established routes and modify them, considering the new information as clear and certain.

Two types of disruptions are studied in this research. On the one hand, new retailer requests may arise and it has to be decided on the fly whether they can be met within the current schedule or not. On the other hand, a second type of disruptions may correspond to initially planned retailers, who can modify their requests, increasing, decreasing, or changing the number and dimensions of the boxes to be picked up. As we deal with a pickup process, changes and new retailer requests can be accommodated if vehicles have empty space left, if the routes can be rearranged to obtain the space required by the new requests, or if additional vehicles are used.

To manage these disruptions, we chose an approach in which the benefits of accepting new or modified requests and the costs of modifying the initial routes are considered. Alternatives concerning the number of vehicles are studied, as it is the common practice of logistics operators who consider the disruptions and balance the cost of changes to the solution and the benefits of accommodating new or modified requests. Using these procedures we have designed three strategies to generate post-disruption plans in terms of the maximum number of trucks that can be used once the routes are started :

— Strategy 1 : as many trucks as we need to cover all the new and modified requests.
— Strategy 2 : only the number of trucks initially planned.
— Strategy 3 : the number of trucks required by the solution of the original instance.

The results of the computational experiments run over benchmark instances extended to fit the dynamic case allow quantifying the impact of disruptions depending on the strategy used. They can help the logistics companies to define their own strategy, considering the characteristics of their customers and products, as well as the available fleet.

4 Conclusion

The results demonstrate the relevant role of disruptions in first-mile logistics and allow identifying cargo size and heterogeneity as determinant factors in obtaining good post-disruption plans. Additionally, fleet flexibility is shown to play a relevant role in responding to this kind of disruptions.

Références

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