A rich vehicle routing problem dealing with perishable food: a case study

Bibliographic data

This paper was published in 2012 by Springer and was written by Pedro Amorim, Sophie N. Parragh, Fabrício Sperandio and Bernardo Almada-Lobo. It goes by the name “A rich vehicle routing problem dealing with perishable food: a case study”.

Definitions and abbreviations

VRP – vehicle routing problem.

Food solution – service that provides a quick response to customers’ orders for a set of food products.

HF-SD-VRP-MTW – heterogeneous fleet site dependent vehicle routing problem with multiple time windows.

ALNS – adaptive large neighbourhood search.

Synthesis of the paper

In Portugal, farm-to-fork associated food industries are responsible for generating €10.6 billion in total sales value and €150 million in total services value, which accounts for 7.2% of the national gross domestic product. Half this amount comes from production and the other half from distribution activities. Distribution companies are usually faced with several typical problems, out of which the main focus for this paper was on the operational level: **Having to design the routes to serve customers previously assigned to that day based on their demand orders on a daily basis**.

The paper presents a successful application of operations research techniques in **guiding the decision-making process to achieve superior operational efficiency** in core activities. The focus is on a **heterogeneous fleet site dependent vehicle routing problem with multiple time windows, an extension of the original VRP**, which is a NP-hard problem, faced by a Portuguese food distribution company.

This company supplies a wide range of food solutions to a diversified spectrum of clients and, due to high seasonality, to reduce fixed and maintenance costs related to fleet management, contracted a pool of third-party logistics providers on the number of vehicles varying in size and compartments that must be available to the company within a 12-hour window.

The difference between the original VRP and this HF-SD-VRP-MTW resides in a few factors:

- **Fleet is not homogeneous**;
    - Considering the company distributes perishable food and the products must be stored at different temperatures, there are three categories of products – dry, cold and frozen.

Refrigerated trucks can carry all types of foods but are more expensive to operate, while dry trucks can only carry food that has a stable behaviour at an ambient temperature.
    - The trucks' size changes according to where they service a customer as different roads impose different size limitations.
- **There can be split deliveries** given the products to be delivered;
- **Routing for night customers may be done independently** since it requires the trucks to go back to the warehouse.

For a company such as this where distribution is the core activity, an **optimized daily routing yields a considerable impact since a mere reduction of 5% in the total distance travelled translates into 150 thousand fewer kilometers travelled each year**, which in turn could significantly impact many resources such as wear and tear on the vehicles, expenses on fuel and others.

The current way the company did things was not efficient considering:

- planned routes were almost fixed from day to day with only small adjustments being performed when the planner saw post-processing opportunities, which resulted in sub-optimal solutions;
- when the senior planner was not at work, the company plans suffered a considerable quality decrease;
- the planner has other functions in the company that were seriously jeopardized by the tremendous amount of time (4 hours per day on average) that he spent improving the generated plans;
- whenever there was a disruptive happening in the amount of clients to be dealt with, the planner required some weeks to adapt to the new situation and, meanwhile, the plans were not of the same quality.

Therefore, **the company intended to cut distribution costs**.

The authors performed an extensive review of existing literature on similar problems and they found that, although different parts of the problem were approached separately, there was never a study of a problem that actually considered all of these aspects simultaneously.

The needed solution would require a **flexible metaheuristic** able to **incorporate all the specifications** of the stated problem and **deliver results in short computation time**. The proposed algorithm was based on the **ALNS for service technician routing and scheduling problems**.

In order to reach the final solution, the following steps were taken: Using Google Maps to calculate travel times and distances and creating a C++ program that uses the Google Maps API to build the complete distance matrix. For this step, the authors used the actual addresses of each clients and adopted as preference prioritizing motorways over small streets. As for the remaining data such as vehicle costs, extra drivers, etc, it simply compiled as the distribution operation is fully outsourced and this information was easily obtained and objective.

The **implementation of the ALNS plans resulted in a significantly better routing which was able to consolidate more demand and deliver every product in a lower total**

distance. In terms of actual figures, the vehicle utilization increased from 75% to 89% enabling a decrease in the number of vehicles used and there was a considerable reduction of about 1,200 kilometres travelled every day. This reduction in kilometres travelled is particularly important considering that the variable vehicle costs amounted for most of the bill and that the increasing price of oil is directly linked to costs rising in new contracts. It was expected that, in peak season, the daily out-of-pocket savings could ascend to 1,200€.

It was possible to reduce the consolidated costs per vehicle by almost 20%.

The proposed solution **surpassed the human difficulties of managing solely by experience**. It **enforced every hard requirement to be met**, **allowed an adaption to changing market conditions** and increased customer satisfaction, which, consequently, affects customer loyalty. The reduction on kilometres travelled every day even has a potential to improve the relationship with third-party logistics providers and reduces the wear of the vehicles themselves. Besides, the developed tool as an **automatic decision support system provides a better starting point for the planner's adjustments** than the previously used method, reducing drastically the daily amount of time spent by this employee in this task.

Considering this tool can handle varied routing extensions, it should be **easy to extrapolate to other companies facing similar real-world problems**, starting with companies with similar business models.

Reflection

The problem dealt with in this paper appears to me to be a very common problem across the distribution industry, which is why I actually found it surprising that it had never been studied before to this depth in full, but only in smaller sub problems across many different papers. However, after careful reading and fully understanding all the difficulties involved, I find it more understandable why no one had tapped into this before. The problem was highly complex, with many relaxations in regard to the original VRP, which increased its difficulty even more.

Mathematically, the solution appears to be very well accomplished as it is fully adapted to the company's specifications by adding the relaxations to the original VRP.

This creates great potential for very personalised accurate results in a solution that can be easily extrapolated into other companies with similar business models. The data used to feed the C++ program that allowed to obtain the distance matrix, for example, corresponded to the actual addresses of each client.

Its efficacy was reinforced by the outstanding results achieved through its application. Not only was it possible to reduce the consolidated costs per vehicle by almost 20%, but there were also very positive spill over effects.

Although toilsome to implement and understand the first time, the proposed solution surpassed the human difficulties of managing solely by experience. It enforced every hard requirement to be met, allowed an adaption to changing market conditions and increased customer satisfaction, which, consequently, affects customer loyalty. The reduction on kilometres travelled every day even has a potential to improve the relationship with third-party logistics providers and reduces the wear of the vehicles themselves.

As I mentioned before, this seems to me a very common problem for distribution companies which is why I think this model could be extrapolated into different companies

and prove very useful. Besides, now that is has been developed, it should be easier to adapt to the different companies' constraints.

Maria Eduarda Santos Cunha
Up201506524
6.06.2019