Vehicle routing optimization for inbound transportation plan of factories in the automotive sector. A Renault case study.

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1 Introduction

Supplying the 38 factories of Renault with raw materials represents a major economic challenge. The contractualized transportation plan with third-party logistics providers must be defined by respecting operational or network constraints. The first step in defining the inbound transportation plan is to decide for each flow whether it will be direct or indirect, knowing its forecast demands. In the literature, this decision problem is called service network design [1] or network planning in the literature of cross-docking [2]. The following decisions consist in finding the routes when the determined volumes do not complete a full vehicle. These routes are composed of multiple loading points (suppliers) and one or more unloading points (factory docks). This problem is called the vehicle routing problem (VRP), extensively studied in the literature [3].

2 Problem description

The Renault inbound supply chain consists of supplying its factories with raw materials by several hundred of geographically dispersed suppliers. The high number of suppliers increases the complexity and cost of operating the inbound supply chain. Thus, a transportation plan must be tailored to the inbound logistic where supplies meet demands at the factories, while seeking to minimize the total logistic costs. The transportation plan is defined based on the forecast demand of factories, the geographic location of suppliers and factories and Renault's operational constraints. It includes tactical and operational decisions. The tactical decisions define the transportation network design for several upcoming weeks, i.e. the flows of supplies. There are two types of flows, (i) Direct and (ii) Indirect. The direct flow (Milk-run and mono-suppliers) is a route with one or more loading point to one or more unloading points. The indirect flow is a pick-up from several loading points, to a cross-dock, then from the cross-dock to one or more unloading points. Since the cross-dock is responsible in designing the routes for the indirect flows, we are only interested in direct flows. The operational decisions determine the routes for every supplier in direct flows, and their respective frequency, loading and unloading points, and arrival day at the factory. We call it Fiches Caractéristique Circuit (FCC). The process of defining the transportation plan ends with the contractualization of the FCC with transporters. This work aims to develop an optimization tool to decrease the transportation costs and to computerize the construction of the inbound transportation plan.

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3 Solution approach

The current process of defining Renault's upstream transportation plan is not optimal. It is done manually through the expertise of Renault Transport Planners (RTP). Hence, we propose a three-phase algorithm, called Clustering-First-Routing-Second-Scheduling-Third. In the clustering phase, we propose three graph-based algorithms, the minimum clique cover problem (MCCP), the minimum dominating set problem (MDSP), and the minimum weighted spanning tree (MWST) to partition suppliers into clusters. Based on these algorithms, different heuristics were developed to construct the clusters respecting two main constraints: the maximum distance inter-suppliers, and the maximum number of suppliers per cluster. In the routing phase, a mixed integer linear programming model (MIP) was developed to identify the type of flows. The objective function minimizes the total transportation cost that includes the variable transportation cost, the fixed cost per vehicle and stop, the cross-dock cost, and the direct cost for mono-suppliers, while respecting Renault's operational constraints. In the scheduling phase, a MIP was developed to assign routes to days of the week to minimize the maximum number of daily routes, while satisfying the constraint of smoothing routes over the week.

4 Computational experiments

We tested the efficiency of the proposed algorithm on several real-world use cases defined by Renault key users. The number of suppliers per use case varies between tens to hundreds of suppliers. At first, the computational experiments consisted in finding the best clustering algorithm and, then, in comparing the existing approach with our solution algorithm. For this, a process was defined to verify the cost of the tactical planning through the operational planning. The tactical planning defines the inbound transportation plan for a defined planning horizon. The operational planning algorithms maximize the loading of the defined vehicles in the tactical planning by grouping together to be consumed demands and bringing them forward to upfront vehicles, by respecting the allowable days that a demand can be delivered before its consumption day at the factory. The two solutions are compared through various KPIs.

5 Conclusion & Future work

A three-phase sequential algorithm was developed for the construction of Renault inbound transportation plan. Preliminary results show an improvement in the total transportation costs. For future work, an integrated approach can be developed and compared with the results of three-phase algorithm. Environmental aspects and inventory optimization can be considered directly while defining the transportation plan. To make the operational planning algorithms work better, the tactical planning should anticipate those algorithms, and especially to integrate the concept of DLO (Optimized Delivery Request) at the factory that allows a demand to be delivered before its consumption date. Finally, the computational experiments can be extended to other Renault factories to ensure the robustness of the proposed approaches.

Références

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