A mat-heuristic approach to solve the dynamic disassembly assembly routing problem with returns

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Introduction

Nowadays in most of the manufacturing companies, the production and the routing problems are solved consecutively where the managers of the two scheduling departments will solve their own optimization problems without being subordinated to the others constraints. Means that there is no coordination between these two main activities within the same supply chain. Since the 1970s the integration of transport into production has been taken into account more seriously [2]. The production routing problem (PRP) and the inventory routing problem (IRP) are among the integrated planning problems studied in the literature. The PRP aims to make production and direct-distribution plan to minimize the production and the inventory cost of products. However, the IRP aims to minimize the total inventory and routing costs by determining the timing and size of each delivery to its customers and the corresponding routes. However, the production quantities for each period are given in advance in the IRP.

In recent years, companies are interested in valuing returned products by setting up a reverse logistics system. Reverse logistics involves structuring the return of these products from the user to the company. This system took into account the case of the return end-of-life products (defective products) or products unwanted by customers for reuse, disassembly or recycling. Disassembly is a process of obtaining components and/or products that can be reused or recycled from defective or worn products. It is a methodical extraction of parts and materials of products discarded after one or more production operations.

In this work, we are interested in solving a dynamic disassembly assembly routing problem with returns (2D-ARP-R). In this problem a supply chain with an assembly disassembly center where converted a set of disassembled components and raw materials into final products to satisfy customer demand. Regrouping these problems makes it possible to synchronize different activities (assembly, disassembly, and transport) and to build a global solution over several periods. The aim is to minimize different costs such as the cost of manufacturing final products, using machines with limited capacity and respecting the constraints of production, storage, and satisfaction of demand. Here we consider a production system in which different types of components are needed to manufacture a final product and a single type of return product need to be disassembled. Components are picked up from suppliers and returned products from customers. The problem of picking is to define a tour for each vehicle to minimize transport costs, respecting the capacity constraint of vehicles. Despite the interrelationship of the different decisions, they have been considered independently. Therefore, considering these decisions together would be beneficial.

Two-phase mat-heuristic approach

A mat-heuristic inspired from [1] based on integer programming and metaheuristic is designed to solve the 2D-ARP-R. The proposed two-phase iterative mat-heuristic performs two main steps. The first step consists of solving the lot-sizing and reverse lot-sizing problems. The second step is used to improve the solution founded by the integer programming by applying a variable neighborhood search algorithm and solves the routing problem. We note that the first iteration of the mat-heuristic is equivalent to the decentralized scheduling problem.

Computational Experiments

To test the efficiency of the proposed mathematical formulation and the mat-heuristic approach we generate a set of instances based on the Chitsaz et al [3], to solve 20 instances with 14 nodes and 10 instances with 50 nodes. The new generated instances have 12 periods. A dynamic demand par period that is randomly generated by uniform distribution between 0.5 × D and 1.5 × D where D is the demand per period in [3] instances. A dynamic setup, purchase, inventory and production costs are randomly generated by uniform distribution ±30 % of the values obtained from [3] instances.

Instances	Integrated model				Decentralized model		
	MILP		Mat-heuristic		Benefit (%)		
	Avg.CPU (sec)	Avg.GAP (%)	Avg.CPU (sec)	Avg.DEV (%)	Min	Max	Avg
14 nodes	56.14	0.00	21.54	0.02	0.00	25.21	8.62
50 nodes	3600	16.14	689.54	-9.26	3.91	37.25	16.34

TAB. 1 – Results on the 2D-ARP-R instances

TAB.1 reports the numerical results of the 2D-ARP-R obtained by Cplex 12.8 for the MILP and the mat-heuristic approach, which is coded in Java with Eclipse Version: 4.9.0. As we see, the mat-heuristic found a 98% optimal solutions on instances with 14 nodes. On instances with 50 nodes, the mat-heuristic prove it efficiently by improving the solution of CPLEX within 1 hour with Dev= 9.26%. We can observe also that joint production and routing decisions result in 8.62% and 16.34% of average improvement on small and medium instances, respectively.

References

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