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A Hybrid Heuristic based on Iterated Local Search for Multivehicle Inventory Routing Problem

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Abstract

We study a multivehicle inventory routing problem (MIRP) in which supplier delivers one type of product along a finite planning horizon, using a homogeneous fleet of vehicles. The main objective is to minimize the total cost of storage and transportation. In order to solve MIRP, we propose an algorithm based on iterated local search (ILS) metaheuristic, using a variable neighborhood descent with random neighborhood ordering (RVND) in the local search phase. Moreover, we combined this algorithm with an exact procedure based on mathematical programming to solve specifically the inventory management as a subproblem. To validate our approach, computational tests were performed on 560 benchmark instances, achieving very competitive results in comparison to the best known algorithms.

Keywords: Multivehicle Inventory Routing Problem, Hybrid Metaheuristics, ILS.

1 Introduction

Over the last years, logistics became an important market trend providing efficiency and control over all stages of the supply chain. In this sense arises the Inventory Routing Problem (IRP) in which decisions acts in minimization of operational costs over distribution and storage of products. In this paper, we study an extension of IRP called Multivehicle Inventory Routing Problem (MIRP), which considers a homogeneous fleet of vehicles to distribute a single product in a finite horizon from a supplier to several customers.

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To solve this problem, different approaches have been proposed. In [2] the problem was modeled and a hybrid heuristic based in Adaptive Large Neighborhood Search (ALNS) which combines the exact solution from two MILP's was developed. To improve the quality of service, authors adopted structural policies such as maximum level and order-up-to. [1] proposed new formulations and branch-and-cut algorithms for two versions of IRP, using symmetry breaking constraints to improve the formulations and an ALNS heuristic to determine upper bounds. In [3] was presented a branch-and-cut algorithm to deal with different classes of MIRP's. In addition, some inequalities were adapted to support multivehicle and a heuristic was developed to improve the quality of the solutions found in search tree. Finally, in [4] was presented a new formulation and a branch-and-price-and-cut algorithm for MIRP, applying an ad-hoc labeling heuristic to solve column generation subproblems.

This paper proposes a hybrid multi-start algorithm based on ILS, using a RVND procedure in local search phase. Furthermore, an exact procedure is used to solve the inventory management subproblem and a new constructive heuristic is presented. This paper is organized as follow. In Section 2, we give a formal definition for MIRP. In Section 3, we describe the solution approaches to solve the problem. Computational experiments are reported in Section 4. Finally, Section 5 presents the concluding remarks of this work.

2 Problem definition

Let $G = (V, E)$ denote a graph where V is the set of vertices and E is the set of edges. Vertex 0 represents the supplier and $V' = V \backslash \{0\}$ the customers. Demand of customer $v \in V'$ in period $t \in T$ is represented by d_v^t. Supplier produces p_t units of product in period t, in such way its inventory is able to supply all demands in planning horizon. Each customer $v \in V'$ keeps an inventory with maximum capacity C_v. To meet all demands, supplier has a homogeneous fleet composed by K vehicles of capacity Q, which perform at most one route per period.

Quantity of product delivered from supplier to customer v in period t is denoted by variable q_v^t. The inventory level at end of period t for a supplier or customer v is represented by variable I_v^t, where for each unit of product stored in inventory, there is an inventory cost h_v associated $(v \in V, t \in T)$. A routing cost associated to each edge $(i, j) \in E$ is defined by c_{ij}. Thus, the main objective is to minimize operational costs regarding to transportation and storage. In MIRP the following decisions must be noticed: when a customer must be served; how many units of products should be delivered in