Multi-periodic VRP models and hybrid solution techniques
for closed loops-reverse logistics

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More and more manufacturers are confronted with the problem of "Reverse Logistics" which, as
defined by the "American Reverse Logistics Executive Council" [Rogers and Tibben-Lembke, 1999],
is: "The process of planning, implementing, and controlling the efficient, cost effective flow of raw
materials, in-process inventory, finished goods, and related information from the point of consumption
to the point of origin for the purpose of recapturing value or of proper disposal". Companies have
different reasons to design a reverse logistic system: legislation, commercial advantage, environmental
issues, etc... In recent years, a significant amount of work has been focused on the design and
optimization of logistic systems with reverse flows [Bostel et al., 2005].

In this paper, we consider generic problems for the multi-periodic planning and optimization of both
routing activities and inventory management policies in a two level distribution network composed of
a central warehouse and $n$ retail stores. Distributed products sold by the stores are transported on
returnable pallets. Two types of reverse flows have to be considered: for the return of unloaded pallets
from the stores to the warehouses and for the return of products brought back to the stores by
consumers or unsold. In order to satisfy the customer demands at the stores and replenish the
inventories as well as balance the availability of pallets, pick up and delivery tours are organized over
the planning period between the central warehouse and the stores using a homogeneous fleet of
vehicles. Store servicing must meet time windows and they may be visited by several vehicles during
one day. The purpose of the planning and optimization of the system is to determine the days of visits
to each store as well as the quantities delivered or picked-up of the products and pallets. The aim of
this problem is to satisfy the customer demands at the stores while minimizing the routing and storage
costs. In order to determine the best management policies, we consider two cases: "just in time"
delivery where the procurement to the stores must coincide with their customers demands on the same
day, or "inventory" where we allow the possibility of delivering the products to the stores in advance
in order to better optimize the shipments and inventories.

In order to solve these problems, we have developed both heuristic solution techniques and a column
generation approach. As a basis for our heuristic solution techniques, we use the GRASP (Greedy
Randomized Adaptive Search Procedure) metaheuristic [1989]. In a first phase we have adapted the
classical construction method "Best Insertion", with greedy, random and adaptative features. In a
second phase, we use two versions: one using a classical local search and one using a hybrid local
search, and compare them. For the classical local search we use different known methods [Laporte and
Semet, 2001]), in specific sequences for the "just in time case" and for the "inventory case". For the
hybrid local search, we adapted the Large Neighbourhood Search (LNS) method originally proposed
by Shaw [1998]. This technique explores the neighbourhood of the solution by selecting a number of
visits to be removed from the routing plan and reinserting them later. To find the best possible
insertion for the nodes removed and determine a good planning on the new routes, we use the Limited
Discrepancy Search (LDS) proposed by Harvey and Ginsberg [1995]. For all these methods, we
combine improvement methods on each route separately (intra-route) and on several routes
simultaneously (inter-route).
As a solution procedure based on exact methods, we consider a set partitioning formulation of the problems. Starting feasible solutions are generated using the previously described heuristics. A column generation procedure [Desaulniers et al., 2004] has been developed in order to solve the restricted Master problems. Several solution techniques for the resource constraint shortest path subproblems have been implemented and compared, using dynamic programming, tabu search, and constraint programming [Rousseau et al., 2002]. In order to find feasible solutions to the global problems, we restrict ourselves to a branch and bound procedure.

A set of 1848 instances has been generated based on the classical Solomon’s testbed [1987] for the VRPTW with 25 sites. The results obtained by the GRASP approach depend on the resolution approach and the instances. With the column generation approach, we have limited the tests to 204 instances with 5 or 6 sites. Using the branch and bound procedure, we could obtain integer solutions for all cases of the “just in time” policy, but only for 25% of the cases of the “inventory” policy. The obtained results will be presented and compared, showing the relevancy of our models for the comparison of different logistics policies as well as for the performance evaluation of the different solution methods, depending on the characteristics of the instances.

References


