Delivery Strategies for Periodic Blood Products Supplies

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Abstract

We introduce a real-life problem faced by the blood bank of the Austrian Red Cross for Eastern Austria: how to cost-effectively organize the periodic delivery of blood products to Austrian hospitals. We present various solution approaches, based on integer programming and variable neighborhood search, and empirically evaluate their performance. Moreover, we study the potential value of switching from the current vendee managed inventory set up to a vendor managed inventory system.

1 Introduction

Hospitals use a variety of products in the treatment of their patients. Many of these products, most notably blood products, have a short lifespan and therefore their supply and inventory has to be managed carefully. Blood products are crucial for hospitals as they are required for surgeries and for the treatment of patients with chronical illnesses, e.g., cancer patients. Most blood products perish within 20 – 40 days; some blood products spoil already after seven days. As a consequence blood products are delivered to hospitals on a regular basis in order to ensure that an adequate supply of the required blood products is available. However, the inventory levels have to be carefully controlled to avoid the spoilage of blood products.

Thus the blood bank is faced with a situation in which a set of customers (hospitals, clinics, medical institutes) requires regular deliveries of certain products (blood conserves) which they

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consume at different rates. Any delivery policy should be such that no shortfalls of products occur at the customer, but at the same time spoilage of products has to be kept at a minimum. The situation is complicated by the fact that product usage is stochastic. Of course, the blood bank also wants to minimize delivery costs.

The problem outlined above was introduced to us by the largest Austrian blood bank - the blood bank of the Austrian Red Cross for Eastern Austria. The blood bank serves 60 hospitals and makes deliveries to these hospitals regularly. About 250,000 blood products are sold and delivered every year. Currently, delivery routes are planned manually. No routing software or geographic information system is used. The hospitals are grouped into four regions and fixed routes for these regions are constructed. Every day the hospitals are visited in the order of these fixed routes. The set of routes is operated unchanged over a period of time.

The logistics department at the Austrian Red Cross has recently decided that they want to change the current system. First, they want to consider a more flexible and dynamic routing system to reduce the delivery costs. Second they want to investigate the benefits of changing from a vendee managed inventory set up to a vendor managed inventory system. A vendor managed inventory system should be of interest to the hospitals as it will reduce their costs, since product inventory no longer has to be checked by hospital employees, it may reduce product spoilage rate, and it may reduce (or eliminate) product shortfalls. For an introduction to vendor managed inventory and inventory routing see [2].

For several practical reasons, it was decided to develop a rolling horizon approach involving planning periods of 14 days. It was also agreed that for the initial analysis, we would assume known and constant daily demand (different for the different hospitals and different products), estimated from historical demand information. The historical demand data revealed that some hospitals require daily deliveries or deliveries every other day, whereas other hospitals it is sufficient to have a delivery once a week or even once every two weeks. As the size of the bags with the blood products is very small, the vehicle capacity is never restricting and therefore are not considered in our models. Also, the number of vehicles available for deliveries is known and fixed. The objective is to minimize the total distance traveled by the vehicles.

2 Solution Approaches

The first approach we investigate is still based on the use of fixed routes but by carefully considering the demand patterns at the hospitals we are able to introduce significantly more flexibility. As in the currently used delivery strategy, hospitals are grouped into clusters and a fixed route visiting all the hospitals is determined for each cluster. At the moment, we solve a traveling salesman problem to obtain the fixed route for visiting the hospitals in a cluster, but it is probably more

appropriate to solve a heterogeneous probabilistic traveling salesman problem ([1]). Given the fixed routes for the clusters, we use an integer programming model to determine the actual routes during the 14-day planning period. Based on the demand patterns and capacity restrictions at the individual hospitals, the integer programming model optimally decides which hospitals to visit on any given day so as to ensure that none of the hospitals experiences a stockout, spoilage is kept at a minimum, and delivery costs are minimize. The only restriction imposed is that the hospitals visited on a particular day are visited in the sequence provided by the fixed routes. The computational advantage of the use of the fixed routes is that the integer program decides on appropriate shortcuts as opposed to appropriate ordering of visits.

The second approach is based on viewing the problem as a periodic vehicle routing problem with tour length constraints. A variable neighborhood search (VNS) [4] algorithm was developed for its solution. The performance of the VNS algorithm on benchmark instances of the PVRP was comparable to the performance of the Tabu search algorithm of Cordeau et al. [3]. To handle the complicating constraints of the blood delivery setting, i.e., no stockouts and limited spoilage, feasible visit patterns are computed in advance in a preprocessing phase and the VNS is restricted to using only these feasible visit patterns.

3 Computational Experiments

A set of computational experiments has demonstrated the efficacy of both approaches and shown that substantial cost reductions are possible for the blood bank of the Austrian Red Cross while still guaranteeing the necessary service level.

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