Evolutionary Algorithm for an Inventory Location Problem

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Summary. This paper deals with minimizing the cost in a joint location-inventory model with a single supplier supplying to multiple capacitated distribution centers. The distribution center faces stochastic demands from multiple retailers. The problem is to determine how to assign retailers to distribution center within the service level constraints. The costs considered include the transportation cost, inventory holding cost and ordering cost. We develop an adaptive real-coded genetic algorithm to solve the problem. We conduct few experiment runs to compare the performance of the proposed method with some existing methods which include the simple genetic algorithm, the column generation method and the greedy method. For the non-capacitated case, the method shows very promising results with respect to both time and quality of the solutions. Similarly for the capacitated case, where the column generation method cannot be applied, the model is also significantly better than all the other methods, especially when the problem size is big.

1. Introduction

This paper studies a distribution problem with joint inventory and location decisions. The system consists of a number of capacitated distribution centers (DCs) which are replenished by a single plant and they are serving their assigned retailers (customers) where the demands are stochastic. The DC and its assigned retailers must satisfy two service requirements. The first requirement is that the delivery leadtime (or the distance between the DC and the retailers) should not exceed a certain threshold value. The second requirement is that the DC should keep
some level of safety stock to meet a certain fill rate. The problem is to
determine which retailer is to be allocated to a particular DC and how
much stock to carry in each DC such that the overall costs can be
minimized and the service requirements can be satisfied.

When a DC is serving many retailers, potential saving can be
achieved through the reduction of the safety stock due to risk pooling.
Moreover, consolidating many retailers at a single DC will also reduce
the total cycle stock. However, this may potentially lead to higher
transportation cost since some of the retailers might be far away from
the DC. Therefore we need to balance the transportation cost and the
inventory holding cost. In addition, the capacity of DCs also has to be
considered.

Formally, the problem is stated as follows: Given a set of DCs each
having its own capacity and a set of retailers with stochastic demands,
determine which retailer is to be allocated to which DC by not violating
the service requirements. Furthermore, determine how often to reorder
as well as the level of stock to be maintained at each DC at the lowest
system cost. The costs consider include the transportation cost, the
inventory holding cost and the ordering cost. The transportation cost
includes both the costs of inbound and outbound transportation of the
DC. The inventory holding cost includes the holding costs for the
average cycle stock and the safety stock. The ordering cost is incurred
for each order placed by the DC to the plant. The set up cost for the
DC is ignored.

Inventory theory deals with developing and evaluating policies for
ordering and fulfillment process at the DC. These are generally
evaluated on the service levels, inventory and shortage costs (Hopp and
Spearman 2000, Silver et al. 1998). On the other hand, location theory
focuses on determining the number of DCs and their locations with
respect to various customers or retailers. Daskin and Owen (1999)
provide a review of facility location modeling. Chan (2001) also
provides an overview of the location theory. However, solving these
two problems independently will lead to a suboptimal solution.

Some works have been done on considering the inventory and loca-
tion problems jointly. Erlebacher and Meller (2000) solve a joint loca-
tion-inventory model but that model is highly non-linear and takes 117
hours to be solved on a Sun Ultra SPARCstation. Shen (2000), Daskin
et al. (2001) and Shen et al. (2003) conduct a study at Chicago blood
bank which looks into the setting up of regional DCs at the hospitals
distributing the platelets on a daily-need basis. However, the proposed
methods can only solve two special cases. The first case assumes the
ratio between the variance of the demand and the mean is identical for