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A steady-state genetic algorithm for multi-product supply chain network design

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Abstract

Supply chain network (SCN) design is to provide an optimal platform for efficient and effective supply chain management (SCM). The problem is often an important and strategic operations management problem in SCM. The design task involves the choice of facilities (plants and distribution centers (DCs)) to be opened and the distribution network design to satisfy the customer demand with minimum cost. This paper presents a solution procedure based on steady-state genetic algorithms (ssGA) with a new encoding structure for the design of a single-source, multi-product, multi-stage SCN. The effectiveness of the ssGA has been investigated by comparing its results with those obtained by CPLEX, Lagrangean heuristic, hyrid GA and simulated annealing on a set of SCN design problems with different sizes.

Keywords: Supply chain network design; Genetic algorithms; Simulated annealing; Lagrangean heuristic

1. Introduction

In recent years, the supply chain design problem has been gaining importance due to increasing competitiveness introduced by the market globalization (Thomas & Griffin, 1996). Firms are obliged to maintain high customer service levels while at the same time they are forced to reduce cost and maintain profit margins. A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Traditionally, marketing, distribution, planning, manufacturing and

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Fig. 1. Illustration of a supply chain network.

purchasing organizations along the supply chain have operated independently. These organizations have their own objectives and they are often conflicting. However, there is a need for a mechanism through which these different functions can be integrated together. Supply chain management (SCM) is a strategy through which such an integration can be achieved (Shapiro, 2000). An example of supply chain network is shown in Fig. 1.

Supply chain network (SCN) design is to provide an optimal platform for efficient and effective SCM. This is an important and strategic operations management problem in SCM. The design task involves the choice of facilities (plants and distribution centers (DCs)) to be opened and the distribution network design to satisfy the customer demand with minimum cost. It belongs to a production-distribution and facility location-allocation problem. When the facilities have a certain capacity, the problem is referred as a capacitated location-allocation problem. Since the multi-stage design problem is difficult to solve optimally, especially if capacity constraints are imposed on both plants and DCs, researchers have utilized heuristic approaches to solve this problem. Jayaraman and Pirkul (2001) have developed a heuristic approach based on Lagrangean relaxation for the single-source, multi-product, multi-stage SCN design problem. Another heuristic approach based on Lagrangean relaxation and simulated annealing has been developed by Syam (2002) for a multi-source, multi-product, multi-location framework. Jang, Jang, Chang, and Park (2002) have presented a combined model of network design and production/distribution planning for a SCN. While they have used a Lagrangean heuristic for the design of SCN, a genetic algorithm (GA) has been proposed for integrated production and distribution planning problem. Syarif, Yun, and Gen (2002) have developed a spanning tree-based GA approach for the multi-source, single-product, multi-stage SCN design problem based on Prüfer numbers. Jayaraman and Ross (2003) have also proposed a heuristic approach based on simulated annealing for the designing of distribution network and management in supply chain environment. Yeh (2005) has developed a hybrid heuristic approach for the problem considered by Syarif et al. (2002). The developed approach is a combination of a greedy method, linear programming technique and three local search methods. Yeh (2006) has also proposed a memetic algorithm (MA) which is a combination of GA, greedy heuristic, and local search methods for the same problem. The author has extensively investigated the performance of the MA on the randomly generated problems.