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Network model and optimization of reverse logistics by hybrid genetic algorithm

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Abstract

The interest about recovery of used products and materials have been increased. Therefore, reverse logistics network problem (rLNP) will be powerful and get a great potential for winning consumers in a more competitive context in the future.

We formulate a mathematical model of remanufacturing system as three-stage logistics network model for minimizing the total of costs to reverse logistics shipping cost and fixed opening cost of the disassembly centers and processing centers. And we consider a multi-stage, multi-product and some attach condition for disassembly centers and processing centers, respectively.

For solving this problem, we propose a genetic algorithm (GA) with priority-based encoding method consisting of 1st and 2nd stages combined a new crossover operator called as weight mapping crossover (WMX). A heuristic approach is applied in the 3rd stage to transportation of parts from processing center to manufacturer. Numerical experiments with various scales of rLNP models show the effectiveness and efficiency of our approach by comparing the recent researches.
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Keywords: Multi-stage reverse logistics network problem (m-rLNP); Genetic algorithm (GA); Priority-based encoding method; Weight mapping crossover (WMX)

1. Introduction

Recently, according as an exhaustion of resources and environment problems, which is related with that are issued as socially and globally, the trade regulations which are environment related also have increased through an international organization and the agreement of environment preservation. So the increase of interest about the collection of the disused products for recovering of resources is reasonable.

Beyond the current interest in supply chain management, recent attention has been given to extending the traditional forward supply chain to incorporate a reverse logistic element owing to liberalized return policies, environmental concern, and a growing emphasis on customer service and parts reuse. Implementation of reverse logistics especially in product returns would allow not only for savings in inventory carrying cost, transportation cost, and waste disposal cost due to returned products, but also for the improvement of customer loyalty and futures sales.

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Recycling problem can affect not only a cost performance of recycling of a company, but also whole strategy of the company including production strategy and purchase policy. To deal with this problem, the government should treat it in one industry.

In the Korea, the extended product responsibility is in force system from 2003 that the obligation is given as a producer as it recycles more than a constant amount of the waste that can be recycled (Biehl, Prater, & Realff, 2007; Ko & Evans, 2007; Lieckens & Vandaele, 2007).

Reverse logistics is defined by the European working group on reverse logistics (REVLOG) as "the propose of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from the point of use back to point recovery or point of proper disposal" (REVLOG, 2004) http://www.fbk.eur.nl/OZ/REVLOG/PROJECTS/TERMINOLOGY/def-reverselogistics.html. In a broader sense, reverse logistics refers to the distribution activities involved in product returns, source reduction, conservation, recycling, substitution, reuse, disposal, refurbishment, repair and remanufacturing (Stock, 1992).

Concerning reverse logistics, a lot of researches have been made on various fields and subjects such as reuse, recycling, remanufacturing logistics etc.

In reuse logistics models, Kroonand Vrijens (1995) reported a case study concerning the design of a logistics system for reusable transportation packages. The authors proposed a mIP (mixed integer programming), closely related to a classical un-capacitated warehouse location model.

In recycling models, Barros, Dekker, and Scholten (1998) proposed a mixed integer program model considered two-echelon location problems with capacity constraints based on a multi-level capacitated warehouse location problem. Pati, Vrat, and Kumar (2008), they developed an approach based on a mixed integer goal programming model (mIGP) to solve the problem. The model studies the inter-relationship between multiple objectives of a recycled paper distribution network. The objectives considered are reduction in reverse logistics cost. This study proposed reverse logistics network of remanufacturing process. The objective of this study is to minimize all shipping costs occurred by remanufacturing process.

In remanufacturing models, Kim, Song, and Jeong (2006) discussed a notion of remanufacturing systems in reverse logistics environment. They proposed a general framework in view of supply planning and developed a mathematical model to optimize the supply planning function. The model determines the quantity of products parts processed in the remanufacturing facilities subcontractors and the amount of parts purchased from the external suppliers while maximizing the total remanufacturing cost saving. Jayaraman, Guide, and Srivastava (1999) presented a mixed integer program to determine the optimal number and locations of remanufacturing facilities for the electronic equipment. They developed heuristic concentration procedures combined with heuristic expansion components to handle relatively large problems.

Lee, Rhee, and Gen (2007) proposed the reverse logistics network problem (rLNP) minimizing total reverse logistics various shipping costs.

Recently, GAs have received considerable attention regarding their potential as a novel approach to optimization problems and is often used to solve many real world problems, including the effective approaches on the SPR (Shortest Path Routing) problem, capacity and flow assignment, and the dynamic routing problem. It is noted that these entire problem can be formulated as some sort of a combinatorial optimization problem.

This paper propose multi-stage reverse logistics network problem (m-rLNP) which consider the minimizing of total shipping cost and fixed opening costs of the disassembly centers and the processing centers in reverse logistics and a new genetic algorithm to solve this one. We developed priority-based genetic algorithm (priGA) and heuristic approach, and proposed a new crossover operator called as weight mapping crossover (WMX).

This paper is organized as follows: in Section 2, the mathematical model of the reverse logistics network is introduced; in Section 3, the priGA approach and heuristic approach are explained in order to solve this problem; in Section 4, numerical experiments are presented to demonstrate the efficiency of the proposed method; finally, in Section 5, concluding remarks are outlined.

2. Mathematical formulation

In this Section, we consider constituents, variables and assumptions for formulating a multi-stage logistics network model. In the remanufacturing process, parts which are disassembled of recovered products of be

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