An Artificial Immune Algorithm for a Closed-Loop Supply Chain Network Design Problem with Different Delivery Paths

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ABSTRACT

The concern about customer satisfaction and transportation cost in the business environment has spurred an interest in designing a flexible logistics network. This paper proposes a multi-delivery path closed-loop supply chain network to find not only the most cost efficient network design but also the best path to deliver the products to customers. To tackle with such an NP-hard problem an Artificial Immune Algorithm (AIA) is modified. To show the efficiency and accuracy of the proposed method numerical experiments are conducted. Consequently, the computational results validate the quality of the proposed approach by comparing them with those of obtained with exact methods.

Keywords: Artificial Immune Algorithm, Closed-Loop Supply Chain, Network Design, Transportation Cost

INTRODUCTION

Logistics network design as a strategic decision plays the main role in the performance of a supply chain. Supply chain network design problem contains the determination of locations, numbers and capacities of network facilities as well as the material flow through the network. The configuration of the logistics network cannot be changed in short term as its change is very costly and time-consuming. Logistics network design is also a crucially important decision, as it constrains the subsequent tactical and operational decisions.

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Products can be returned for reasons such as customer dissatisfaction and warranty. Such products can be sorted for reuse, remanufacture, recycle and disposal. Reuse of used products by some value addition is not a new concept. In addition, industries are using remanufacturing for expensive products such as turbines used in airplane and electricity generation systems. In these cases, recovery of used products is economically more attractive than disposal (Koh, Hwang, Sohn, & Ko, 2002).

One of the most important and strategic issues in supply chain management is the configuration of the logistics network having a significant effect on the total performance of the supply chain. The configuration of the reverse logistics network, however, has a strong influence on the performance of the forward logistics network and vice versa, as they share a number of resources. Due to the fact that designing the forward and reverse logistics separately leads to sub-optimal designs with respect to strategic and tactical costs, the design of the forward and reverse logistics networks should be integrated (Fleischmann, Beullens, Bloemhof-Ruwaard, & Wassenhove, 2001; Lee & Dong, 2008; Verstrepen, Cruijssen, de Brito, & Dullaert, 2007).

Previous researches in the area of forward, reverse and integrated logistics network design often limited themselves to only consider the flow to be transported between two consecutive stages. In other word, there is no flow between facilities which are not consecutive. Nevertheless, considering flows between facilities which are consecutive will enhance the logistics network efficiency and flexibility.

Based on the aforementioned considerations, this paper addresses the issue of flexible integrated, multi-stage forward/reverse logistics network design including suppliers, production, distribution, collection/inspection, recovery and disposal facilities with limited capacity. The rest of this paper is structured as follows. Section 2 offers a literature review to assess the state-of-the-art in forward/reverse logistics network design. To design the flexible integrated forward/reverse logistics networks, a generalized mixed integer linear programming (MILP) formulation is developed in Sections 3 and 4. Section 5 presents an efficient artificial immune algorithm using a dynamic search strategy to find solutions for large-scale problems. The computational performance of the heuristic algorithm is analyzed in Section 6. Section 7 concludes this paper and offers guidelines for further research.

LITERATURE REVIEW

In this section, we relate our work with the existing literature by discussing the features comprised by the new model we propose in Section 3. In particular, we analyze the extent to which such features have been addressed in the literature.

Integrated forward and reverse logistics refers to all those activities associated with the transformation and the flows of goods and services with their information from the sources of the materials to the end users. (Dullaert, Bräysy, Goetschalckx, Raa, & Center, 2007) give a general review of the supply chain design models to support the development of richer supply chain models, capable of taking into account all logistics costs. These models range from simple un-capacitated facility location models to complex capacitated multi-objective models aimed at determining the cost minimizing or profit maximizing system design.

A large part of the literature in logistics network design is related to forward logistics network design aimed to determine the configuration of a directed network from suppliers to customers, including production and distribution centers. A smaller part of the literature is associated with reverse logistics network design aimed at determining the number of collection, recovery and disposal centers, their location and capacities, and the optimized reverse flow from customers to recovery and disposal centers. Also, in recent years a few papers have attended to integrated logistics network design. In the integrated paradigm, the objective is to integrate the forward and reverse network design
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