

Chapter 12

Algorithms and Methods Inspired from Nature for Solving Supply Chain and Logistics Optimization Problems: A Survey

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ABSTRACT

The current work surveys 245 papers and research reports related to algorithms and methods inspired from nature for solving supply chain and logistics optimization problems. Nature Inspired Intelligence (NII) is a challenging new subfield of artificial intelligence (AI) particularly capable of dealing with complex optimization problems. Related approaches are used either as stand-alone algorithms, or as hybrid schemes i.e. in combination to other AI techniques. Ant Colony Optimization (ACO), Particle Swarm Optimization, Artificial Bee Colonies, Artificial Immune Systems and DNA Computing are some of the most popular approaches belonging to nature inspired intelligence. On the other hand, supply chain management represents an interesting domain of OR applications, including a variety of hard optimization problems such as vehicle routing (VRP), travelling salesman (TSP), team orienteering, inventory, knapsack, supply network problems, etc. Nature inspired intelligent algorithms prove capable of identifying near optimal solutions for instances of those problems with high degree of complexity in a reasonable amount of time. Survey findings indicate that NII can cope successfully with almost any kind of supply chain optimization problem and tends to become a standard in related scientific literature during the last five years.

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INTRODUCTORY CONCEPTS

The current survey deals with the use of a subdivision of intelligent algorithms and techniques, usually referred as nature inspired intelligent techniques, in solving hard optimization problems related to supply chain and logistics management. Ant Colony Optimization (ACO), Particle Swarm Optimization, Artificial Bee Colonies, Artificial Immune Systems and DNA Computing are some of the most popular approaches belonging to nature inspired intelligence. Related literature is rich during the last two decades and seems to grow further during the last five years, as this survey depicts, especially for the most common and open optimization problems related to supply chain, such as vehicle routing, travelling salesman or travelling purchaser, knapsack, inventory, and logistics network optimization problems.

Most modern firms face difficulties in obtaining a competitive advantage over other companies due to the fact that the majority of their underlying processes have become complex. A remedy to this issue is to adopt the organizational scheme of supply-chains: an international network of external partners such as suppliers, warehouses, distribution centres. A starting point of this functional chain can be considered the collection of raw materials and an ending point the preparation of the final product and the delivery to its final destination (customer or any other terminal) (Silva et al. 2002). Logistics is a particular part of this process and deals with the planning, handling and control of the storage of goods between the manufacturing and the consumption point. One crucial challenge for decision makers is to satisfy all customers, using the available transportation fleet, while at the same time minimizing any intermediate costs (storage costs, transportation costs, delivery time etc.). The above problem can get very complex, especially in the case where various real life constraints regarding time, cost, availability etc. are imposed. A general term that

characterizes these kinds of problems is the term “scheduling problems” (Silva et al. 2002).

A wide range of methodologies has been used to solve this optimization problem. However, traditional mathematical methods have proven insufficient in tackling the requirements rising from the development of market competition (Silva et al. 2003). Nature-inspired intelligent techniques are considered to be quite efficient in handling NP-hard problems (i.e. optimization problems in which the optimum cannot be found in polynomial time). Some examples of nature-inspired algorithms are ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Memetic Algorithms, Artificial Immune Systems and DNA Computing. All of these methods have been applied to hard optimization problems, as well as to the optimization of logistic processes. Their main characteristic is the imitation of the way natural systems function and evolve in order to deal with real-world situations (Vassiliadis and Dounias 2009). For example, natural ant colonies cooperate so as to find high-quality food source, a flock of birds implements a scheme of indirect communication with the aim of finding the optimal direction, etc.

The aim of this paper is to present a literature review of the application of nature-inspired algorithms in supply chain management. Specifically, the focus is on certain parts of the supply chain, where certain processes need to be optimized such as finding the optimal route for a fleet. Academic research indicates that the use of NI methods is beneficial in dealing with this kind of problems. The contribution of this study is to collect a representative sample of academic work regarding the application of NI algorithms in logistic processes emphasizing in most recent research conducted in the field, while also tries to give a clear presentation of the usefulness and applicability of these techniques for future research projects. In total, 245 research reports were collected, classified and analysed for this purpose.

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