Chapter 2
An Algorithm to Supply Chain Configuration Based on Ant System

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ABSTRACT

This work proposes a new approach, based on Ant Colony Optimisation (ACO), to configure Supply Chains (SC) so as to deliver orders on due date and at the minimum cost. For a set of orders, this approach determines which supplier to acquire components from and which manufacturer will produce the products as well as which transportation mode must be used to deliver products to customers. The aforementioned decisions are addressed by three modules. The data module stores all data relating to SC and models the SC. The optimization engine is a multi-agent framework called SC Configuration by ACO. This module implements the ant colony algorithm and generates alternative SC configurations. Ant-k agent configures a single SC travelling by the network created by the first agent. While Ant-k agent visits a stage, it selects an option to perform a stage based on the amount of pheromones and the cost and lead time of the option. We solve a note-book SC presented in literature. Our approach computes pareto sets with SC design which delivers product from 38 to 91 days.

INTRODUCTION

Since the beginning of the decade of the 1990', the SC design has been emerge as a competitive advantage to improve companies' performance (Melynk, 2009). Therefore, many techniques and approaches have been used in order to solve the problem of determining the configuration of SC because the impact of it has in the average return. AMR Research stated that in 2008 the companies with best SC practices reported an average return of 17.89% compared with 6.43% for the Dow Jones Industrial (Reuters January 10, 2008)

SC is a network that encompasses different entities such as suppliers (S), manufacturers (M) and customers (C) in which three kinds of flows run: a flow of materials (raw material, work in process and

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finished product); a flow of information (demand, capacity of the different components, orders' due date, transport and production costs, and bill of materials) and a flow of funds (money transferred by M to S and by C to M including the payment made for transportation service) (Goetschalckx, 2011).

The process of finding the best flow patterns for every product in terms of cost and time is known as

Optimization of the SC Design; it means, when the SC's structure is set, it is being optimised in terms of setting up the relationship among the different entities.

When a manufacturer decides from which supplier to get components and in which plant the product must be produced in order to deliver the order to the client, the who-serves-whom relationships are established. Hence, the flow pattern for every component and product is determined.

The way in which the who-serves-whom relationships are established depends on both time and cost although the SC strategy plays an important role. A make-to-order strategy corresponds to a pull SC process and a make-to-stock strategy matches a push SC process, (Simchi-Levi, et al, 2007). In a push process the execution of the manufacturing operations is initiated in anticipation of customer orders while from a pull point of view the manufacturing operations begin when a costumer submits an order. Therefore, at the time of execution of a pull process, customer demand is known (make-to-order strategy) whereas in a push process demand is unknown and must be forecasted (make-to-stock strategy).

The SC process, considered in this work, is a pull strategy where the inventory across the SC tends to be zero. This kind of SC encompasses the following activities: submit orders, supply raw materials, manufacture components, assemble products, and deliver orders.

The problem of SC's Configuration is stated as:

Given an order for a product P, consisting of a number of components $C = \{c_1, c_2, \ldots, c_n\}$ the required decisions are from which supplier S the component c_i for $i = 1, 2, \ldots, n$ will be acquired and where the product P will be assembled every time P is requested by a customer and how the product must be delivered such that the total cost is minimised and orders are delivered on the due date.

In general the problem is to select for every supplying and manufacturing entity an option to perform the task, e.g. if two suppliers can supply the same component c_i, we have to select a supplier based on the time and cost provided by every supplier. The same for the manufacturing entity as well as the transportation mode.

In order to optimize the total cost and orders' lead time, simultaneously, the two--objective problem could be transformed into a single-optimization problem; this could be done by two methods (Collette & Siarry, 2013). In the first one, called weighting methods, every objective is associated with a weighting coefficient and then the weighted sum is minimized.

In the constrain method, the idea is to pick one of the objectives while the other objectives are turned into an inequality constraint with parametric right-hand side. The solution is a Pareto optimal set (POS) that contains all the non-dominated solutions. In addition empirical evidence suggests that the weighting method performs poorly in case of multi-objective optimization (Miettinen, 2012); consequently the use of the constraint method is used to solve the SCD problem.

Every non-dominated solution represents a SCD with two values associated with it, the total cost and orders' lead time, TCSCD and LTSCD, respectively.