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A top-down approach and a decision support system for the design and management of logistic networks

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ABSTRACT

This paper presents an original top-down approach, made of original models and solving methods, and a decision support system (DSS) for the execution of the strategic planning, the tactical planning and the operational planning in a multi-echelon multi-stage multi-commodity and multi-period production, distribution and transportation system. The DSS is a software platform useful for the design, management and control of real instances. It can efficiently supports the decision making process of logistic managers and planners of large enterprises as multi-facilities companies and production–distribution networks. A significant case study is illustrated. The results obtained by the application of different problem settings are compared and discussed.

1. Introduction

Supply chain management (SCM) is the process of planning, implementing and controlling the operations of a supply chain (SC) in an efficient way (Melo et al., 2009). SCM is "the integration of key business processes from end-user through original suppliers" (Lambert et al., 1998). Very important issues for SCM are the definition of the best possible network configuration and the identification of the best management rules and operational procedures. Both are objects of this manuscript.

Fig. 1 presents a distribution network made of three stages and four levels. The generic stage involves two consecutive levels of entities based on the relationship supplier-customer. The available levels are the sources, named also production plants (at the first level), the central distribution centres (CDCs) (at the second level), the regional distribution centres (RDCs) representing the third level, and finally the customers/consumers points of demand (Pods) at the fourth level. This is an example of a generic distribution network and it is the basic configuration adopted in this study and treated by the proposed models, methods and DSS as discussed below.

The aim of the manuscript is the development of an original top-down and multi-step original approach for the effective design, management and control of multi-echelon logistic production–distribution networks, typical of large enterprises made of thousands of entities at different levels of the system. The proposed approach has been implemented in a DSS, named *LD-LogOptimizer*, which supports the decisions making process on *strategic*, *tactical* and *operational* issues. This software platform can be applied to the design, management and control of real and complex instances and can efficiently support managers, planners and practitioners from industry and large enterprises as multi-facilities companies and distribution–production networks.

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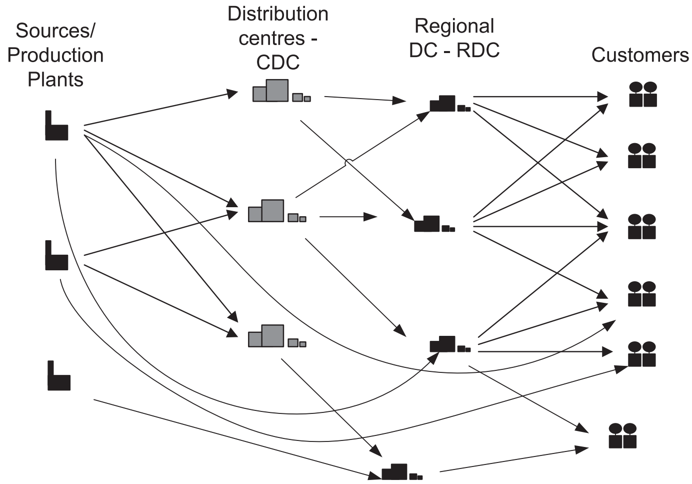

Fig. 1. Supply chain network, 3 stages and 4 levels.

The proposed approach and DSS are based on the application of original models and solving methods, including both optimization and heuristic techniques. A significant case study, as rarely presented by the literature, is illustrated: the results obtained by a multi-scenario what-if analysis and different problem settings are reported and discussed.

The remainder of this paper is organized as follows. Section 2 presents a review of the literature on models and tools for the design, management and control of a distribution system. Section 3 illustrates the proposed top-down multi-step approach for strategic, tactical and operational planning of a logistics network. Section 4 presents an original and effective MILP optimization model for the strategic planning. Similarly, Section 5 presents a multi-period optimization MILP model for the tactical planning. Section 6 illustrates an effective heuristic approach for the operational planning and capacitated vehicle routing. Section 7 presents a significant case study. It demonstrates the effectiveness of both the proposed approach and DSS. Finally, Section 8 discusses conclusions and further research.

2. Review of the literature

Facility location (FL) and SCM are two important and interrelated disciplines in logistics and management science. In logistic systems the generic FL problem can be defined as the taking of simultaneous decisions regarding design, management, and control of a generic distribution network:

1. Location of new supply facilities given a set of demand points, which correspond to existing customer locations.
2. Demand flows to be allocated to available or new suppliers.
3. Configuration of a transportation network, i.e. design of paths from suppliers to customers, management of vehicles and routes in order to supply demand needs, in presence (or absence) of the so-called "groupage strategy".

Recent literature reviews on SCM and FL are presented by Arabani and Farahani (2012), Van der Vaart and van Donk (2008), Gebennini et al. (2009) and Melo et al. (2009). Literature presents also a very large number of studies on models and methods for the design and control of complex distribution systems, but the largest part of them deals with one specific problem such as the facility location, the location and allocation problem (LAP), the vehicle routing, etc., renouncing to find a global solution, as close as possible to the optimum, for the whole systems by the application of an integrated approach for production, distribution and transportation issues (Manzini et al., 2008). Researchers have focused relatively early on the design of distribution systems considering the distribution system as a whole (Melo et al., 2009).

Recent contributions to the management and optimization of inventory/distribution systems are presented by Abdul-Jalbar et al. (2009), Amiri (2006), Manzini and Gebennini (2008), and Monthatipkul and Yenradee (2008). They are based on mixed integer linear programming (MILP) models and deal with one-warehouse/multi-retailer systems. Kengpol (2008) proposes an analytical hierarchy process (AHP) combined to the use of MILP for the design and management of a logistic distribution network. All these contributions refer to simplified operating contexts where the variable time is not modelled, a single commodity hypothesis is generally adopted and one stage made of two levels (the sources level or the DCs level, and the customers level) is considered.

A recent production–distribution model based on MILP is presented and applied by Tsiakis and Papageorgiou (2008). Thanh et al. (2008) present a MILP-based dynamic model focusing on strategic and tactical decisions. Classifications and reviews of the existing models and tools for the logistic networks design and optimization are presented by Klose and Drexl (2005), ReVelle et al. (2008), Thanh et al. (2008), Gebennini et al. (2009), and Melo et al. (2009).