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Route planning for a mixed delivery system in long distance transportation and comparison with pure delivery systems

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ABSTRACT

The long distance routing problems are divided into three kinds of pure delivery systems where every order is allocated the same distribution strategy. Pure delivery systems have been generally, independently and widely studied. This research provides a solution to help pallet and package delivery companies in decision making, considering a mixed delivery system to improve the use of resources. It returns the route planning after allocating to each order the distribution strategy that best fits to the global scene and proves if a mixed delivery system achieves best results than a pure one and under which circumstances.

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1. Introduction

For [1], an efficient freight transportation industry is the key to facilitating the required movement of raw materials and finished goods. It involves maintaining the availability of intermediate materials and providing fast and reliable delivery of the final product, supports production, trade and consumption activities. Freight transportation is a major element of the economy and needs to adapt to the currently changing economic trends such as just-in-time production, Internet based

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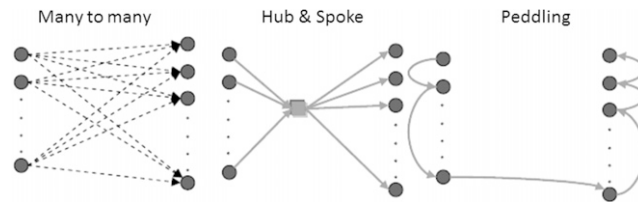
Fig. 1. Pure distribution strategies. Adapted from [2].

electronic businesses (e-commerce) and business-to-customer environments where distributors and retailers are being eliminated.

From an operational point of view, trucking services are classified as TL (Truckload) and LTL (Less-Than-Truckload). Truckload offers door-to-door transportation where a truck is assigned to each customer. In LTL, several customers are served simultaneously by using the same truck. The LTL trucking service can be characterized by the type of network, line operations network and load planning network.

Different types of distribution strategies apply, depending upon the features of the network and the trucking service. For [2] there are three types of pure distribution strategies in long distance transportation: many to many, hub&spoke and peddling as it is shown in Fig. 1.

Decision makers have to calculate the route planning where every order follows the same distribution strategy. In order to improve the use of resources and minimize the total distance a mixed delivery system is proposed where each order is allocated one of the previous adopted strategies in specific conditions and satisfying several constraints. Additionally, a methodology is developed to calculate the route planning, and finally, this research looks into the features that characterize the election of the distribution strategy.

2. Literature review

The many to many and peddling routes bear relation to the most common truck dispatching problem, that is known as Vehicle Routing Problem and it is an optimization problem that returns how to serve a set of customers geographically diffused around a central depot using a fleet of vehicles. It is one of the most widely studied topics in the field of operations research. For several authors, such as [3], the first research about the VRP was introduced by [4]. Since it appeared, several varieties of the original problem have arisen such as Capacitated Vehicle Routing Problem (CVRP), Multidepot Vehicle Routing Problem (MVRP) or Vehicle Routing Problem with Time Windows (VRPTW) and commonly they deal with local distribution. In the case of long distance carrier problems the literature about the Vehicle Routing Problem is not widely studied and it is more related with hub&spoke distribution strategies.

Fig. 2 shows several pure distributions solutions and how they have evolved to mixed delivery systems. In this figure, *empty* refers to minimization of unloaded trucks distance and *tight times* to a close schedule that allows little time.

The first time hub&spoke network was studied was in the late 1960s [5]: however, it was not until the late 1980s that this was considered to be an important aspect of research. The first formal studies were introduced by [6,7] and a large number of new possibilities have emerged. Usually the problem is settled as a pure distribution strategy, as the following emblematic studies [8–11] or [12] show.

There are few researches that introduce features to evolve a pure distribution into a mixed distribution strategy; for example [13–16] were the first to allow direct shipments; although somewhat uncommon, some authors allow stopovers to be made between the origin and the hub and between the hub and the destination. The first such research was [17], which proposed only a hub and allowed two stopovers as maximum. In [18], the number of stopovers was unlimited. Another feature of this research paper is that it included the waiting time. Other studies that include time as a constraint are [19,20].

Other perspective is provided by the Location Routing Problem which appeared in the late 1970s. This combines the (HLP) to solve the hub&spoke and the Classical Vehicle Routing Problem (VRP). The last way to interpret the problem is as a Multidepot Vehicle Routing Problem (MDVRP), where the nodes are allocated to the depots and then the routes are planned as in [21–24]. This paper is based on this perspective and more exactly in [25], which considers only a hub and allows direct shipments and stopovers in all the links. The problem was solved dividing the problem into three Capacitated Vehicle Routing Problems and previously the algorithm decided if an order was allocated to the hub or not. The author asserts that in this case a mixed delivery system is more efficient than a pure one.

3. Problem description

This research objective is to find the least distance to serve all the orders of the customers selecting the distribution strategy under different boundary conditions and constraints values. The main features are explained as follows: every order consists of two operations placed in different locations; one is the picking in the origin node and the other one is the delivery in the destination node. The distance between both of them is over 150 km and below 1500 km.