A Model and Solution Method for Solving the Real-world and Complex Problem of Scheduling Visits to Customers

M.G. Baldoquin de la Peña[1], A. Escalera Fariñas[2] and R. Linfati[*3]

[1] Facultad de Ingeniería, Pontificia Universidad Javeriana Cali
Cali, Colombia
[2] Centro de Estudios de Matemática, ISPJAE
La Habana, Cuba
[3] Departamento de Ingeniería Industrial, Universidad del Bío-Bío
Concepción, Chile
* rlinfati@ubiobio.cl

ABSTRACT
Some of the complex logistical problems faced by companies combine the needs for strategic and tactical decisions concerning the interrelated issues of clustering, scheduling, and routing. Various strategies can be used to solve these problems. We present a problem of this type, involving a company whose fundamental objective is the commercialization of its product in the domestic market. The paper focuses on a model of and method for a solution to the problem of scheduling visits to customers, taking into account the relationship with other phases of product marketing. The model is nonlinear, involves binary and continuous variables, and solved heuristically. Computational experiments show that the proposed solution performed very well for both real-life and theoretical instances.

Keywords: logistics, scheduling, heuristic.

1. Introduction

This work involves part of a complex real-world logistical problem faced by a company operating on public and private investments whose main objective is the commercialization of its product in the domestic market.

The study's fundamental practical contribution is solving the real-world problem presented, allowing an improved supply chain through one of its two main activities, the logistics, by combining strategic and tactical decisions. The real-world problem is the partitioning of customers into certain groups and planning visits to these customers over a given time horizon (strategic decisions) and the construction of efficient routes by which to visit the customers (tactical decisions). Theoretically, this problem contains the sub-problems of clustering, scheduling, and vehicle routing and the interdependent complexities imposed by certain restrictions not considered by the literature's classical models.

Solving the problem while addressing clustering and the location of the warehouse and routing is very complex. There exists an extensive literature on solving integrated problems such as location-routing [1] [2], assignment-routing [3], cluster-routing [4] [5], vehicle and crew scheduling [6], routing-scheduling [7] [8], facility location, and modes inventory [9]. The literature also features complex logistical problems divided into phases with minor levels of complexity. For example, the urban transit network design problem (UTNDP) has been divided into two main sub-problems: routing and scheduling [10]. The transportation scheduling problem for mobile devices described in [11] presents a model with nonlinear time intervals, which is transformed into a mixed integer program (MIP) by the same decomposition principle of Dantzig-Wolfe.

The crew scheduling problem is usually divided into three phases [12]. In [13], we see different methods for the selection and allocation of warehouses to customers. A study of different versions of the assignment problem and their solutions can be found in [14]. The proposed model is mixed integer nonlinear non-convex. A study of heuristic methods for solutions to this kind of model can be found in [15].

This paper summarizes the methodology for solving this problem, divided into phases. Its main contribution is the model and solution for the second phase: the problem of scheduling visits to customers. We have designed an experiment to validate the proposed solution method using information drawn from the real-world problem and have adapted relevant instances from the literature.

The structure of the real-world problem is as follows. The company has a set of points of sale for a product that must be visited every month at a frequency determined by its sales volume by one of the nine company trucks travelling from a central depot to which they must return after their journey. Each customer must always be visited by the same truck. Some customers are visited on the same day by the same truck, as happens when at least one customer associated with a headquarters customer is visited.

There are 4 types of visit frequency, each depending on the customer's sales volume: weekly (the same day each week, for example every Tuesday), biweekly (two visits per week, which must be Monday and Thursday or Tuesday and Friday), bimonthly (2 times a month, in the first and third weeks or the second and fourth weeks, but always on the same day of the week) and monthly. The trucks are available from Monday to Friday. A month is considered to be 4 weeks with 20 days of delivery.

The length of the truck's stay with customers is not constant and does not depend on delivery frequency or the amount delivered (the sales volume) but on the type of visit. Though the trucks have a limited capacity, the current restriction is the truck's total available travel time, not its capacity. Thus, the capacity of the trucks is generally higher than the load equal to the maximum number of customers who can be visited in a day.

2. Methodology

The problem was solved using a heuristic involving three key phases in the order listed below:

a) Customer clustering problem based on the use of clustering techniques.

b) Scheduling visits to customers located in the same cluster in a given period, a month in our case.

c) Vehicle routing with time windows and additional restrictions for each set of customers to be visited each day by the same truck.

These three phases were not resolved by ignoring the others phases; the solution method proposed includes constraints defined by the other phases. In Phase 1, restrictions are taken into account to help the later phases of scheduling visits and to try to balance the volume of monthly visits in each cluster, containing the customers with equal visit frequencies and who must be visited together. This involves constructing clusters with constraints mainly of capacity. Similarly, Phase 2 seeks to achieve well-formulated routes. Phase 3 seeks to minimize the total distance among the customers visited every day to its geometric centroid. In this work, Phase 1 and 3 are not considered. First, a short review of Phase 1 is presented (detailed in [16]) due to the relationship between the instance structures used in the design of experiments developed to solve the problem of scheduling visits to customers and the clusters obtained in the first phase.

2.1 Phase 1: Building the customer cluster

To solve the problem of the formation of distribution areas with capacity constraints, we decided to follow a philosophy similar to that proposed by Pacheco and Beltran [17] and Éric Taillard in [18]. They have adapted a k-means method using centroids to provide a clear physical interpretation of a real-world problem (the grouping of geographical areas) and provided the geometric center of each cluster.

```
Select the first seed randomly from the set of customers.
REPEAT
        Select the customer that is farther from all
        seeds already selected as new seed
UNTIL the number of selected seeds is less than k
```

Figure 1. Pseudocode of Phase 1, Method 1.