A solution GVNS for an intermodal VRPTW

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1 Introduction

In this paper, we present a route planning problem with combined transport features. A real problem of transportation planning for some companies in the Canary Islands is analyzed. The companies have warehouses on the larger islands and distribute their goods to other islands from these warehouses. In this situation, the planning takes into account the combined use of road transport and sea transport. We consider a single transport network combining both modes, which allows ships to move trucks between islands. In this network, there are some special nodes, which do not represent demand points, but modal change nodes of the network. These nodes have time windows that are influenced by the waiting frequencies and departure of ships. The presented problem is modeled as a Vehicle Routing Problem with Time Windows (VRPTW), which uses a multimodal network that allows alternative paths for routes. The VRPTW considers time windows for each customer and the customers have to be served by a vehicle within their time windows [1]. Different methods have been developed to solve the VRPTW, including Variable Neighborhood Search (VNS) [2]. Our problem is solved by an algorithm based on VNS, which provides operational planning solutions.

2 Intermodal VRPTW

The Intermodal VRPTW (IVRPTW) tackled in this paper is defined by means of a network $G = (V, A)$, where V is the set of nodes, and A is the set of arcs. The set V contains the depot, D, a set of n customer nodes, C, and a set of t ports, P. Customers are characterized by a demand, location and time window. Each customer is served at maximum once during the day. The depot has an associated time window. The fleet is composed of a set of m heterogeneous vehicles with different capacities. Moreover, associated with each vehicle k, there is a working shift composed of several time intervals during the planning horizon that can be different from one vehicle to another. Finally, the ports are characterized by their locations and time windows. Additional problem features are required for the IVRPTW:

- Each customer and each port is assigned a geographical zone. In our real case, a zone corresponds to an island.
- Each port is assigned a certain number of possible links with other ports.
- The ports do not have any associated demand.
- The time window corresponding to the ports is the one given for the depot.
- Each port is assigned a service time, which corresponds to the time required to put a vehicle on a ship.

3 General Variable Neighborhood Search proposed

In this work a particular implementation of General VNS (GNVS) is designed. VNS is a metaheuristic based on a simple principle, systematic changes of neighborhoods within the search [3]. Let $N_k(k = 1, ..., k_{max})$ be a finite set of neighborhood structures, and $N_k(s)$ the set of solutions in the k-th neighborhood of a solution s. In our particular implementation of the VNS, the neighborhoods used for the shaking process are selected following the ideas described by Repoussis et al. [4]. The proposed sequence of movements ($k_max = 6$) is defined as follows: GENI, Or-opt, CROSS, 2-opt, relocate and swapInter. This sequential selection is applied based on cardinality, which implies moving from relatively poor to richer neighborhood structures. The GENI operator

[5] chooses a customer from a route and inserts it into other route between the two closest customers to the previous one. The Or-opt operator [6] relocates a chain of consecutive customers of a route. The CROSS operator [7] selects a subsecuence of customers from a route, other subsequence of customers from other route, and interchanges both subsequences. The 2-opt operator [8] chooses two customers of a route and inverts the sequence of customer visited between them. The relocate operator [9] deletes a customer from a route and inserts it into another route. The swapInter operator selects a customer from a route, other customer from other route, and swaps them. Additionally, let $N_l, (l = 1, ..., l_{max})$ be the finite set of neighborhood structures that will be used in the local search conducted by a Variable Neighborhood Descent (VND). The VND method is obtained if the change of neighborhoods is performed in a deterministic way. The sequence of movements considered in this work ($l_{max} = 3$) is the following: relocate, swapIntra and swapInter.

4 Experimental results

In order to test our algorithm, test instances based on a real one have been created. Expected values have been obtained and the results have been usefull to verify the good behaviour of the approach. Relevant aspects of distribution planning between islands are obtained, as seen in Figure 1.

Fig. 1. Example of obtained routes planning

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