An Improved GRASP Interactive Approach for the Vehicle Routing Problem with Backhauls

C. Carreto[*] *B. Baker*[†]

[*] Departamento de Informática, Instituto Politécnico da Guarda
Av.Francisco Sá Carneiro 50, 6300-559 Guarda. Portugal.
Email: ccarreto@ipg.pt

[†] School of Mathematical and Information Sciences, Coventry University
Priory Street, Coventry CV1 5FB, England.
Email: b.baker@coventry.ac.uk

1 Introduction

GRASP (Greedy Randomised Adaptive Search Procedure), is a restart procedure where each iteration consists of a construction phase, followed by a local search phase that finds a locally optimal solution. See Resende [9] for a survey of GRASP. This method has been applied with success to many combinatorial optimisation problems [3], including the VRP [7] [8].

In the present study we investigate the incorporation of interactive tools into a GRASP algorithm to solve the Vehicle Routing Problem with Backhauls (VRPB), where the Backhaul customers, if any, are served after all Linehaul customers.

The aim of the interactivity is to integrate the insight and experience of the user, and the power and precision of the heuristics in an interactive environment. An interactive approach enables us to search for a solution by means of a trial and error procedure, in which man and machine divide the tasks in accordance with their best respective capabilities. The machine is by far superior in what concerns calculations and exhaustive search tasks. The human user is superior in judging fuzzy situations. Through interaction the user is able to control the solution process by selecting initial parameters, selecting algorithms and adjusting solutions. Furthermore, special knowledge of the real life problem can be included. In this way the user guides the heuristics towards promising parts of the solution space.

In the last decade we have witnessed rapid advances in information technology, which have resulted in enormous increases in processing power and man-machine interaction capabilities. It is now feasible to involve humans throughout the solution process for solving routing problems. Baker [1], has shown that excellent results for the basic Vehicle Routing Problem (VRP) can be obtained by an interactive approach based on the Generalised Assignment approach of Fisher and Jaikumar [4]. Carreto and Baker [2], extended this approach into a GRASP interactive algorithm also showing that excellent results can be obtained for the VRPB. In this paper we present an improved GRASP interactive approach that includes a more powerful local search phase.

2 The interactive Solution Method

We identify three different phases in our interactive solution method: *Seeds Selection*, *Routes Construction and Improvement*, and *Solution Refinement*. The next sections describe these phases.

2.1 Seeds Selection

The seeds are the customers that for some reason the user forces to be serviced by specific vehicles. The user selects the seeds for each vehicle in accordance with his local knowledge and experience of a real life problem, or by identifying certain patterns such as clusters of customers, customers with very high demands or isolated customers. During the selection process the user is helped by the computer, which checks for constraint violations.

The selection of the seeds can be seen as a critical phase since the seeds are the starting point for the solution method. If they are not well chosen, the solution will be poor or infeasible. It is also the seed selection that determines the number of vehicles used. Although being a critical phase, the interaction makes it easy for the user to try different seeds in order to obtain a satisfactory solution. The user can do this by selecting completely new seeds or making minor adjustments during the solution process as explained in section 2.3.

2.2 Routes Construction and Improvement

The routes construction and improvement phase constructs the routes by clustering the remaining customers according to the vehicles defined by the seeds while applying a modified 3-optimal heuristic in order to reduce the total distance travelled by each vehicle. This clustering is done without user intervention and is implemented in the construction phase of the GRASP algorithm. The heuristic may find a feasible solution where all the customers have been allocated to the vehicles; or the clustering may result in an infeasible solution, because there was a violation of a capacity or distance constraint.

The clustering heuristic allocates each customer to the position in a route where the insertion cost is minimised, giving allocation priority to customers with a more obvious insertion route, and to customers for which the number of routes they can go on is smallest, and while applying a modified 3-optimal heuristic in order to reduce the total distance travelled by each vehicle.

If the clustering heuristic results in a feasible solution, a local search phase is called to try to improve it. Our GRASP local search phase makes use of two well-known inter-route interchange procedures, the *one-node interchange* and the *two-node interchange* procedures. The procedures are applied in sequence, first the one-node interchange and next the two-node interchange.

We considered two strategies for selecting the next move in each procedure: *Best-improve*, which examines all the possible interchanges and chooses the one resulting in the largest saving, and *First-improve*, which immediately accepts the first interchange that gives a positive saving.

We also implemented a p-Neighbourhood strategy, similar to the one presented by Gendreau et al [5], to speed up the local search phase by reducing the number of interchanges to consider in each iteration. The reduction is achieved by considering as destination routes of the interchanges, only those that are "close" to the customer that is being repositioned.

We considered two metrics to determine the "closeness" of the customers in the p-Neighbourhood: *Circular*, which corresponds to the straight line distance between customers, and *Savings*, which corresponds to the savings metric proposed by Yellow [10].

As described in section 2.1, the user initiates the GRASP interactive approach with the selection of a set of seed customers that he chooses by identifying certain patterns of customers, or by using his experience or local knowledge about the instance. It may be desirable that the seed customers continue to be served by the same routes in the final solution, especially in real life instances. Therefore, the interactive setting allows the user to enable or disable interchanges involving seed customers, during the local search phase.

2.3 Solution Refinement

After the routes construction and improvement phase, the user can try to refine the solution in order to improve it (especially if it is infeasible), by using interactive tools. With no formal rules to follow, the interactive system we developed is sufficiently flexible to allow creativity and imagination from the user, and different refinement techniques are possible for using these tools. The simplest example consists of the removal of some customers from their current routes, followed by a new call to the construction and improvement heuristics. A new set of GRASP iterations will be performed that will try to reallocate the removed customers and search for a possible local optimum, eventually improving the solution. This is a very effective procedure when there is some overlap between routes, and can lead to several different feasible solutions in a very short period of time.

3 Conclusions

Interactive methods for vehicle routing are appealing because they integrate the insight and experience of the user, and the power and precision of heuristics in an interactive environment. Computational results for 14 problems proposed by Goetschalckx and Jacob-Blecha [6] showed that results within 1% of the best known can be obtained for all the problems, within reasonably short interactive sessions. A new best-known solution was obtained for one of the problems. The improved GRASP interactive approach was also compared with four metaheuristics from the literature, obtaining similar or better results than all of them.

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