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Large Neighborhood Search for Variants of TSP

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1 Large Neighborhood Search

To solve problems with Local Search procedures, neighborhoods have to be defined. During the resolution, a solution is typically replaced by the best solution found in its neighborhood. A question concerns the size of the neighborhood. If a small neighborhood can be explored in polynomial time, a large neighborhood search may bring a faster convergence to a local optimum of good quality (see [1] for further details). In this paper, we propose a class of large neighborhood search which can be implemented on some extensions of the Traveling Salesman Problem.

2 Considered TSP Variants

In the Traveling Salesman Problem, one has to find a closed tour of minimal length connecting n given cities. The problems we are interested in are the problems which allow to visit a subset of the cities: Generalized Traveling Salesman Problem (GTSP) [5], Traveling Salesman Problems with Profits [4], Traveling Purchaser Problem (TPP) [6] ... All those problems are NP-hard. In the GTSP, the nodes are partitioned into clusters and the salesman has to visit at least one node in each cluster. TSP with Profits are a generalization of the TSP where it is not necessary to visit all vertices. A profit is associated with each vertex. The overall goal is the simultaneous optimization of the collected profit and the travel costs. In the TPP, cities have to be visited to collect a set of commodities. Each city sells a number of commodities at a known price. The TPP consists in selecting a subset of cities purchasing every product, while minimizing the sum of the routing costs and the purchase costs.

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3 The dropstar neighborhood

In this section, we present a large neighborhood operator for the TPP. The dropstar neighborhood is an extension of the drop neighborhood [6]. In the drop neighborhood, a city is dropped from the tour, when the decrease in traveling costs offsets the increase in purchase costs. A single city is dropped each time the procedure is called. Through the dropstar neighborhood, we determine the optimal set of cities, consecutive or not, that should be dropped while keeping the ordering of the cities that remain in the tour. This extension permits to expand the size of the neighborhood. Unfortunately, computing this subsequence is NP-hard. Indeed, it can be easily seen that when distances are zero, the problem reduces to a Set Covering Problem. It can however be solved efficiently by means of a dynamic programming algorithm inspired from the algorithm developed in [3] for the Elementary Shortest Path Problem with Resource Constraints.

The objective is to find a shortest path between two copies of the depot in a graph built as presented in Figure 1 for the example of a current tour (4,2,7,3,10), with the constraint that all commodities have to be purchased. In this graph, each path represents a sub sequence of the tour. Among these paths, the dropstar procedure determines the optimal one. In order to improve efficiency, ad hoc dominance rules can be defined.

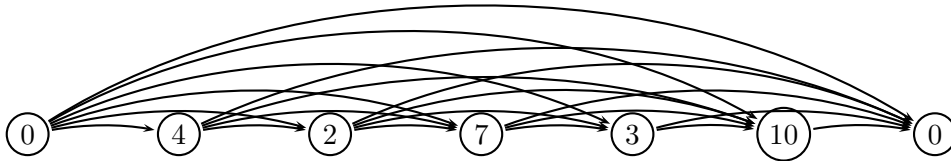


Figure 1: Example of a tour and resulting graph used by *dropstar*

4 Results and perspectives

We addressed the solution of the TPP with an Ant Colony Optimization procedure combined with local-search scheme [2]. The global method integrates dropstar into a large neighborhood descent method each time a promising solution is found by the Ant Colony Optimization method. Our algorithm has been evaluated on 140 instances proposed by Riera-Ledesma and Salazar-González [6], for which 89 optimal solutions are known. It succeeds in finding 86 out of the optimal solutions and 48 new best known solutions out of the 51 remaining instances. On other instances it achieves good or very good solutions most of the times. The dropstar procedure consumes a reasonable amount of time.

As far as we know, such kind of operators is new for the TPP or for other routing problems where subsequences can be searched for as the one referred to in Section 2. An interested extension of this operator is to use this principle to insert unvisited cities in the tour or to simultaneously insert and drop cities.

The subject of this talk will be the description of the dropstar mechanism applied to the TPP, and its extensions to both insertion mechanisms and similar problems as the GTSP and the TSP with Profits.

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