An Adaptive Variable Neighborhood Search for the Travelling Salesman Problem with Relaxed Priority Rule

Doan Thanh Tan[1], Nathalie Bostel[1], Ha Minh Hoang[2]

[1] Université de Nantes, LS2N, SLP team, France
doan.tan@imt-atlantique.fr
[2] Université de Nantes, LS2N, SLP team, France
Nathalie.Bostel@univ-nantes.fr
[3] VNU University of Technology and Engineering, OR Lab, Vietnam
minhhoangha.vth@gmail.com;

Keyword : *AVNS, TSP-RPR, priority, service level routing, d-relaxed rule*

1 Introduction

The Travelling Salesman Problem (TSP) is a well known problem in the family of vehicle routing problems (VRP). In this study, we focus on the problem in which customers require different priority levels. The problem is motivated by the study by Panchamgam [2] in the context of humanitarian relief. In this study, the author used a rule called d-relaxed priority to control the service of distributing relief goods to vulnerable groups depending on their emergency. We are studying some practical applications of this problem in addition to the humanitarian relief. For example, dispatching Unmanned Aerial Vehicles (UAVs) to serve customers with different priorities or distributing goods based on inventory backlog, etc. We name this problem the Travelling Salesman Problem with Relaxed Priority Rule (TSP-RPR).

2 Travelling Salesman Problem with Relaxed Priority Rule

The TSP-RPR is defined on a symmetric graph $G = (N, E)$ where $N = \{0, \ldots, n\}$ is a set of nodes and $E = \{(i, j) : i, j \in N, i \neq j\}$ is a set of edges. In N, node 0 represents the depot while nodes $i = 1, \ldots, n$ represent customers. Customers are divided into g groups. Service level of each group is represented by a priority $p \in P = \{1, \ldots, g\}$. In P priorities are sorted in descending order. The objective is to find a Hamiltonian tour of minimum cost respecting the d-relaxed priority rule as follows:

Definition 1 *A tour satisfies the d-relaxed priority rule if at any customer i, the next customer has priority no greater than $p + d$ where p is the highest priority of all customers behind i.*

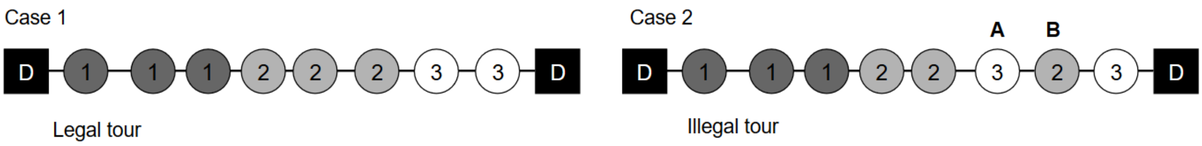

FIG. 1: Two example tours with $d = 0$

We illustrate the rule in Figure 1 with $d = 0$, number in circle represents priority of customer, D represents the depot. Case 2 is a illegal tour because after node A, priority of node B must smaller than 4 (note that the lower value of priority, the higher priority). The TSP-RPR is also known as the Hierarchical TSP (HTSP). In 2018, an improved model, a metaheuristic method and experiments on this problem were proposed with instances up to 200 nodes [1]. To solve the instances, the authors used IBM-CPLEX and compared with a metaheuristic called GILS-RVND (Greedy Randomized Adaptive Search Procedure, Iterated Local Search and Random Variable Neighborhood Descent). In [3], we present the general case of this problem, called the Hierarchical VRP (HVRP) and the Adaptive Large Neighborhood Search (ALNS) to solve both the HTSP and the HVRP with different instances.

3 Adaptive Variable Neighborhood Search (AVNS)

Previously, we proved that ALNS can achieve a balance between runtime and solution quality [3]. It was designed to handle different situations at large scales. These situations require fast runtime and sometimes, operation cost is not the first requirement. Therefore, the solution quality in ALNS is comparable to GILS-RVND. To emphasize the solution quality and to adapt to small and moderate instances, we have designed an AVNS algorithm that is different from ALNS on the perturbation design and the adaptive mechanism to select operators in the perturbation list. It allows to simultaneously increase the probability of choosing a stronger and a weaker operator at the same time. We also adapt classical local search operators to the d-relaxed priority rule as well as the data structure to shorten runtime.

4 Results

The preliminary experiments on the TSP-RPR with 116 instances in [1] show that compared to ALNS in [3] and GILS-RVND in [1], our AVNS can find the new best solutions for most of the instances with 200 nodes and can improve the average cost for 68% of all instances. The average deviation (the difference between the average and the best cost of all instances) is 0.08% in comparison with 0.46% and 0.51% in the case of ALNS and GILS-RVND, respectively. Runtime is also a competitive point of AVNS for instances up to 100 nodes. For instances of 200 nodes, ALNS is the fastest and GILS-RVND is the worst. Although AVNS is not the best in terms of runtime, it can produce equivalent or better results compared to the other algorithms in about ten seconds on average. This runtime is not very far from that of ALNS.

5 Conclusions

In this study, we attempt to introduce a new formula for the TSP-RPR and a new metaheuristic method to solve the problem effectively. The preliminary experiments show the potential performance of the new method.

References

[1] Nguyen Phuong H, Nhat H T N, Hoàng Hà M, Langevin A and Trépanier M. Solving the clustered traveling salesman problem with d-relaxed priority rule. *ArXiv e-prints:1810.03981*, 2018.

[2] Panchamgam K. Essays in retail operations and humanitarian logistics. PhD thesis. *Robert H.Smith School of Business, University of Maryland (College Park, Md.)*, 2011.

[3] Doan T, , Bostel N, Hoàng Hà M. An Adaptive Large Neighborhood Search for the Hierarchical Vehicle Routing Problem. *Congrès ROADEF 2019: Livre des Résumés*, 65–66, 2019.