New model and metaheuristic for the Clustered Traveling Salesman Problem with relaxed priority rule

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1 Introduction

We address a recent variant of Travelling Salesman Problem (TSP) called Clustered TSP with relaxed priority rule (CTSP-d). The problem was first introduced in [2] in the context of humanitarian relief and named the Hierarchical TSP (HTSP). In [3], the authors compare the HTSP to the TSP in terms of worst case behavior. In this problem, customers are divided into several priority groups with a rule called d-relaxed priority rule to control service plan. In 2020, the HTSP is improved by [1] with new models and the problem is renamed the CTSP-d. The authors also generate a new instance set with instances of up to 200 nodes. To solve the instances, the authors use IBM-CPLEX and a metaheuristic called GILS-RVND, which is a combination of the Greedy Randomized Adaptive Search Procedure (GRASP), Iterated Local Search (ILS), and Random Variable Neighborhood Descent (RVND). In this study, we introduce a new model and a ILS-based metaheuristic for the CTSP-d and we compare the results to the previous studies.

2 CTSP-d and d-relaxed priority rule

The CTSP-d is defined on a symmetric graph $G = (N, E)$ where $N = \{0, \dots, n\}$ 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 $i = 1, \dots, n$ represent customers. Customers are divided into g groups. Service level of each group is represented by a priority $p \in P = \{1, \dots, g\}$. In P, the 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 *Given a tour $\mathcal{S}$ and a positive integer d, the service order of a node i with priority p is always smaller than the service order of a node j with priority $q > p + d$, $\forall p, q \in P$.*

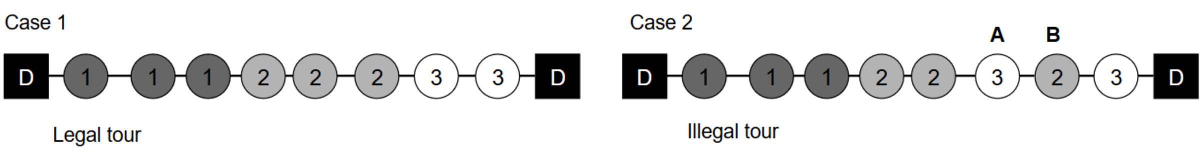

FIG. 1: Two example tours with $d = 0$

We illustrate the rule in Figure 1 with $d = 0$. Number in circle represents the priority of the customer and D represents the depot. Case 2 is a illegal because with $d = 0$, the service order of node B with priority $p = 2$ cannot be greater than the service order of node A with priority $q = 3 > 2$. In other words, B must be served before A.

3 New model and ILS-based metaheuristic for the CTSP-d

In this study, we develop a model for the CTSP-d based on the classical TSP model combined with constraints to simulate the d-relaxed priority rule and additional constraints to improve the model performance. In addition, to solve medium and large instances effectively, we present a new ILS-based metaheuristic integrating a mechanism to deal with the rule. This mechanism has been previously presented in [4]. In the metaheuristic, we design and adapt 3 perturbation and 3 local search operators to solve the problem with two different settings. Some techniques to improve the search are also applied.

4 Results

We perform experiments on the instance set of [1] with two types of instances, which are type R (random) and type C (Clustered). We use CPLEX to solve small instances with 48 and 52 nodes. Results show the advantage of our model compared to the best model in [1]. With the ILS-based metaheuristic, we solve 116 instances from 52 to 200 nodes and achieve outperformed results compared to the ALNS of [4] and the GILS-RVND of [1] in most of the tests. More specifically, our ILS finds 23 new best solutions compared to GILS-RVND, 14 new best solutions compared to ALNS. ILS often yields high solution quality with very low gaps (the gap between the average solution and the best solution after 10 runs). For example, the average gap of all type R instances in ALNS is 4.1 times higher than that in our ILS while in GILS-RVND, it is 6.6 times higher. On the runtime aspect, after considering CPU power between authors, our ILS also proved that it can effectively solve larger instances in shorter running times.

5 Conclusion

In this study, we introduced a new model for the CTSP-d and a ILS-based metaheuristic to solve the problem with instances of up to 200 nodes. The experiments show that both new model and metaheuristic yield promising results compared to the previous studies.

References

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