# The Selective Traveling Salesman Problem with Draft Limits

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## 1 Introduction

Recently, new variant of Traveling Salesman Problem (TSP) in the context of maritime transportation, called Traveling Salesman problem with Draft Limits (TSPDL) has been proposed [2]. TSPDL consists of visiting and delivering goods for a set of ports using a ship located initially at a depot. Since each port has a delivery demand known in advance the ship starts the tour with a load equal to the total demand, visits each port exactly once and comes back to the depot performing the lowest cost (length) tour. However, to each port it is assigned a draft limit, which represents the maximal allowed load on the ship upon entering some port.

In this paper, we propose a variant of TSPDL called Selective TSPDL (STSPDL). The differences between STSPDL and TSPDL are the following :

- Visiting a port in STSPDL results in collecting ceratin amount of the profit assigned to that port.
- Unlike to TSPDL, in STSPDL it is not required to visit all ports.
- Objective function of STPDL seeks to maximize the total profit captured on a tour, which equals to the difference of the sum of profits of visited ports and the tour length.

Formally, the problem may be stated as follows. Given an undirected graph $G = (V, E)$ where $V = \{0, 1, ..., n\}$ represents the set of ports including the starting port, i.e., the depot denoted by 0, while $E = \{(i, j)|i, j \in V, i \neq j\}$ represents the edge set where each edge $(i, j)$ from the set $E$ has the associated cost $c_{ij}$. For each port $i$, apart from the depot, a draft limit, $l_i$, a demand, $d_i$, and a profit $p_i$ are given. Therefore the goal of STSPDL is to design maximal profit tour respecting draft limit constraints of each visited ports. Additionally, let us denote by $L_i$ the load on the ship upon entering the port $i$, calculated relatively to a given tour $T$. The tour $T$ will be called a feasible tour if $L_i \leq l_i$ for all $i \in V$, otherwise it will be called an infeasible tour.

## 2 Proposed solution approach

In order to tackle STSPDL, we propose a mixed integer programming formulation of STSPDL as well as a heuristic based on a variable neighborhood search methodology [1]. Variable neighborhood search (VNS) is a metaheuristic proposed by Mladenovic and Hansen in 1997 [1]. The basic variant of variable neighborhood search (called Basic VNS) consists of executing alternately, one local search procedure (used to improve a solution) and one so-called shaking procedure (used to hopefully resolve local minima traps) together with neighborhood change. A well-known and widely-used VNS variant is the so-called General VNS (GVNS). It is derived from the basic VNS scheme by replacing a simple local search by some more advanced improvement procedure that examines several neighborhood structures. The most common improvement procedures used within GVNS are based on variable neighborhood descent (VND), such as sequential VND, nested VND, cyclic VND and so on.

The proposed GVNS heuristic as a local search applies a variable neighborhood descent procedure which explores eleven neighborhood structures. Three of these eleven neighborhood structures are used to determine subset of ports to be visited, while the remaining eight are used to determine the lowest cost tour connecting currently chosen ports. Each of those neighborhoods contains both feasible and infeasible solutions. Hence, in order to quickly recognize infeasible solutions, we implement an efficient procedure for checking the feasibility of the explored solutions.

In order to escape from the current local optima our GVNS uses a shaking function which returns a solution obtained by preforming $k$ times a random insertion move on a given tour. More precisely the shaking function at each iteration chooses at random one port from the tour and moves it, either forward or backward, after another port, also chosen at random.

## 3 Conclusions

In this paper we introduce new variant of Traveling Salesman Problem with Draft Limits (STSPDL) called Selective TSPDL and formulate it as a mixed integer program (MIP). The proposed MIP formulation turns out suitable for solving small size instances, while on large size instances General Variable Neighborhood Search (GVNS) appears to be good alternative. In addition, GVNS succeeds to find all solutions whose optimality were proven solving MIP formulation.

## Références

[1] Nenad Mladenović and Pierre Hansen. Variable neighborhood search, *Computers and Operations Research*, 24 : 1097–100, 1997.

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