Load-Dependent and Precedence-Based Models for Pickup and Delivery Problems

Luís Gouveia\textsuperscript{a,1}, Mario Ruthmair\textsuperscript{b,c,2,}\textsuperscript{*}

\textsuperscript{a}Centro de Investigacao Operacional \& Faculdade de Ciencias, University of Lisbon, Lisbon, Portugal
\textsuperscript{b}Institute of Computer Graphics and Algorithms, Vienna University of Technology, Vienna, Austria
\textsuperscript{c}Mobility Department, Austrian Institute of Technology, Vienna, Austria

Abstract

We address the one-to-one multi-commodity pickup and delivery traveling salesman problem (\textit{m}-PDTSP) which is a generalization of the TSP and arises in several transportation and logistics applications. The objective is to find a minimum-cost directed Hamiltonian path which starts and ends at given depot nodes and such that the demand of each given commodity is transported from the associated source to its destination and the vehicle capacity is never exceeded. In contrast, the many-to-many one-commodity pickup and delivery traveling salesman problem (1-PDTSP), just considers a single commodity and each node can be a source or target for units of this commodity. We show that the \textit{m}-PDTSP is equivalent to the 1-PDTSP with additional precedence constraints defined by the source-destination pairs for each commodity and explore several models based on this equivalence. In particular, we consider layered graph models for the capacity constraints and introduce new valid inequalities for the precedence relations. Especially for tightly capacitated instances with a large number of commodities our branch-and-cut algorithms outperform the existing approaches. For the uncapacitated \textit{m}-PDTSP (which is known as the sequential ordering problem) we are able to solve to optimality several open instances from the TSPLIB and SOPLIB.

Keywords: Transportation, Traveling Salesman, Sequential ordering problem, Pickup and Delivery, Precedence constraints

1. Introduction

In this paper we propose a new approach for the one-to-one multi-commodity pickup and delivery traveling salesman problem (\textit{m}-PDTSP) introduced by Hernández-Pérez \& Salazar-González (2009). The problem arises in several

\textsuperscript{*}Corresponding author

Email addresses: legouveia@fc.ul.pt (Luís Gouveia), mario.ruthmair@ait.ac.at (Mario Ruthmair)

\textsuperscript{1}This work is supported by National Funding from FCT - Fundaçao para a Ciência e a Tecnologia, under the project: PEst-OE/MAT/UI0152

\textsuperscript{2}This work is supported by the Vienna Science and Technology Fund (WWTF) through project ICT10-027.