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The Constrained Shortest Path Tour Problem

Daniele Ferone * Paola Festa * Francesca Guerriero †‡ Demetrio Laganà†

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Abstract

In this paper, we study the constrained shortest path tour problem. Given a directed graph with non-negative arc lengths, the aim is to find a single-origin single-destination shortest path, which needs to cross a sequence of node subsets that are given in a fixed order. The subsets are disjoint and may be of different size. In addition, it is required that the path does not include repeated arcs.

Theoretical properties of the problem are studied, proving that it belongs to the complexity class **NP**-complete. To exactly solve it, a Branch & Bound method is proposed. Given the problem hardness, a Greedy Randomized Adaptive Search Procedure is also developed to find near-optimal solutions for medium to large scale instances.

Extensive computational experiments, on a significant set of test problems, are carried out in order to empirically evaluate the performance of the proposed approaches. The computational results show that the Greedy Randomized Adaptive Search Procedure is effective in finding optimal or near optimal solutions in very limited computational time.

Keywords: *Shortest path problems, Network flow problems, Combinatorial optimization, Branch & Bound, GRASP.*

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1 Introduction

The constrained shortest path tour problem ($\mathcal{CSPTP}$) consists in finding a single-origin single-destination shortest path in a directed graph such that a given set of constraints is satisfied. In particular, in addition to the restrictions imposed in the original version of the problem (see [2], [6], and [7]), requiring that the path needs to cross a sequence of node subsets that are given in a fixed order, in the $\mathcal{CSPTP}$ it is imposed that the path does not include repeated arcs.

The $\mathcal{CSPTP}$ can be viewed as a special case of the network interdiction problem on a flow network ([15]), in which an attacker disables all the arcs of a network, whenever they

*Department of Mathematics and Applications, University of Napoli FEDERICO II, Italy. E-mail: daniele.ferone@unina.it, paola.festa@unina.it

†Department of Mechanical, Energetic and Management Engineering, University of Calabria, Italy. E-mail: francesca.guerriero@unical.it, demetrio.lagana@unical.it

‡Corresponding author. Phone: 39-0984-494620, francesca.guerriero@unical.it

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