

# Relaxations and algorithms for the traveling salesman problem with time-dependent service times

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## Abstract

We consider the Traveling Salesman Problem with time-dependent Service Times (TSPST), which is a generalization of the well-known NP-hard Asymmetric TSP (ATSP). As in the classical ATSP, we are given a directed complete graph, and each arc is assigned a cost representing the corresponding travel time. In the TSPST, each customer also requires a service time whose duration depends on the time at which the service starts at that customer. The TSPST calls for finding a Hamiltonian tour minimizing its total duration (i.e. the sum of the travel times and of the service times).

In a recent paper by Tas, Gendreau, Jabali and Laporte (*European Journal of Operational Research* 248, 372-383, 2016), "compact" Mixed Integer Programming (MIP) formulations, using a polynomial number of constraints, are presented. With the aim of improving the Lower Bound corresponding to the Linear Programming (LP) Relaxation of the MIP model, we propose strengthened exponential-size formulations that explicitly incorporate subtour elimination constraints and additional valid inequalities. An exact branch-and-cut algorithm and a metaheuristic are also proposed for the solution of the TSPST. Extensive computational experiments on symmetric and asymmetric benchmark TSPST instances are reported, showing the effectiveness of the proposed relaxations and algorithms.

## Keywords

TSP, mixed integer programming, relaxations, exact algorithms, metaheuristics

## Biography

**Paolo Toth** is "Professor Emeritus" of "Combinatorial Optimization" at DEI, University of Bologna, Italy.

His research interests include Operational Research and Mathematical Programming and, in particular, the definition of mathematical models and the design and implementation of effective exact and heuristic algorithms for the solution of NP-hard Combinatorial Optimization and Graph Theory problems.

He is author of more than 190 papers published in international journals and of several books. His h-index is 71, and his number of citations is over 23,000.

He was Chairman of the Program Committee and of the Organizing Committee of several national and international Conferences. He is currently member of the Editorial Boards of the journals: "European Journal of Operational Research", "Journal of Heuristics", "Networks", "Journal of the Operational Research Society", "Discrete Optimization", "Discrete Applied Mathematics", "International Transactions in Operational Research", "EURO Journal on Transportation and Logistics".

He was President of EURO (Association of the European Operational Research Societies) for the period 1995-1996, and President of IFORS (International Federation of the Operational Research Societies) for the period 2001-2003.

He was the recipient of the following international awards: "Harold Larnder Memorial Lecture" (1996); "EURO Gold Medal" (1997); "Doctorate honoris causa" in Operational Research from the University of Montreal (2003); "Robert Herman Lifetime Achievement Award in Transportation Science" from INFORMS (2005); "INFORMS Fellowship" (2016).