Sparse Capacitated Arc Routing Problem
Deterministic and Robust Approaches: Formulations and algorithms

Abstract

In this work, we study the capacitated arc routing problem (CARP) over a special class of underlying graphs under a deterministic case and under a set of scenarios. In particular, we deal with CARP under sparse underlying graphs. For simplification, we call this problem the sparse CARP. More precisely and to avoid any misunderstanding that may concern the definition of our studied problem, we treat the CARP with underlying graphs of densities between 0.5 and 0.001. Our sparse graphs are graphs in which the degree of each vertex does not exceed 3. Such CARP problem instances have not been treated before, and to the most of our knowledge, we are the first who study such cases. The importance of this study lies in its applications especially in the cases of crisis such as wars and distribution of dangerous and sensitive goods as chemical or nuclear substances or medicines. An example from the real life situations of a sparse CARP is given in the following; if a natural disaster took place such as earthquake or hurricane, then any transportation will be limited on the resulting sparse underlying graph. This is due to the fact that many routes will be cut and barred. Throughout this work, we study (1) the sparse CARP which is defined over a sparse underlying graph and (2) the robust sparse CARP under travel costs uncertainty. A capacitated arc routing problem is said to be sparse if its graph or network G is sparse from graph theory point of view, i.e. a sparse graph is a graph which has a relatively small density which is defined to be the ratio of the number of actual edges of the graph to the maximum possible number of edges in the graph. We present new mathematical formulations, new resolution methods and new algorithms. We develop greedy heuristics and new adapted metaheuristics based on adapted tabu search algorithm. Our work is divided into two parts: in the first part we study the deterministic approach of the sparse capacitated arc routing problem (sparse CARP), and we introduce a new transformation technique of CARP into CVRP over sparse underlying graphs. Moreover, we give new mathematical formulations of the sparse CARP and we develop heuristic and metaheuristic algorithms to solve the studied problem in addition to computational experiments that show the effectiveness of the developed approaches and methods. In the second part of this work, we treat the robust sparse capacitated arc routing problem under travel costs uncertainty where we introduce this uncertainty by a set of scenarios. A mathematical modeling of the robust problem is given in addition to a greedy heuristic algorithm and an adapted tabu search algorithm to solve the problem. Promising numerical results showing the robustness of the developed methods are presented in the end of this part.