1-1-2019

The application of Evolutionary Computation and Metaheuristics for Solving the Network Design Problems

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Abstract

Network Design Problems (NDPs) can model many real-life problems in a wide range of domains from transportation, supply chain management and logistics, through to the design of telecommunication networks and airline routes. NDPs are generally tackled through employing sophisticated exact methods and (meta-)heuristics. Exact methods mainly include mixed integer programming, column generation, and branch and bound techniques. Metaheuristics, as the second strategy of solving NDPs, can comprise any construction methods, local searches (point-based), evolutionary (population-based) techniques as well as their hybrids. In this abstract, we discuss the challenges and potentials of designing an effective hybrid metaheuristic for solving NDPs by considering the Steiner tree problem as a representative for NDPs...

Keywords

network, solving, application, evolutionary, problems, computation, design, metaheuristics

Disciplines

Engineering | Physical Sciences and Mathematics

Publication Details

Amirghasemi, M., Du, B., Barthelemy, J., Ogie, R. I. & Perez, P. (2019). The application of Evolutionary Computation and Metaheuristics for Solving the Network Design Problems. In S. Elsawah (Ed.), 23rd International Congress on Modelling and Simulation (MODSIM2019) (p. 194). Australia: Modelling and Simulation Society of Australia and New Zealand.

The application of evolutionary computation and metaheuristics for solving the Network Design Problems

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Abstract: Network Design Problems (NDPs) can model many real-life problems in a wide range of domains from transportation, supply chain management and logistics, through to the design of telecommunication networks and airline routes. NDPs are generally tackled through employing sophisticated exact methods and (meta-)heuristics. Exact methods mainly include mixed integer programming, column generation, and branch and bound techniques. Metaheuristics, as the second strategy of solving NDPs, can comprise any construction methods, local searches (point-based), evolutionary (population-based) techniques as well as their hybrids. In this abstract, we discuss the challenges and potentials of designing an effective hybrid metaheuristic for solving NDPs by considering the Steiner tree problem as a representative for NDPs.

The Steiner tree problem can be considered as a generalised minimum spanning tree problem. Whilst the objective of minimum spanning tree problems is to find the minimum-total-weight subset of edges that connects *all* the nodes, the Steiner tree problem is not constrained to include all the nodes. It still has the same objective but only requires a *subset* of nodes, called *terminals,* to be connected and the rest of nodes are optional for being included. This simple relaxation makes the problem highly intractable (NP-Hard). Such relaxation of constraints makes the design of a hybrid metaheuristic a valid alternative for this very interesting problem.

Metaheuristics applied to Steiner tree problem can be categorized into construction methods, point-based methods and local searches as well as population-based and evolutionary methods. Whereas construction methods incrementally create a solution in each iteration, point-based methods start with a complete solution and they then traverse the search space by moving from one solution to another in each iteration, aiming to improve the solution quality. In effect, population-based techniques enhance the solution quality by operating on a pool of complete solutions, employing the notions of *competition* (via selection) and *co-operation* (via genetic recombination).

The key to proposing an effective general metaheuristic the Steiner tree problem is a synergistic combination of the aforementioned techniques, aiming to strike a balance between *intensification* and *diversification* aspects of the search process (Figure 1). Analysing the fitness landscape of the problem in question is also of high importance in this regard.

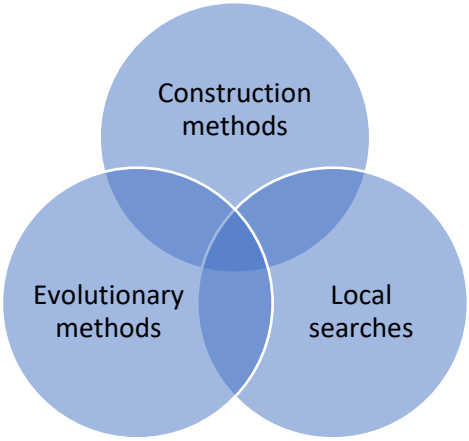

Figure 1. A synergistic hybrid of three search strategies

Keywords: *Network Design Problem, evolutionary computation, metaheuristics, minimum spanning tree, Steiner tree problem*