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The One-Commodity Traveling Salesman Problem with Selective Pickup and Delivery

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Abstract

This paper discusses a novel combinatorial optimization problem which arises in the domain of wireless sensor networks. A mobile robot with limited cargo capacity replaces damaged sensors, previously deployed over an area of interest, with passive ones so as to preserve the network coverage. The one-commodity traveling salesman problem with selective pickup an delivery is strongly related to the pickup and delivery traveling salesman problem and the prize-collecting travelling salesman problem. The problem is characterized by the fact that the demand of any delivery customer can be met by a relatively large number of pickup customers. While all delivery spots are to be visited, only profitable pickup locations will be included in the tour. A hybrid meta-heuristic approach between genetic algorithms and ant colony optimization is put forward.

Keywords: traveling salesman problem, wireless sensor networks, genetic algorithm, ant colony optimization

This paper discusses a novel combinatorial optimization problem: *"the one-commodity traveling salesman problem with selective pickup and delivery"* (1-TSP-SELPD). The 1-TSP-SELPD is strongly related to the pickup and delivery traveling salesman problem (PDTSP) and the prize-collecting travelling salesman problem (PC-TSP). The one-commodity PDTSP (1-PDTSP) was introduced in [1] as a TSP departure in which all nodes are either delivery customers or pickup customers. A certain amount of a unique commodity is demanded by the former and provided by the latter. It differs from the general TSP with pickups and deliveries (TSPPD) [2] in that the commodity gathered at a pickup customer can be used to meet the need of a delivery customer, as opposed to TSPPD where all commodities have to depart from or end up at the depot. The PC-TSP is a particular instance of a more general TSP taxonomy labeled TSP with profits [3], in which the chief assumption is that not all nodes have to be visited and that a certain profit is associated with every node in the problem. In the PC-TSP, the objective is to minimize travel costs while the collected profit is not smaller than a predefined value.

The 1-TSP-SELPD shows resemblance to both the 1-PDTSP and the PC-TSP. Its distinctive feature is the underlying assumption that all delivery customers must be readily served but we visit only those pickup locations which are deemed profitable in terms of total travel distance. This is equivalent to say, from the PC-TSP standpoint, that a delivery customer bears a much greater profit than a pickup customer. This type of travelling salesman problem arises in the domain of wireless sensor and robot networks [4]. A mobile robot with limited cargo capacity replaces damaged sensors (previously deployed over an area of interest) with passive ones so as to preserve the network coverage. The robot is located at a base station. Its goal is to collect passive sensors all over the field and drop them at sensing holes. An optimal robot tour is to be computed so that the network coverage can be repaired by replacing all damaged sensors with spare ones. An optimal tour is defined as a minimal-cost, feasible robot tour, where the tour cost is defined as the total distance traveled and the tour length is the number of nodes in the tour.

The 1-TSP-SELPD is solved with a hybrid metaheuristic algorithm that finds promising solutions within an acceptable time frame. The exploratory power of genetic algorithms is combined with an intensive exploitation of good visiting sequences based on pheromone trails from artificial ant colonies. The genetic algorithm is strengthened via problem-specific local search operators and via an adaptive population renewal mechanism which is enforced through generational pre-crossover parent mutation. Results from extensive simulations confirm the quality of the proposed hybrid heuristic method.

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