A skewed general variable neighborhood search for solving the battery swap station location-routing problem with capacitated electric vehicles

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Abstract

The routing and location of the recharging station decisions can be considered as two primary roles for reducing the amount of energy consumption in several companies. Moreover, many studies demonstrate that taken this two decisions separately is often more easy to take the good decision. In this work, we consider a new variant of location-routing problem for an electric vehicle with a single depot, which integrates the decision of the location of the Battery Swap Stations (BSS) with the elaboration of vehicle routing. The battery swap station location-routing problem with capacitated electric vehicles (BSS-EV-LRP) considers a fleet of electric vehicles with a limited battery power level and a capacity of the electric vehicle. The electric vehicles deliver goods from depot to customers with given demands and can stop at BSSs to exchange their discharged battery for a fully charged one. The aim of the problem is the problem is the: (i) location of a set of the BSS from a set of BSS candidates, (ii) distribution of customers to electric vehicle, (iii) distribution of electric vehicles to the BSS and (iv) building the routes from the depot to serve customers with the BSS service considering the battery driving range and the loading capacity limitation of the electric vehicles.

We propose a Skewed General Variable Neighborhood Search (SGVNS) method to solve the problem. Our method involves the application of the set neighborhood structures in the local search algorithm between the location and routing decisions. We have developed different type of moves within five neighborhood structures where one neighborhood concerns the location decision: relocated station move in which the move consists in replacing a located station by unlocated or already located one while the other four neighborhoods were developed to take the routing decision into consideration. In fact, they are alternated between intra-route and inter-route moves. The four proposed routing neighborhoods are described as follows: (i) relocate a selected node from the current position into a new one, (ii) select two different nodes and then exchanging their positions, (iii) exchange two selected adjacent nodes with one other node, and finally (iv) remove a sequence of consecutive nodes from a current position and reinsert them in another position.

Our local search corresponds to the mixed variable neighborhood descent algorithm which includes two main steps: a relocated station move and a sequential variable neighborhood descent (Seq-VND). The sequential VND iteratively explores each of the routing neighborhood structures sequentially, and return to the first neighborhood at each time a better solution can be found. The solution generated by the local search is compared to the current solution according to a distance function. The distance function value is computed taking into account the list of located battery swap station in both current solution and the new generated one. We disturb the solution by removing a customer node from its position and insert it randomly.

Experimental results show the effectiveness of the VNS approach to solve this variant of location-routing problem in comparison with a two hybrid heuristics: the first heuristic combines between two approches: the Tabu Search with modified Clarke and Wright Savings method (TS-MCWS) while the second hybrid heuristic combines a four-stage heuristic: modified sweep algorithm, iterated greedy method, adaptive large neighborhood search metaheuristic and split procedure (SIGALNS).

Keywords: routing, location, variable neighborhood search, electric vehicles.