A New Multi-Objective Green Location Routing Problem with Heterogenous Fleet of Vehicles and Fuel Constraint

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ABSTRACT

This paper introduces a new variant of Multi-Objective Green Location Routing Problem (MOGLRP) in which the start and end location of each route can be distinct. In this paper, the authors present a new mathematical formulation for the MOGLRP with consideration of environmentally issues. MOGLRP states for the problem of finding routes for vehicles to serve a set of customers while minimizes the total traveled distance, minimizes the total cost including vehicle fixed cost and variable travel cost and the CO\textsubscript{2} emissions. In order to solve the proposed model, two solution methods are used. Firstly, an exact method which is able to solve small sized problems is applied. Since the exact methods are not able to solve NP-hard problems in a reasonable time, the second method which is called multi-objective evolutionary algorithms (MOEA) are taken into account to deal with large instances. Furthermore, four well-known multi-objective evolutionary algorithms, including non-dominated sorting genetic algorithm (NSGA-II) and multi-objective particle swarm optimization (MOPSO), Strength Pareto Evolutionary Algorithm II (SPEA- II) and Pareto Envelope-based Selection Algorithm II (PESA-II) are used to compare obtained results. A comparison results show the proficiency of the proposed algorithm with respect to the four performance metrics, including quantity metric, diversification metric, spacing metrics and mean ideal distance. Finally, concluding remarks and future research directions are provided.

KEYWORDS

Fuel Constraint, Green Location Routing Problem, Heterogenous Fleet of Vehicles, Multi-Objective Optimization

1. INTRODUCTION

A supply chain is a network of suppliers, manufacturers, warehouses and distribution channels organized to acquire materials, convert them into finished products and distribute them to clients. The Supply Chain Management (SCM) consists of finding best practices, policies and strategies to solve efficiently all encountered problems. That is by employing the available resources with respect to different constraints and while optimizing many different and generally conflicting objectives. One of the most important SCM phases is the logistics and transportation processes that allow the moving of different materials from and to different nodes in the supply chain network. Generally, the objective of the logistics process is to optimize transportation related costs such as traveled distance, time, routes flexibility and reliability. Recently, the concept of greenness for sustainable development

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has emerged to represent a human concern for the undesirable effect of the industrial processes on the environment. This environmental awareness intends to show the effect of toxic emissions on the environment (Albareada-Sambola et al., 2005; Koç et al., 2016).

Nowadays, governments and industries have seriously considered this concern. Several industries started enhancing their procedures to show an explicit interest to minimize the volumes of their missions. In transportation, the aim is to construct low-cost routes for vehicles, trucks, planes and ships to transport goods. However, in order to obtain these aims, huge quantities of co2 are released that affect directly the quality of breathing air particularly in large cities. The major concern of transportation firms is the material benefit without reviewing vehicle emissions and their effect on the environment. Recently, transportation companies have started to take explicitly into account the emissions reduction objective in the definition of their working plans. This trend was encouraged by governmental regulations and customer preference in order to consume environment friendly products. Therefore, the generated working plans must minimize costs and co2 emissions. These two objectives are not necessarily positively correlated and for some cases, they are completely conflicting (Cuda et al., 2015).

The basic transportation model which is generally used to represent the problem of finding routes for vehicles to serve a set of customers is called the Vehicle Routing Problem (VRP) (Li et al., 2016). In the basic VRP and also in many other variants the purpose of the problem is analogous and it is to minimize the overall transportation costs in term of distance, time, the number of vehicles, etc. Here, the literature is really extensive where several single objective VRP has been studied and solved efficiently. However, like other optimization problems, the objectives may be multiple and also conflicting. Then, the multi-objective VRP was defined to represent a class of multi-objective optimization problem.

In this paper, the aim is to study and define the Multi-Objective Green Location Routing Problem (MOGLRP). The Multi-objective GLRP asks for designing vehicle routes to serve set of customers while minimizes the total traveled distance, the total co2 emissions and minimize the total cost, including vehicle fixed cost and variable travel cost with respect to classical routing constraints mainly capacity constraints. Consequently, we will implement the NSGA-II and MOPSO evolutionary algorithm to solve the Multi-objective GVRP model via solving some test problem. The paper is organized as follows. In the next section, we present the concept litterer review. Section 3 defines a mathematical model for the Multi-objective GLRP. In section 4, we present the evolutionary solving approach based on the NSGA-II, SPEA-II, PESA-II, and MOPSP algorithms. Section 5 will report the computational results and then compare the meta-heuristic algorithms. Finally, conclusion remarks are provided.

2. LITERATURE REVIEW

Vehicle routing problem (VRP) is a typical optimization problem, in which a set of vehicle service a set of customers. Each vehicle that services customers starts the travel from the depot and finishes it in the depot as well. This problem was first defined by Dantzig and Ramser (1959). VRP is a generalization of a Traveling Salesman Problem (TSP), where only one traveler takes into account. The TSP is defined as a set of cities, where a single traveler needs to visit all of them and return to the starting city. The objective of the TSP is to find the shortest route. The objective of the typical VRP is to find the solution, at first, minimizing the total vehicle number required, and secondly, minimizing the length of the total traveled path.

Various constraints can be added to the VRP to make the problem more realistic. The well-known constraints for the VRP are capacity and time window constraints. A capacitated vehicle routing problem (CVRP) is usually defined with equal capacities for all vehicles. However, in the real-life vehicle fleet with different capacities can be used to solve the delivery problem. Dominguez et al. (2016) discuss the two-dimensional loading capacitated vehicle routing problem (2L-CVRP) with
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