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A Benders based rolling horizon algorithm for a dynamic facility location problem

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ABSTRACT

This study presents a well-known capacitated dynamic facility location problem (DFLP) that satisfies the customer demand at a minimum cost by determining the time period for opening, closing, or retaining an existing facility in a given location. To solve this challenging $\mathcal{NP}$-hard problem, this paper develops a unique hybrid solution algorithm that combines a rolling horizon algorithm with an accelerated Benders decomposition algorithm. Extensive computational experiments are performed on benchmark test instances to evaluate the hybrid algorithm's efficiency and robustness in solving the DFLP problem. Computational results indicate that the hybrid Benders based rolling horizon algorithm consistently offers high quality feasible solutions in a much shorter computational time period than the stand-alone rolling horizon and accelerated Benders decomposition algorithms in the experimental range.

1. Introduction

The problem of locating a set of facilities to serve customers has received extensive attention from researchers, managers, and practitioners due to the problem's presence in almost any supply chain. Therefore, various types of facility location problems have been investigated in order to determine which facilities should be opened, closed or relocated to serve select customers to minimize the total cost (Melo et al., 2009). This paper examines a version of the capacitated facility location problem (CFLP) in which facilities are assumed to provide a finite amount of goods to meet time-dependent and deterministic customer demand subject to time-dependent cost parameters in a multi-period planning horizon. This problem is referred to as the capacitated *Dynamic Facility Location Problem* (DFLP) (Arabani and Farahani, 2012; Torres-Soto and Uster, 2011). In order to be able to respond to varying demand, the decision maker must determine whether to open new facilities, keep the existing facilities open or closed, or relocate them at any time period. In addition, the portion of customer demand needs to be satisfied by each operating facility must be decided. The ultimate objective is to minimize the total cost, which may include transportation and operating costs, facilities opening and closing expenses, or other costs during all planning periods.

Arabani and Farahani (2012) categorize the facility location problem into two main groups based on whether the (re)location decisions vary by time. The static facility location problem is referred to as single-period facility location problem in which the facility location decisions and their parameters are independent of time. Since the dynamic counterpart relaxes this assumption, dynamic model variants are more suitable to reflect the impacts of vital factors that cannot be represented by static models, such as incentives, energy prices, and market growth. Thus, dynamic model variants have many application areas, including, but not limited to, combat logistics (Gue, 2003), electronics logistics (Manzini and Gebennini, 2008), and healthcare (Ghaderi and Jabalameli, 2013). Current et al. (1998) further apply another classification criteria for the DFLP based on facility (re)location decisions. The *explicitly* DFLP controls the opening and closing of a facility in a planning horizon, whereas the parameters may change over time, but the (re)location decisions can be made only at the beginning of the time horizon in the *implicitly* DFLP. Mirchandani and Odoni (1979) study a version of the implicitly DFLP in which the travel times are treated as random variables with known discrete probability distributions. Drezner and Wesolowsky (1991) demonstrate an optimal solution method for the single facility location problem with a single (re)location option with known demand of each serving point and a continuous linear function of time. Farahani et al. (2009) extend this work by including multiple relocation opportunities and proposing an exact algorithm to make optimal relocation decisions. The implicitly DFLP proposed by

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