

ABSTRACT

Maritime transportation supports international trade and the economic growth of numerous countries, as well as the development of globalization. Over 80 percent of international trade is accomplished by maritime transport, and for most developing countries, this proportion is even higher. Marine container terminals (MCTs) play a key role as nodes in global supply chains since vessels of different liner shipping firms deliver containers to MCTs. One of the most challenging decision problems, which must be addressed by MCT operators across the globe, is the berth allocation and scheduling problem.

The research objective of the berth allocation scheduling problem is to determine the berthing position and the berthing time for each coming vessel while taking into account all the operational and physical constraints that are already in place. The complexity arises from its resemblance to the machine scheduling problem, in which jobs are assigned to machines with varying characteristics that influence their processing times. The constraints amplify the difficulty of achieving optimal solutions, as the problem is classified as NP-hard. This classification implies that the computational complexity of the problem increases exponentially with the number of variables and constraints, particularly when operational disruptions or additional requirements are considered.

A detailed literature review of the state-of-the-art research effort on berth allocation and scheduling problem is conducted and presented. According to the literature review conducted, it was found that numerous studies on various berth allocation and scheduling problems have been published in recent years, however, alternative optimization models and solution methodologies still must be explored to improve the efficiency and timeliness of berth allocation and scheduling. In this dissertation, two mathematical models were presented to effectively capture the properties of operations at an MCT. The Discrete Dynamic Berth Allocation and Scheduling Problem (**DDBASP**) and the Green Berth Allocation and Scheduling Problem (**GBASP**) were formulated as mixed-integer linear programming models to minimize the total costs associated with vessel scheduling and berth allocation.

This dissertation introduced a Hyperheuristic Hybridized with Exact Optimization (HHEO) algorithm to address the **DDBASP** model. The HHEO algorithm integrated multiple evolutionary strategies, enabling it to adapt dynamically to different problem scenarios. A distinctive feature of the algorithm was its ability to select and apply various genetic operators dynamically, optimizing the search process in real time. Additionally, the HHEO framework incorporated intelligent exact optimization techniques, periodically applied to refine solutions, and enhanced overall solution quality. These domain-specific optimization procedures ensured that the algorithm achieved both high computational efficiency and robust performance in solving this highly constrained and computationally demanding problem.

In addition to the HHEO algorithm, a Customized Hyperheuristic Algorithm (CHA) was proposed to explicitly solve the **GBASP** model. The CHA leverages a combination of evolutionary strategies and applies a variety of genetic operators dynamically to address the optimization challenge. Its adaptive selection mechanism allows for real-time performance evaluation and tailored application of heuristic operators, enhancing the effectiveness of berth scheduling compared to traditional methods.

Comprehensive computational experiments compared HHEO and CHA with several well-established optimization techniques, including CPLEX and some wide-applied metaheuristic algorithms. The results demonstrated the superior performance of the hyperheuristic frameworks, which consistently matched the exact optimization outcomes of CPLEX for small-scale problem instances, with a significantly more promising computational efficiency. For scenarios of various scales, both hyperheuristics outperformed all the competitors, achieving the most promising solutions while maintaining very competitive computational times. These findings underscore the ability of the proposed method to enhance operational performance by delivering effective and efficient berth allocation and scheduling plans. Sensitivity analyses were also conducted to provide critical insights into port management practices. By leveraging these invaluable tools in optimizing the complex logistics of container ports thus to ensure smoother and more efficient port management, port operators can enhance operational performance, reduce service costs, and ensure a competitive edge in maritime logistics.