Berth Allocation Planning Optimization in Container Terminals

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Abstract: We study the problem of allocating berth space for vessels in container terminals, which is referred to as the berth allocation planning problem. We solve the static berth allocation planning problem as a rectangle packing problem with release time constraints, using a local search algorithm that employs the concept of sequence pair to define the neighborhood structure. We embed this approach in a real time scheduling system to address the berth allocation planning problem in a dynamic environment. We address the issues of vessel allocation to the terminal (thus affecting the overall berth utilization), choice of planning time window (how long to plan ahead in the dynamic environment), and the choice of objective used in the berthing algorithm (e.g., should we focus on minimizing vessels’ waiting time or maximizing berth utilization?). In a moderate load setting, extensive simulation results show that the proposed berthing system is able to allocate space to most of the calling vessels upon arrival, with the majority of them allocated the preferred berthing location. In a heavy load setting, we need to balance the concerns of throughput with acceptable waiting time experienced by vessels. We show that, surprisingly, these can be handled by deliberately delaying berthing of vessels in order to achieve higher throughput in the berthing system.
1. Introduction

Competition among container ports continues to increase as the differentiation of hub ports and feeder ports progresses. Managers in many container terminals are trying to attract carriers by automating handling equipment, providing and speeding up various services, and furnishing the most current information on the flow of containers. At the same time, however, they are trying to reduce costs by utilizing resources efficiently, including human resources, berths, container yards, quay cranes, and various yard equipments.

Containers come into the terminals via ships. The majority of the containers are 20 feet and 40 feet in length. The quay cranes load the containers into prime movers (container trucks). The trucks then move them to the terminal yards. The yard cranes at the terminal yards then unload the containers from the prime movers and stack them neatly in the yards according to a stacking pattern and schedule. Prime movers enter the terminals to pick up the containers for distribution to distriparks and customers. The procedure is reversed for cargo leaving the port.

The problem studied in this paper is motivated by a berth allocation planning problem faced by a port operator. For each vessel calling at the terminal, the vessel turn-around time at the port can normally be calculated by examining historical statistics (number of containers handled for the vessel, the crane intensity allocated to the vessel, and historical crane rate). Vessel owners usually request a berthing time (called Berth-Time-Requested or BTR) in the terminal several days in advance, and are allowed to revise the BTR when the vessel is close to calling at the terminal. Note that the terminal operator allocates berth and quay side cranes according to the long term schedules and weekly ETA (Estimated-Time-of-Arrival) provided by the Lines. To minimize disruption and to facilitate planning, the terminal operator normally demands all containers bound for an incoming vessel to be ready in the terminal before the ETA. Similarly, customers (i.e., vessel owners) expect prompt berthing of their vessels upon arrival. This is particularly important for vessels from priority customers (called priority vessels hereon), who may have been guaranteed berth-on-arrival (i.e., within two hours of arrival) service in their contract with the terminal operator.

On the other hand, the port operator is also measured by her ability to utilize available resources (berth space, cranes, prime-movers, etc.) in the most efficient manner, with berth utilization, berthing delays faced by

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21 This is the ratio of berth availability (hours of operations × total berth length) to berth occupancy (vessel time at berth × length occupied). The utilization rate is affected by the number and types of vessels allocated to the terminal. However, service performance (i.e.,