Dispatching AGVs in Automated Port Container Terminals

Jong Wook Bae* · Kap Hwan Kim*

*Department of Industrial Engineering, Pusan National University, Korea

Abstract

We consider an automated port container terminal in which three types of equipment are used for ship operations: container crane (CC), AGV as prime mover, and automated yard crane. CCs transfer containers from a containership to an AGV (we call this discharging operation). Then, the AGV delivers the discharged container to a yard crane that picks it up and stacks into a position in the marshalling yard. For the loading operation, activities are carried out in the reverse order of the discharging operation. The handling activities performed by CCs are called seaside operations, while those performed by AGVs and yard cranes are called landside operations.

There exist two alternative strategies for seaside operations: a single-cycle operation and a dual-cycle operation. When a CC performs the seaside operation in the single-cycle manner, only either the loading operations or the discharging operations are performed consecutively. But, when the ship operation is performed in the dual-cycle manner, the loading operation and the discharging operation are performed alternately so that the empty traversal time of a CC trolley is reduced. The landside operation can also be performed in either a single-cycle manner or a dual-cycle manner. During the single-cycle landside operation, an AGV delivers a container from apron (yard) to yard (apron) and returns empty for the next inbound (outbound) container. When the dual-cycle landside operation is performed, an empty AGV that delivered an outbound container to a CC can receive another inbound container from the CC at apron. Also, an AGV that delivered an inbound container to an ASC can receive another outbound container instead of traveling empty to the apron.

With respect to the dispatching strategy for AGVs, two different strategies can be considered. As the first strategy, every AGV can be dedicated to only one CC and delivers a container to/from

the dedicated CC. We call this strategy a monopolistic dispatching of AGVs. Under this strategy, even though the dispatching of AGVs becomes simplified, the utilization of AGVs may be low. The other strategy is a shared dispatching in which every AGV is not dedicated to a specific CC and can deliver containers for more than two CCs. Though the dispatching of AGVs under the shared dispatching is more complicated than under the monopolistic strategy, it is expected that the utilization of AGVs becomes higher. Under the shared dispatching, it is possible that the landside operation is performed in a dual-cycle manner even when the seaside operation is performed in a single-cycle manner.

A mixed integer programming model is suggested for the assignment of delivery tasks to AGVs under the assumption that the list of loading/discharging task is given and the operation time of each task is deterministic. And a heuristic algorithm is provided for which the performance is compared with that of the mathematical model. Since the most important objective of the ship operation is to complete the whole loading/unloading operation as soon as possible, the delay of ship operations should be avoided if possible by wisely assigning delivery tasks to AGVs. The main issue in this study is to analyze the effect of various dispatching strategies on the overall performance of the ship operation. As the secondary objective, the total travel distance of AGVs is minimized. The single-cycle and the dual-cycle operation in both the seaside and the landside operation are compared with each other. The performances of monopolistic and shared dispatching strategies are analyzed. Intensive computational experiments are carried out to compare various strategies with each other.