Scheduling serial locks: a combinatorial Benders’ based approach

J. Verstichel and G. Vanden Berghe

KU Leuven, Department of Computer Science, CODeS & iMinds-ITEC
jannes.verstichel@cs.kuleuven.be

Abstract

With the increasing share of waterbound multimodal transportation in the logistics chain, inland locks are becoming a major bottleneck whose unpredictable service times may limit the long term viability of inland waterway transport. The presentation focuses on scheduling locks in a serial configuration. We introduce a mathematical model for the single-chamber serial lock scheduling problem with traffic-dependent capacity constraints and apply a combinatorial Benders’ decomposition approach. The results show promising performance on small to medium sized instances, while leaving an improvement gap for large and real-size instances.

Keywords: serial lock scheduling problem, combinatorial Benders’ decomposition

Barges travelling on a network of inland waterways often have to pass several locks before reaching their destination. With the increasing share of waterbound multimodal transportation in the logistics chain, these inland locks are becoming a major bottleneck whose unpredictable service times may limit the long term viability of inland waterway transport. The aim of this research is to reduce the waiting times at locks while increasing the planning horizon of the entire chain of locks, thus overcoming the main downsides of waterbound transportation. Indeed, by not only reducing the total travel time but also offering accurate estimates of the expected travel time for each ship, waterbound transportation could well gain a significant boost in interest from industry, and become a competitive alternative for road and rail transportation.

We present a mathematical model for the single-chamber serial lock scheduling problem with traffic-dependent capacity constraints. An exact combinatorial Benders’ decomposition has been developed. It enables a highly efficient evaluation of the ship placement aspect of the lock scheduling problem in a sub problem, while tackling the lockage scheduling aspect in a strongly reduced master problem. The method’s performance is evaluated on a large set of small to medium sized instances, while analysing the influence of parameters such as ship inter arrival time, travel distance between locks and minimal lockage.
time on both the ship waiting time and the total computation time. Despite very promising results on small and medium sized instances, it is clear that this exact approach will not suffice when realistic instances need to be tackled. The need for quick response times and a rolling time horizon as well as the much larger instance sizes, both with respect to the number of ships and the number of locks, will undoubtedly require the application of (math) heuristics.

Acknowledgement

Work supported by the Belgian Science Policy Office (BELSPO) in the Interuniversity Attraction Pole COMEX (http://comex.ulb.ac.be) and Leuven Mobility Research Center and funded by an innovation mandate of the Institute for the Promotion of Innovation through Science and Technology in Flanders. (IWT-Vlaanderen).