A matheuristic for the liner shipping network design problem considering transit time restrictions

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Abstract

The liner shipping network design problem (LSNDP) is to construct a set of cyclic services (routes) to form a capacitated network for the transport of containerized cargo. The network design maximizes the revenue of container transport considering the cost of vessels deployed to services, overall fuel consumption, port call costs and cargo handling costs. The liner shipping industry transports about 60% of the value of seaborne trade and inherently the lead time for a container transport incurs an inventory cost to the shipper. Therefore, the transit time of a container transport is an important parameter for a competitive liner shipping network. Literature on the LSNDP is quite scarce [3] compared to related maritime shipping transportation problems, but recent years showed increased interest in the LSNDP (Agarwal and Ergun [1], Alvarez [2], Reinhardt and Pisinger [7], Brouer et al. [3], Plum et al. [6]). Research on the LSNDP has focused on maximizing revenue through efficient capacity utilization and minimization of cost. A reference model for the LSNDP and a benchmark suite of liner shipping network instances was introduced by Brouer et al. [3]. The benchmark instances for the LSNDP without transit time restrictions have been solved by a heuristic column generator using a MIP to construct new routes in Brouer et al. [3] and by a composite matheuristic in Brouer et al. [4]. In the present work we will extend the matheuristic presented in Brouer et al. [4], which combines a greedy construction heuristic with an improvement heuristic fine tuning the current solution by solving an integer program (IP) for each service to identify a set of promising port call insertions and removals for each individual service. The transit time restrictions are not necessarily aligned with the desire to maximize utilization of the vessels in the network, and increases the complexity of the multi-commodity flow problem (MCFP), which needs to be solved repeatedly to evaluate a given network configuration. Solving the MCFP without transit time restrictions has been identified as a bottleneck in local search methods for the LSNDP in [2, 3]. Karsten et al. [5] introduce a time constrained multi-commodity flow problem and computational experiments are performed on liner shipping networks from the matheuristic of Brouer et al. [4] extending the evaluation of the network to consider transit time restrictions on each individual cargo flow. The time constrained multi-commodity flow problem restricts all cargo transports to respect the maximal transit time from *LINER-LIB 2012* for each commodity. The computational experiments of Karsten et al. [5] show that as little as 65% of the cargo, that could potentially be transported in an unconstrained network, can be met, when imposing time limits in the considered instances. In Karsten et al. [5] a reduction of the graph along with an extension to handle groups of commodities in a single pass of a resource constrained shortest path problem result in computationally efficient evaluation of a given network design. In this work we

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will present a reformulation of the reference model from Brouer et al. [3] to consider transit times for each individual commodity in the liner shipping network design problem with transit time restrictions (LSNDP-TT). We will extend the matheuristic of Brouer et al. [4] to consider transit time restrictions in the search. Computational results for the benchmark suite *LINER-LIB 2012* will be presented.

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