Discrete time formulations and valid inequalities for a maritime inventory routing problem

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A single-product maritime inventory routing problem (MIRP) is studied in which one actor or cooperating actors in the maritime supply chain have the responsibility for both the transportation of goods and the inventories at the ports. The product is produced at loading (production) ports and consumed at discharge (consumption) ports. It is possible to store the product in inventories with time-dependent capacities at both types of ports. The production and consumption rates are deterministic but may vary over the planning horizon. There are berth capacities at the ports, limiting the number of ships that can load or discharge at the same time. A heterogeneous fleet of ships is used to transport the product. Each ship has a given capacity, speed and loading/discharge rate. The ships can wait outside a port before entering for a loading or discharge operation. In order to fit the short sea shipping segment with long loading and discharge times relative to the sailing times, the time in port depends on the quantity loaded or discharged. A ship can both load and discharge at multiple ports in succession. The initial position and load on board each ship is known at the beginning of the planning horizon. The planning problem is to design routes and schedules for the fleet that minimize the transportation and port costs and determine the load or discharge quantity at each port visited without exceeding the storage capacities.

In the presentation, we give an original discrete time model of the problem. Further, we discuss how this model can be reformulated to a pure fixed charge network flow (FCNF) model with side constraints. We have identified mixed integer sets arising from the decomposition of the formulations. In particular, several lot-sizing relaxations are derived for the formulations and used to establish valid inequalities to strengthen the proposed formulations. Until now, the derivation of models and valid inequalities for MIRPs has mainly been inspired by the developments in the routing community. Here, we will present some of these new valid inequalities obtained for MIRPs by generalizing valid inequalities from the recent lot-sizing literature.

Finally, we will present computational results for a set of instances based on real data, where we compare the original and FCNF formulations and the effectiveness of the valid inequalities.