Ship Routing and Scheduling with Persistence and Distance Objectives

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Summary. It is well known that decision support systems (DSSs) usually only solve models that simplify and approximate the real problem. The planners might therefore be more interested in a set of diverse high quality solutions to choose from, than in only the optimal (or near-optimal) solution to the model as is usually produced by a DSS. In ship routing and scheduling plans are generated following a rolling horizon principle, where schedules are updated when new relevant information appears. However, the planners have often already made commitments to the customers for the next few voyages, for instance regarding arrival times and which ships that are assigned to service given cargoes. Therefore, the planners are interested in a set of high quality schedules that are close to the current (baseline) schedule in the near future, and diverse from each other in more distant time. We suggest a multi-start heuristic, including a persistence penalty function and distance measures, to produce such schedules. The method has been tested on a set of real-life problems and it provides valuable decision support flexibility for planners in shipping companies.

Key words: Ship routing and scheduling, Decision support, Distance measure, Persistence

1 Introduction

Ocean shipping is the major transportation mode in international trade and more than 6 billion tons of goods are carried by ships every year [15]. A ship involves a major capital investment, and its daily income and operating costs often amount to several...
thousands of dollars. Proper planning of the fleet of vessels is therefore crucial for shipping companies to survive in an increasingly competitive market.

In this paper we focus on decision support for short-term routing and scheduling problems faced by many tramp shipping companies transporting bulk products. A shipping company operating in the tramp market usually has a set of mandatory contract cargoes that they are committed to carry, while trying to increase their profit from optional spot cargoes. The mandatory contract cargoes come from long-term contracts between the shipping company and the cargo owners (shippers). Each cargo (contract and spot) consists of a given quantity to be shipped between a given pair of ports. There are given time windows for loading of the cargoes and sometimes also for unloading. The fleet used for transporting the cargoes is heterogeneous where the ships have different load capacities, speeds, equipment, etc. The ship routing and scheduling problem mainly deals with (1) selecting spot cargoes to service, (2) assigning cargoes to ships in the fleet, and (3) deciding optimal ship routes and schedules. All these tasks must in principle be performed simultaneously. The planners in the shipping companies daily solve this ship routing and scheduling problem, which is basically similar to a multi-vehicle pickup and delivery problem with time windows (m-PDPTW), as described by [8].

TurboRouter [9] is a decision support system (DSS) developed by MARINTEK in Trondheim for solving this type of ship routing and scheduling problems by using local search-based heuristics [2]. However, the model solved by this DSS represents only a simplification of the real-world problem. When implementing and testing the DSS at shipping companies, we have often experienced that there exist constraints that are fuzzy and hard to model. There are sometimes also secondary objectives, which can be unclear, hard to model or to give proper weight to, in addition to the primary one (that usually is measured in monetary terms). The inherent stochastic nature of ocean shipping (for instance sailing times that are influenced by weather conditions) also contributes to make the real-life problem hard to model and to solve. During the work with TurboRouter and from discussing with planners in shipping companies, we realized that it was hardly possible to model all these complicating aspects in a good manner, neither was it desirable. This was something the planners wanted to evaluate themselves, based on their experience. However, a good contribution for the planners would be a DSS that could present a set of diverse high quality solutions to analyze and choose from instead of only one optimal (or near-optimal) solution.

In ship routing and scheduling, planning follows a rolling horizon principle, where plans are updated when new information (new cargoes, ship delays, etc.) appears. Figure 1 illustrates a typical workflow for the planning process.

When the planners perform a complete rescheduling using TurboRouter, the solution after rescheduling is often very different from the solution prior to the changes. However, the planners have often already made commitments to some of the customers, for instance regarding time for start of servicing, and they may have nominated specific ships for loading given cargoes. The planners are therefore interested in new solutions that are in some sense close to the current solution, the baseline