ABSTRACT

While intermodal freight transport has the potential to introduce efficiency to the transport network, this transport method also suffers from uncertainty at the interface of modes. For example, trucks moving containers to and from a port terminal are often uncertain as to when exactly their container will be released from the ship, from the stack, or from customs. This leads to much difficulty and inefficiency in planning a profitable routing for multiple containers in one day. In this chapter, the authors examine agent-based solutions as a mechanism to handle job arrival uncertainty in the context of a drayage case at the Port of Rotterdam. They compare their agent-based solution approach to a well-known on-line optimization approach and study the comparative performance of both systems across four scenarios of varying job arrival uncertainty. The chapter concludes that when less than 50% of all jobs are known at the start of the day then an agent-based approach performs competitively with an on-line optimization approach.
INTRODUCTION

Scheduling the routes of trucks to pick-up and deliver containers is a complex problem. In general such Vehicle Routing Problems (VRPs) are known to be NP-complete and therefore inherently hard and time consuming to solve to optimality (Toth & Vigo, 2002). Fortunately, these problems have a structure that can facilitate efficient derivation of feasible (if not optimal) solutions. Specifically, the routes of different trucks are more or less independent. Such “locality” in a problem is a first sign that an agent-based approach may be viable.

Modeling and solving a VRP by coordinating a set of agents can bring a number of advantages over more established approaches in the field of operations research even when using state-of-the-art mixed integer solvers such as CPLEX (ILOG, Inc., 1992). Agent advantages include the possibility for distributed computation, the ability to deal with proprietary data from multiple companies, the possibility to react quickly on local knowledge (Fischer et al., 1995), and the capacity for mixed-initiative planning (Bürckert et al., 2000).

In particular, agents have been shown to perform well in uncertain domains. That is, in domains where the problem is continually evolving (Fischer et al., 1995). In the VRP, for example, a very basic form of uncertainty is that of job arrivals over time. To the best of our knowledge, however, the effect of even this basic level of uncertainty on the performance of agent-based planning in a realistic logistics problem has never been shown.

We think it is safe to assume, based on its long history, that current practice in operations research (OR) outperforms agent-based approaches in settings where all information is known in advance (static settings). However, in situations with a high level of uncertainty, agent-based approaches are expected to outperform these traditional methods (Jennings & Bussmann, 2003).

In this chapter we investigate whether a distributed agent-based planning approach indeed suffers less from job arrival uncertainty than a centralized optimization-based approach. Our main contribution is to determine at which level of job arrival uncertainty agent-based planning outperforms on-line operations research methods. These results can help transportation companies decide when to adopt an agent-based approach, and when to use an on-line optimization tool, depending on the level of uncertainty job arrivals exhibit in their daily business.

In the next section we provide a survey of current work on agent-based approaches to logistics problems. We then introduce the case of a transportation company near the port of Rotterdam. Based on this literature review and the specific nature of our case study VRP, we propose a state-of-the-art agent-based approach where orders are auctioned among trucks in such a way that each order is assigned to the truck that can most efficiently transport the container. Moreover, these trucks continuously negotiate among each other to exchange orders as the routing situation evolves. This agent-based approach is fully described in this chapter. We follow this description with a description of the centralized on-line optimization approach used in comparison to our distributed agent-based system. The structure of our test problems and the computational results are covered in the next to last section. In the final section we discuss the consequences of our results, summarize our advice to transportation companies, and give directions for future work.
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