2.9 Autonomous Decision Model Adaptation and the Vehicle Routing Problem with Time Windows and Uncertain Demand

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2.9.1 Introduction

The instruction of resources in logistic systems in order to ensure an effective as well as efficient usage is a very sophisticated task. A lot of data and requirements have to be considered simultaneously. For this reason computerized decision support (Makowski 1994) is strongly recommended (Bramel and Simchi-Levi 1997; Crainic and Laporte 1998).

A prerequisite for the application of computerized methods to tackle logistics decision problems is the representation of the current decision situation in a formalized fashion, a so-called decision model, normally described in terms of mathematical expressions (Williams 1999). Such a model, often of optimisation type, is than tackled by, typically heuristic, algorithms (Ibaraki et al. 2005; Michalewicz and Fogel 2004) in order to derive one (best possible) solution that is the instruction predicting the future activities in the logistic process execution system.

If the decision problem in the real world changes, the existing problem model becomes void and a re-modelling is required. Additional knowledge about the current system state and performance enters the model in order to propagate the problem changes to the used decision support system. However, this topic has received only minor attention so far in the scientific literature although it is of very high practical relevance and importance.

In this contribution, we investigate generic procedures and rules for an automatic feedback controlled adaptation of decision models for a variant of the well-known Vehicle Routing Problem with Time Windows. The considered problem differs from the generic problem because the customer
sites, which require a visit, emerge successively over time so that a plan revision becomes necessary. In Subsection 2.9.2 we present the considered decision problem in more detail. Subsection 2.9.3 introduces the algorithmic framework for an autonomous adaptation of the decision model and in Subsection 2.9.4 we prove the framework's general applicability within numerical simulation experiments.

2.9.2 The vehicle routing problem with time windows and uncertain demand

This section is about the investigated decision problem. The problem is non-stochastic, e.g. requests are released consecutively but we do not know anything about their arrival times. In Subsection 1 we survey the scientific literature related to the problem considered here. Subsection 2 outlines the problem informally. The life cycle model of a request is presented in Subsection 3 and the decision problem that requires a solving whenever at least one additional request arrives is stated in 4. The construction of artificial test cases developed for a numerical simulation of selected problem instances is subject of Subsection 5.


Jensen (2001) understands robust planning as the generation of plans that maintain their high or even optimal quality after subsequent modifications. He defines flexible planning as the generation of plans whose quality does not significantly decrease after the execution of algorithmic rescheduling and alterations of the so far used plans.

Jaillet (1998), Jaillet and Odoni (1988) as well as Bianchi et al. (2005) propose a robust transport scheduling approach. They construct optimal a-priori-routes. Such a route has a minimal expected length among all possible routes through the potential customer sites. However, this approach assumes that probability distributions of the actual demand at the customer sites are known. As soon as a vehicle has visited a customer site and the corresponding demand becomes sure it has to be decided whether a replenishment visit at a depot has to be executed before the next customer (again with uncertain demand) is met.