Dynamic Vehicle Routing With Uncertain Customer Demand

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Many difficult combinatorial problems have been modelled as standard CSPs and solved by classic constraint programming techniques. However, in practice, many problems are dynamic, uncertain and changing, while the decisions have to be made before the full problem is known. For example, in the Dynamic Vehicle Routing Problem (DVRP) [1], new customer orders appear over time, and new routes must be calculated as we are executing the existing solution. In the literature, there are many methods and strategies have been proposed to tackle DVRPs. [2] considered a DVRP as the extension to the standard VRP by decomposing a DVRP as a sequence of static VRPs and then solving them with ant colony system algorithm. [3] used a reactive method (agent-based constraint programming) to solve DVRPs. [4] introduced a consensus approach to the problem.

We are considering an alternative dynamic version of the VRP, in which the customers have uncertain demand. Specifically, our vehicles carry multiple types of product; each customer has an initial reported demand for certain quantities of each product; when the vehicle reaches the customer, the customer may change their request based on the current contents of the vehicle. As an example, consider a baker's delivery van carrying different types of bread. Customer A originally requested 20 white loaves. When the van arrives, A sees sun-dried tomato bread and decides instead to take 10 white loaves and 10 sub-dried tomato loaves. The van is now short of the loaves requested by Customer B. Should the van continue to B, change its route to reload at the bakery, or request another van to visit B instead? There has been some previous research on VRPs with uncertain demand. Erera and Daganzo in [5] proposed strategies allowing vehicles to cooperate by minimizing and approximating "logistic cost function". A Cross-Entropy heuristic and integer linear programming have been applied in [6]. However, all of that research restricts the problem to single commodity vehicles, and most of it examines reactive approaches.

We assume that we have probability distributions of the customer demand, and we want to use this information to make better decisions. Our intention is to use constraint programming and scheduling techniques to search for solutions at each time step, aiming to get close to the retrospectively optimal solution. In general, we aim to combine off-line robust plans with on-line rescheduling, using probabilistic models of the future. Bent & van Hentenryck have proposed a regret algorithm for online stochastic optimization under time constraints. It solves as many samples as possible and avoids distributing them among requests

[7]. Our initial plan is to adapt this approach to our problem, and then extend it to problems with more combinatorial constraints. Finally, we will attempt to extend our solutions to other problems, including dynamic bin packing and online scheduling, based on the features they have in common with VRPs [8].

Acknowledgements

This work has received support from Enterprise Ireland (SC/2003/81), Science Foundation Ireland (00/PI.1/C075), and ILOG, SA.

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