Abstract

The vehicle routing problem with time windows (VRPTW) is one of the most important and widely studied transportation optimization problems. It abstracts the salient features of numerous distribution related real-world problems. It is a problem of finding a set of routes starting and ending at a single depot serving a set of geographically scattered customers, each within a specific time-window and with a specific demand of goods to be delivered.

The real world applications of the VRPTW can be very complex being part of higher level systems i.e. complex supply chain management solutions. For a successful deployment it is important for these systems to be flexible in terms of incorporating the problem specific side-constraints and problem extensions in an elegant way. Also, employing efficient means of addressing the dynamism inherent to the execution phase of the relevant operations is vital.

The multi-agent systems are an emerging architecture with respect to modeling multi-actor heterogenous and dynamic environments. The entities within the system are represented by a set of agents endowed with autonomic as well as social behavioral patterns. The behavior of the system then emerges from their actions and interactions. The autonomic nature of such a model makes it very robust in highly uncertain dynamic environments. The problem specific side-constraints can then be embedded within the agents' local subproblem solving. Empowered with efficient behavioral and communication patterns the multi-agent paradigm provide an intriguing alternative to traditional optimization methods.

In this work we present a reformulation of the VRPTW as a multi-agent optimization problem within a society of agents representing individual vehicles being part of the problem. Alternative local planning strategies used by the agents as well as efficient interaction patterns enabling for finding efficient solutions to the global problem are introduced, providing for several incremental versions of the resulting VRPTW algorithm. A detailed experimental assessment of the resulting VRPTW algorithms is presented including the comparison to the traditional centralized as well as previous agent-based algorithms. Such a comparison was missing from most previous comparable agent-based works. An in-depth analysis of the underlying solving process is provided as well spawning interesting future research opportunities.

Over the relevant benchmarks, the algorithm equals the best-known solutions achieved by the state-of-the-art traditional algorithms in 90.3% of the cases, resulting in a 0.3% overall relative error. This represents a significant improvement over the previous comparable agent-based studies. A parallel version of the algorithm is presented as well, boasting exceptional anytime attributes, outperforming even the traditional algorithms in this respect. Underlying the presented algorithm is the introduced abstract task allocation framework, significantly extending the previous similar works. The core contribution of this thesis is the deeper understanding of the implications of adopting agent-based approach to solve the VRPTW and complex transportation optimization problems and in general.