Supply chain optimization using reinforcement learning

Problem

The problem is a version of a CTTRPTW (Capacitated Truck and Trailer Routing Problem with Time Windows) and some additional restrictions. In the depot, vehicles have to be unloaded in the FIFO way. Although the load is homogenous, there exist multiple types of it, so each vehicle must carry only one type of load during one trip. Each trip has to be a cycle (begin and end in the depot). There also exist multiple types of vehicles with different capacities and load/unload times. Some vehicles can have a trailer attached, which expands its capacity, but can make visitation of some customers impossible. Each trailer can be used by many vehicles and left at one of the customer nodes that enable leaving trailer (a transshipment point). Vehicles could serve multiple trips but they may be used only during defined time windows, also maximum time of usage of a vehicle may be restricted.

No customers can be omitted, some of them must not be served at the beginning of a trip and all of them can be served only during defined time windows. Each customer could restrict a maximum weight of a vehicle or demand lack of a trailer. If trailers and transshipment points are used, the decision where to leave the trailer and start a sub-route, should be a part of the result.

The goal is to find a cost-efficient solution, satisfying the above conditions. The cost of a solution is determined by the number of vehicles used and the number of kilometers travelled. the time spent

Data

The problem space consists of up to 3000 pickup points handled by up to 100 vehicles. The matrix of distances between points is given. All edges contain information about the length and traversal time. The customers and the depot are placed on some of the nodes. A customer node contains information about type of its load, its quantity, a time window when it can be visited by a vehicle, whether it is possible to leave a trailer, and whether the customer can be serviced by a vehicle with a trailer. For each vehicle in the fleet, its position, capacity and a possibility to attach a trailer is known. Also all necessary information about trailers, like their capacity, position and their compatibility with vehicles is given. The cost function is defined in terms of the type and weight of a vehicle and the distance of a trip.

Use Case

This is a problem specific to the milk production industry. The specificity of the load provides a need for fast service. Because of many different types of milk with various certifications

and a risk of a contamination with antibiotics, each producer has to be served by only one cistern.

State of The Art

The current algorithm is a local search based CVRP algorithm. It is used to limit the aggregated visited distance and number of vehicles, with a restricted capacity and time windows. Additionally, it merges neighboring nodes in clusters (restricted to some capacity and a limit of a single edge length) to achieve better time performance. Finally, it solves the problem for these clusters, tries to fix routes and repeats until the solution is acceptable. It could serve as a benchmark to compare time of execution and the quality of a solution provided by a new approach.

The current algorithm can provide acceptable results within 10 minutes, however time is not the biggest constraint. Solutions and approaches going beyond the current state of the art are welcome regardless of their limitations. Costs improvements without significant changes in routes would be an added value.