AN MILP FRAMEWORK FOR DYNAMIC VEHICLE ROUTING PROBLEMS WITH TIME WINDOWS

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Abstract — A key issue in logistics is the efficient management of a vehicle fleet servicing a set of customers with known demands. Every vehicle route must start and finish at the assigned depot, each customer is to be visited by a single vehicle and vehicle capacities must not be exceeded. These are the constraints for the capacitated vehicle routing problem (VRP) whose objective is usually the minimization of the travel distance. When every customer has an associated time window, we are dealing with the vehicle routing problem with time windows (VRPTW), an NP-hard problem extensively studied. In the static VRPTW, all the problem data are given. A more challenging subject is the dynamic VRPTW (DVRPTW) where routes must be periodically updated because of new service requests. In DVRPTW, the information on the problem is time-dependent since the data are in part given a priori and in part dynamically updated. As a result, the best solution must be periodically revised. There are two classes of DVRPTW solution methodologies: the immediate assignment that updates vehicle routes as soon as a new service request is received, and the deferred assignment retaining the new service calls for a certain time period before dispatching them all at once. The latter type has been adopted in this paper. At the time of revising their routes, the vehicles are already on duty and some nodes have already been visited. The remaining old customers that have designated vehicles are either being serviced or awaiting service. The customers to be considered in the DVRPTW include not only old customers still to be serviced but also new visit requests. The DVRPTW is tackled by solving a series of static VRPTW problems, with each one being defined every time the input data is updated. The approach assumes that each vehicle will start its new route at the location where it is servicing or to which it is traveling.

Keywords — Dynamic routing problems, MILP reactive strategy, Deferred assignment.

I. INTRODUCTION

The dynamic vehicle routing problem with time windows (DVRPTW) represents an interesting research issue since it presents some distinctive features with regards to the static VRPTW. In addition to the routing issue, another major topic is the dynamic scenario within which decisions are to be taken. Repeated changes in vehicle routing and scheduling have to be made at different times over a rolling time-horizon that should account for new service calls but also for earlier routing decisions. Real-world experience indicates that dynamic routing problems must be studied because:

i) The economic benefits of an efficient logistical system are very significant

ii) Distribution scenarios where the information is dynamically updated are more frequent.

iii) Real-time data processing is becoming a feasible option due to the dramatic advances in computation and communications technology.

In dynamic routing problems, when re-routing is executed, the vehicle fleet is already on duty and some nodes already serviced are no longer considered. The remaining “old” customers that have designated vehicles are either being serviced or waiting for the service. Therefore, the set of customers in the DVRPTW problem should include old nodes still to be serviced and new pickup requests. Since quick execution time is a prerequisite for on-line solution of the DVRPTW, a good trade-off between the solution quality and the required computer time must be achieved. Most proposed solution algorithms for the DVRPTW are heuristics/metaheuristics but little research has been focused on model-based reactive formulations. This work introduces a reactive solution strategy for the DVRPTW that is based on a novel mixed integer linear problem (MILP) formulation and accounts for heterogeneous fleets. Using both angular and Euclidean metrics to identify neighboring routes for a given node, a small set of candidate tours for the (re)insertion of old/new customers can be defined and embedded in the formulation. Each time the proposed MILP model is solved, multiple vehicle-to-node (re)assignment and reordering of nodes are simultaneously performed. The proposed mathematical model has been derived by reformulating the reactive approach of Dondo and Cerdá (2005). The new methodology applies an “insertion & local search” strategy each time the vehicle routes & schedules are updated. By using such a two-step search strategy, the new customers are first assigned to vehicles while allowing a partial reassignment of old nodes (the insertion step), and subsequently the nodes on a given route visited by the same vehicle are optimally reordered (the local search step). The approach can be regarded as a deferred assignment methodology that retains the new service calls for a certain period of time before dispatching them all at once. The method was applied to a DVRPTW example that involves 50 nodes and 8 vehicles yielding satisfactory results at low CPU time.