Proceedings of the 2014 Winter Simulation Conference
A. Tolk, S. Y. Diallo, I. O. Ryzhov, L. Yilmaz, S. Buckley, and J. A. Miller, eds.

FIRST APPROACHES ON SIMULATION AND OPTIMIZATION TECHNIQUES TO SOLVE A WORK SHIFT TRANSPORT PROBLEM IN EMERGENCIES APPLIED TO WILDFIRE FIREMEN RELAY

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ABSTRACT

In case of a fire emergency a set of resources are mobilized to response to this critical situation. Depending on each emergency scenario the mobilized resources are placed during several days forcing to create shifts to relay the personnel. The vehicles placed in the emergency locations cannot always be used since they are required to perform more critical tasks. This problem can be modelled as a Vehicle Route Problem Pickup and Delivery with Time Windows (VRPPDTW) adding a set of new constraints. Different stochastic variables have critical influence on the performance of the transportation orders. The most important is the pick-up since huge delays appear due to firemen maneuvers at the fire front that cannot be interrupted or travelling time from the fire front takes longer due to off-road conditions. A simulation model in combination to an optimization model helps on reducing the search space orienting it and removing infeasible solutions.

1 INTRODUCTION

This paper focuses in the work shift transportation problem of the Catalonia wildfire fire-fighters. In this particular case firemen usually move to the wildfire using pump trucks that are placed along the fire front or creating a water and hose supply chain. The deployment of these vehicles makes them unusable to transport new firemen from their base stations to the fire front and vice-versa. Also other vehicles placed in the fire stations cannot be used because they must remain in the stations in case of other emergencies. This situation forces the firemen to use other vehicles usually provided by police mobile units and then requiring planning protocols for personnel collection and driver assignment selected from different locations.

2 PROBLEM DEFINITION

This problem can be modelled as a Vehicle Route Problem Pickup and Delivery with Time Windows (VRPPDTW) Toth and Vigo (2002) adding new constraints. Although this problem is similar to the School Bus Problem (SBP) Park, Junhyuk, and Byung-InKim (2010) and Corberan, Fernández and Laguna (2002) or the Vehicle Routing Problem with Backhauls (VRPB) Goetschalckx and Jacobs-Blecha (1993) these approaches cannot be used for multiple destination locations or not back-hauling to the depot is possible. The solution to this problem is to minimize the transportation cost using also a minimal number of vehicles and returning off-shift staff as earlier as possible to their stations. Finally, different stochastic variables have critical influence on the performance of the transportation orders. The most important is the pick-up at the emergency location since huge delays appear due to the firemen maneuvers at

the fire front that cannot be interrupted at the work shift changing time and because travelling time from the fire front to the pick-up locations is longer than expected due to off-road and track conditions. A simulation model in combination to an optimization model helps on reducing the search space orienting it and removing infeasible solutions and selecting easily the fleet size. This paper presents the first approaches on solving this problem using simulation techniques as an heuristic to reduce the complexity of the problem and thus reducing the computational time to find a solution. The objective of this work is to explore the possibilities of simheuristics Juan, Faulin and Ruiz (2010), Dror and Trudeau (1986) in the transportation field and to explain the results obtained. It does not intend to be a complete efficiency comparison between different optimization methodologies.

3 SIMULATION PROCESS

Introducing a simulation as an heuristic in the optimization process can improve the fleet size decision and introduce measures of the delays to evaluate. The stochastic variables introduced in the problem are: travel time between locations, service times in the locations and arrival times of firemen teams at pickups.

The reality of the problem tolerates all delays at the pickup and delivery locations that are not measured and not evaluated by the optimization, but introducing this delays in the simulation process the decision process can be fine-tuned introducing this delays as available time for the vehicles

4 RESULTS

The simulation of the different possible solutions (optimization and clustering) with different number of vehicles (simheuristics) produce two different results, the total travelling time of the vehicles, that has to be of five hours or less and the costs of the services (costs of the driver and cost of the travelled distance) that have to be the less possible from the solutions with less than five hours of travel time.

As more vehicles are used to service the firemen transportation less time is used, arriving to the problem limit of having as much vehicles as pickups, giving the lowest travel time. With different cluster sizes we arrive at the same conclusion. The 5 hour limit is reached with eight or more vehicles.

ACKNOWLEDGMENTS

This work has been funded by the Ministerio de Ciencia e Innovación, Spain. Project reference TIN2011-29494-C03-03.

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