An Adaptive Large Neighborhood Search for the Maintenance Scheduling and Routing problem

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1 Problem presentation

Maintenance is a primary service in industry, especially when failures cause important damages on personnel and environmental safety. The companies mostly outsource their maintenance operations to a service provider in order to focus on their core business. The maintenance provider agrees to satisfy the requirements of its customers by ensuring good quality maintenance services at the lowest overall cost. Finding when and how to execute the maintenance are therefore major concerns.

In this work, we consider several geographically distributed machines in multiple customers sites that are subject to random failures that can lead to sudden breakdowns and production losses. Preventive maintenance operations are scheduled for each machine at regular time intervals to limit the risk of sudden failures. We determine a set of preventive operations each one associated with a specific time window. The technicians are then routed to perform these preventive operations while respecting problem constraints (time windows, time horizon,...). When a machine suddenly breaks down, it should be repaired by a technician that performs a corrective maintenance operation. In this case, the machine stays unused in failure state for a certain waiting time until the arrival of the technician. Each category of maintenance operations has a specified cost.

The problem studied is an integrated maintenance scheduling and vehicle routing problem that minimizes both travel and maintenance costs. Our proposed approach aims to jointly integrate maintenance and routing considerations in the technicians assignment to maintenance tasks.

2 Modeling and resolution method

We propose a stochastic integrated maintenance scheduling and routing model with two objectives. The first objective can be either minimizing the total preventive and corrective maintenance cost or minimizing the failure cost with the outsourcing cost. The second objective is the minimization of the total travel cost related to technicians routing. If a preventive operation cannot be performed within its time window because of the high workload of the technicians, it will be outsourced. The model considers maintenance operations time windows, outsourcing options and maintenance costs under uncertainty which are interesting features of real industrial problems. We finally propose an Adaptive Large Neighborhood Search with dedicated destroying and construction operators for the problem. The initial solutions are constructed in

a greedy manner, based on the maintenance behaviour of the objective functions, which makes the algorithm compound integrating the construction and the improvement phases.

3 Originality of the contribution

We propose in this work a new bi-objective stochastic model for the maintenance scheduling and vehicle routing problem. We then propose an Adaptive Large Neighborhood Search that includes maintenance considerations to solve the problem. The contributions of this work are threefold: we have first introduced a stochastic failure cost that uses information from equipment degradation. It includes direct costs (failure cost) and indirect costs (production losses). This objective is particularly valuable for industries, where failures have serious damages. This objective is then compared with the use of the total maintenance cost previously proposed in the literature balancing the costs of both preventive and corrective operations. As a second contribution, we propose the association of each of these objectives with the routing cost in a bi-objective approach. We finally propose an Adaptive Large Neighborhood Search to solve the problem.

In the results, we first present a comparison with the literature for the problem with as objective only the maintenance cost [5] to measure the performance of the proposed approach. We finally show how taking into account multiple objectives and additional real industrial features can change and improve these results.

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