A Matheuristic Algorithm for the Production Routing Problem: Infeasibility Space Search and Mixed Integer Programming

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1 Extended Abstract

This work proposes a novel hybrid algorithm for solving the Production Routing Problem (PRP). The PRP is a hard-to-solve combinatorial optimization problem with numerous practical applications in the field of freight transportation, logistics and supply chain management. The generic PRP variant under the Vendor Managed Inventory (VMI) policy that is examined, describes the situation in which a manufacturer of a product is responsible for production and replenishment of customers inventories over a given time horizon, ensuring that no stock-outs occur. The decision-maker is responsible for deciding: i) the time periods at which the production takes place, ii) the product quantities that are produced, iii) the timing for replenishing each customer inventory, iv) the associated replenishment quantity and v) the routing of all customer services, with respect to the minimization of the total cost of the system.

Our contribution lies on the benefits enabled by integrated logistics models, the high complexity of PRP and the effectiveness of infeasible space search. In specific, the paper presents a novel matheuristic algorithm for the PRP. Numerous authors define matheuristics as the optimization algorithms made by the interoperation of metaheuristics and mathematical programming methods. The proposed two phase matheuristic oscillates between feasible and infeasible space (in terms of vehicle capacity) of the basic PRP model. Initially, the production-distribution decisions are taken by solving a PRP relaxation which considers approximated routing costs for customer visits (Phase I). During the next phase, a heuristic GRASP algorithm completes the partial solution with routing information. The complete solution is then iteratively improved by the main matheuristic framework, which consist of a hybrid local search framework equipped with MIP

and LP procedures to tackle various subproblems such as infeasibility elimination and simultaneous quantities optimization. This framework alternate the search between infeasible and feasible space by allowing vehicle capacity infeasibilities and applying a feasibility restoration MIP procedure, respectively. Finally, apart from the matheuristic optimization algorithm, a new PRP two-commodity flow formulation along with adapted and new valid inequalities are also proposed.

Extensive computational experiments have been conducted on 1530 well-known and widely used PRP instances to analyze the proposed algorithm performance and to access its effectiveness. To motivate the proposed algorithm design, detailed experiments on the infeasible space contribution are provided. Finally, analytic comparisons of the proposed algorithm results against state-of-the-art PRP methodologies are drawn. Computational experiments demonstrate that the infeasibility space exploration significantly contributes to the quality of the final solutions. The results obtained by the proposed matheuristic outperform the known results by matching or generating new solutions for the majority of the instances examined. More specifically, for 1440 small-medium and 90 large problem instances, our algorithm matched or improved the best known solutions for 999 and 55 test cases, respectively. More precisely, 594 and 55 of these are new best solutions.